System Operator for Northern Ireland

TRANSMISSION SEVEN YEAR STATEMENT

2009/10 – 2015/16

FOREWORD

The Transmission Seven Year Capacity Statement is required to comply with Condition 33, Part 1 of the "Licence to Participate in the Transmission of Electricity".

This is the eleventh publication of the Statement, the first having been issued in March 1993.

This document is posted on the SONI website in a form approved by the Northern Ireland Authority for Utility Regulation (NIAUR).

TRANSMISSION SEVEN YEAR CAPACITY STATEMENT

FOR THE YEARS 2009/10 TO 2015/16

DECEMBER 2009

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EXECUTIVE SUMMARY

This Transmission Seven Year Statement (TSYS) has been prepared by SONI (System Operation in Northern Ireland Ltd) in accordance with Condition 33 of the Licence to Participate in the Transmission of Electricity. It describes the status of the Northern Ireland (NI) transmission system over the seven year period 2009/10 to 2015/16.

SINGLE ELECTRICITY MARKET

A major change since the last TSYS has been the introduction of the Single Electricity Market (SEM). The SEM was established in November 2007, and was designed to enable both NI and Republic of Ireland (RoI) to benefit from reduced electricity costs and increased competition. As a result, for this TSYS, generation is now dispatched on an all-island basis, and power flows can now be seen across the connections with RoI.

Under the SEM, the 275kV and 110kV connections between NI and RoI are treated as 'internal circuits', and are no longer referred to as interconnectors, as in previous statements.

Following the introduction of the SEM both SONI and NIE's Licences were modified to reflect the new structure of the electricity supply industry on the island of Ireland. SONI has a licence obligation to operate, co-ordinate and direct the flow of electricity onto and over the NI transmission system. On the other hand, NIE has a licence obligation to plan, develop and maintain the NI transmission system. In doing so, SONI and NIE must comply with both the Transmission and Distribution System Security and Planning Standards, and the Grid Code. SONI is required to cooperate and assist the Transmission System Owner, NIE, in meeting its licence obligations regarding the planning and development of the NI Transmission System. A Transmission Interface Agreement (TIA) exists between the companies which, amongst other things, sets out the information exchange requirements and timescales to assist each party to meet its licence obligations. This TSYS forms part of the transmission planning process described in Section C of the TIA.

An agreement also exists between SONI and EirGrid called the System Operator Agreement (SOA). EirGrid are the Transmission System Operator (TSO) in RoI. This agreement sets out the key principles and arrangements at the interface between the two companies as TSOs in NI and RoI respectively. This describes the information exchange and timescales required to enable each TSO to meet its licence and Grid Code obligations. All-island system planning is covered in Schedule 4, which deals with the sharing of information to facilitate the publication of this TSYS.

THE TRANSMISSION SYSTEM

The NI transmission system comprises some 2000 circuit kilometres of 275kV and 110kV overhead lines and cables. The primary purpose is to transport power from generators to demand centres, or Bulk Supply Points (BSPs).

The NI transmission system is connected electrically to the (RoI) transmission system via a double circuit 275kV connection at Tandragee and two 110kV connections at Enniskillen and Strabane. It is planned to have a new 400kV connection in place by 2012/13. The NI transmission system is also connected to the Great Britain (GB) transmission system by the Moyle Interconnector, a 500MW DC link between Ballycronan More and Auchencrosh in Scotland.

This TSYS includes comprehensive listings of all transmission network data, as well as describing planned developments into the future. Information is provided in the form of tables, maps and network diagrams.

FREEZE DATE

The freeze date for data collection in this TSYS was **30 April 2009**. This is the date that all data for the network files, and associated sequence data for use with short circuit analysis, was collected.

GENERATION

At the beginning of 2009, some 2999MW of generation capacity was installed in NI, of which 267MW comprised renewable generation connected to the distribution system. Generation planned to connect over the next seven years is listed in table S.1 below.

GENERATION TYPE	MW
THERMAL	440
RENEWABLE	331

Table S.1: Planned Generation Connections by 2015/16

EU emissions targets are anticipated to result in the loss of some 340MW of capacity at Ballylumford by the start of 2014. This will be offset by the connection of 440MW of CCGT plant expected in 2013. Over the seven year period covered by this TSYS, renewable generation totalling some 331MW is committed to connecting. Therefore, by the year 2015/16, the installed capacity would be 3430MW.

The implications of these developments are discussed in **Sections 8** and **9**, which deal with transmission network capability.

It should be noted that a government renewable generation target level of 40% is being considered for the year 2020 in NI. This would result in the region of 1800MW of installed renewable generation capacity to achieve the 40% target. This represents a considerable challenge for the TSO to manage, and is discussed in more detail in **Section 4** of this TSYS.

DEMAND

Demand forecast projections are based on growth trends seen at BSPs over the last number of years, as well as economic growth data. This TSYS includes the latest forecasts which have been calculated after the recent economic slump. The methodology of this forecast is discussed in **Section 5**, and table S.2 below shows the seven year peak demand forecast used throughout this TSYS.

The most likely scenario adopted in this report is 0% growth from 2009/10 to 2010/11, with a very modest increase in 2011/12, before returning to a 1.5% growth per annum in following years.

YEAR	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
DEMAND (MW)	1793	1793	1802	1820	1847	1875	1903

Table S.2: Seven Year Peak Demand Forecast

Previous statements have highlighted the seven year demand forecast at all BSPs for the time of peak demand only (winter maximum). This TSYS also includes seven year forecasts for the time of minimum demand (summer minimum), as well as summer maximum. These forecasts can be seen in **Appendix D**.

POWER FLOWS

In a change to previous statements, this TSYS provides power flows for summer minimum conditions, to go along with summer maximum and winter maximum conditions. Power flows for 2015/16 with all renewable generation expected and committed to connect have been included too. These extra power flows are included to provide an indication of normal system flows with high levels of renewable generation.

The major changes in the power flows include:

- Power flows emanating from the West of NI.
- 110kV reinforcement around Tamnamore and Coleraine to aid connection of renewables
- The introduction of the 400kV tie-line with RoI.

FAULT LEVELS

Fault levels have been calculated in accordance with Engineering Recommendation G74, which itself is based upon International Standard IEC60909. Previous statements have calculated fault levels for winter maximum demand for one particular year- this TSYS provides fault levels at times of maximum and minimum demand for 2010/11 and 2015/16. This highlights changes in fault levels brought about by increased generation- both thermal and renewable- and the introduction of the 400kV connection with RoI. Fault levels for Winter Max, 2010/11, are shown below in figure S.1.

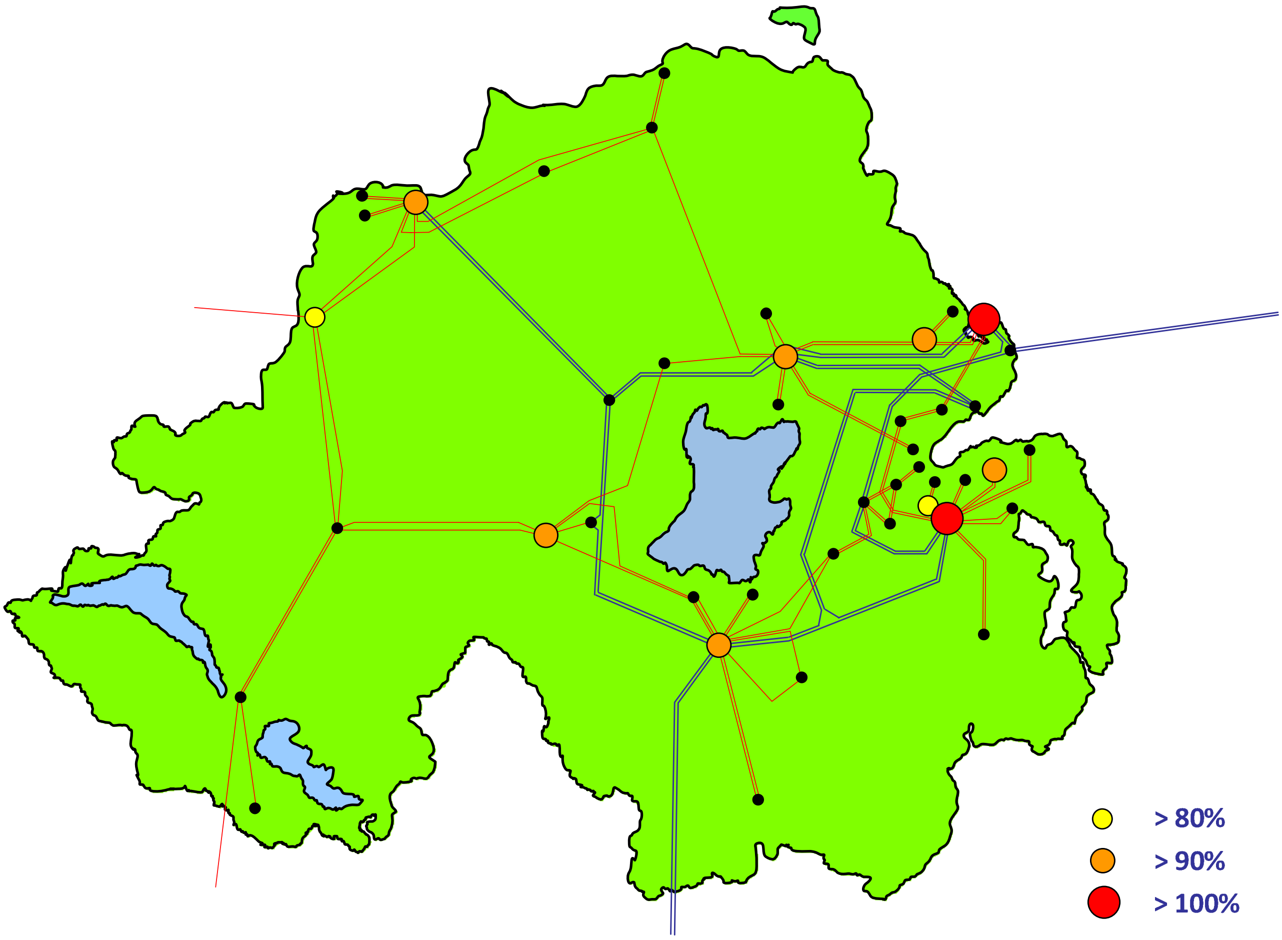


Figure S.1: Fault Levels for Winter Max 2010/11

The results indicate that a number of substations are approaching, or have exceeded, their rated short circuit current level, under maximum generation conditions. These issues have been flagged up to NIE and work is planned to resolve these issues. In the interim risk mitigation measures have been employed by SONI, pending equipment uprating. The increase in fault levels has resulted from the new calculation methodology, which, amongst other measures, calculates a fault contribution from demand. In later years, increased generation and the new 400kV tie-line with RoI raise fault levels further. The rise in fault level means that all future connections to the NI transmission system will require careful analysis as plant margins are considerably reduced. Details on fault levels are in **Section 7**.

TRANSMISSION CAPABILITY

This TSYS examines the capability of the NI transmission system to accommodate a new source of generation in the year 2015/16, in addition to the power flows caused by existing and planned generation.

Sections 8 and **9** describe in detail the analysis and results involved with the capability studies. For the purposes of the analyses, generation was dispatched on an all-island basis, as this reflects the manner of generation dispatch in the SEM. However, for testing capability at existing generation nodes, all generation at that node (existing and planned) was maximised before analysis was performed. Figure S.2 below geographically represents the capability of all nodes at 275kV (map on the left) and 110kV (map on the right) to accept new generation in 2015/16. At each substation, the available capacity is indicated. However, where no capacity is available, this is shown by a red dot, while nodes where there is in excess of 400MW of capacity are represented with a yellow dot.

OPPORTUNITIES FOR NEW LARGE GENERATION AT 275kV

The analysis showed that several 275kV nodes could accept a new generator of size 400MW without requiring significant transmission network reinforcement. Other nodes in the greater Belfast area would also be capable of connecting a generator of significant size. However, the analysis also highlighted several areas where there is extremely limited or no capacity. These are the Island Magee area (Ballylumford and Moyle) and at Coolkeeragh.

OPPORTUNITIES FOR SMALLER GENERATION AT 110kV

The results indicate that in 2015/16, there is very limited spare capacity in the North-West area of the country, despite a number of unapproved reinforcement schemes at 110kV level in the area. This is due to the large amount of existing and planned renewable generation in the area. The results also showed that this large amount of renewable generation introduced voltage stability issues under certain critical contingencies, and for the purpose of these studies, additional reactive power support in the form of a Static Var Compensator was required to support the voltage in the North-Western area.

As with the 275kV studies, the best opportunities for new generation at 110kV level exist in the East of the country.

It is important to note that the studies assess nodes individually, and therefore the results are not cumulative. If a new generator planned to connect at a particular node, the capability of all other nodes would then need to be reassessed. It should also be noted that these results are indicative, and factors such as fault levels and evolving generation and demand profiles would also need to be taken into account

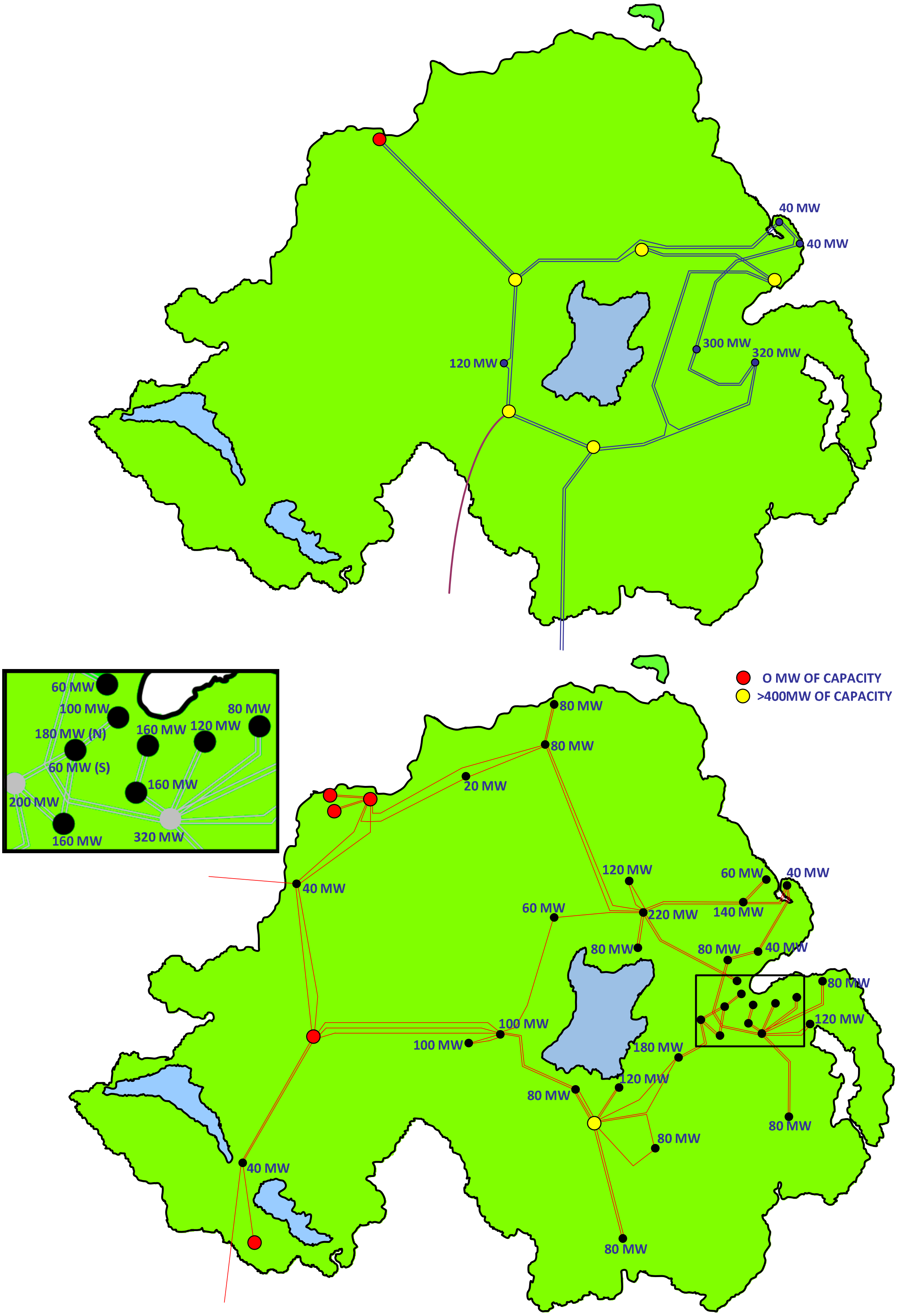


Figure S.2: Generation Opportunities at 275kV and 110kV for 2015/16

CONCUSIONS

The existing transmission system in NI has reached saturation point, and further connection of renewables in the North-West is not possible without significant reinforcement by NIE. Without the assumed major unapproved 110kV developments between Omagh-Tamnamore and Kells-Coleraine, it would not have been possible to model the levels of renewables in this TSYS (600MW by the year 2015/16). It is now essential that reinforcement occurs, taking into consideration past experience of the time lags associated with the construction of transmission circuits.

SONI continues to have concerns regarding voltage stability under certain export and dispatch scenarios. These concerns heighten considerably as the penetration of renewable generation increases. It is therefore important that increased reactive support is installed on the transmission network.

1

INTRODUCTION

1 INTRODUCTION

This Transmission Seven Year Statement (TSYS) has been prepared by the System Operator for Northern Ireland (SONI) Ltd, in accordance with Condition 33, Part 1 of the “Licence to Participate in the Transmission of Electricity”.

Following the introduction of the Single Electricity Market (SEM) both SONI and NIE’s Licences were modified to reflect the new structure of the electricity supply industry on the island of Ireland. SONI has a licence obligation to operate, co-ordinate and direct the flow of electricity onto and over the NI transmission system. On the other hand, NIE has a licence obligation to plan, develop and maintain the NI transmission system. In doing so, SONI and NIE must comply with both the Transmission and Distribution System Security and Planning Standards, and the Grid Code. SONI is required to cooperate and assist the Transmission System Owner, NIE, in meeting its licence obligations regarding the planning and development of the NI Transmission System. A Transmission Interface Agreement (TIA) exists between the companies which, amongst other things, sets out the information exchange requirements and timescales to assist each party to meet its licence obligations. This TSYS forms part of the transmission planning process described in Section C of the TIA. One of the aims of the TIA is to operate the NI transmission system in an efficient, economically co-ordinated, safe, secure and reliable manner, as part of the all-i0sland transmission network.

An agreement also exists between SONI and EirGrid called the System Operator Agreement (SOA). EirGrid are the Transmission System Operator (TSO) in RoI. This agreement sets out the key principles and arrangements at the interface between the two companies as TSOs in NI and RoI respectively. This describes the information exchange and timescales required to enable each TSO to meet its licence and Grid Code obligations. All-island system planning is covered in Schedule 4, which deals with the sharing of information to facilitate the publication of this TSYS.

The NI transmission network is operated at 275kV and 110kV. The primary purpose of the network is to transport power via overhead lines and cables from Generators to Bulk Supply Points (BSPs). The power is then transformed to lower voltages and distributed to customers via the distribution network.

This TSYS describes the statutory operational requirements, the existing network, its configuration and its planned development over the seven year period to 2015/16. Network utilisation is reported under normal operating conditions. Potential locations for large generation or demand connections are analysed and the impact of network outages resulting from planned and unplanned outages is considered.

This TSYS provides information on electricity demand forecasts, the transmission network, generation capacity and interconnection. Sufficient detailed modelling parameters are provided to facilitate analysis by third parties.

1.1 OUTLINE OF STATEMENT

Section 2 states the technical requirements of the supply system and the Licence standards which apply. System reliability, stability and quality of supply are discussed and the impact of increased penetration of wind generation and interconnection are considered.

Section 3 describes the existing transmission network, including connections with the Republic of Ireland (RoI) and interconnection with Great Britain (GB). An assessment of the existing system and the impact of future developments are included in this section.

Section 4 describes the existing generation capacity, and provides information on generation operation.

Section 5 provides the network data including demand forecasts and electrical parameters of plant.

Section 6 provides the capacity of the transmission network by use of power flow diagrams for the years 2010/11, 2012/13 and 2015/16.

Section 7 analyses the network fault levels. They are calculated for Winter Maximum and Summer Minimum conditions for the years 2010/11 and 2015/16.

Section 8 analyses the capability of the network by means of a matrix study. This examines the potential locations for large generation connections.

Section 9 is a review of the development opportunities that exist for the connection of new generation and load.

1.1.1 OTHER INFORMATION

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

- The SONI Grid Code
- Licence Standards- Transmission and Distribution System Security and Planning Standards
- The SONI Transmission Connection Charging Methodology Statement
- The Statement of Charges for Use of the NIE Transmission and Distribution System
- The Bulk Supply Tariff
- The 2009 Generation Seven Year Capacity Statement
- The SONI Transmission System Performance Report

Copies of the most up to date versions of the above documents may be obtained from SONI upon payment of a fee, or downloaded from the SONI website www.soni.ltd.uk

This TSYS does not assess the adequacy of generation capacity in NI. This assessment is undertaken separately and reported in the 2009 Generation Seven Year Capacity Statement detailed above.

1.2 PURPOSE OF STATEMENT

The purpose of this TSYS is to provide:

- Such further information as shall be reasonably necessary to enable any person seeking use of the transmission system to identify and evaluate the opportunities available when connecting to and making use of the system. This includes information on the status of transmission capacity and the anticipated future requirements of transmission capacity.
- A commentary prepared by the Transmission System Operator (TSO) indicating the TSO's views as to those parts of the transmission most suited to either new generation or new demand connections, and the capability of the transmission system to transport further quantities of electricity.

1.3 THE SINGLE ELECTRICITY MARKET

On the 1st November 2007, a Single Electricity Market (SEM) began operating on the island of Ireland. The all-island wholesale electricity market allows both NI and the RoI to benefit from increased competition, reduced energy costs and improved reliability of supply than if the markets had not been combined. It will also encourage the entry of new market participants, both generators and suppliers.

The NI transmission network is connected to the RoI transmission network by a double circuit 275kV connection between Tandragee and Louth, and two 110kV single circuit connections between Enniskillen and Corraclassy, and Strabane and Letterkenny. With the introduction of the SEM, these circuits are treated as internal circuits, rather than interconnection between the two transmission systems.

With the introduction of the SEM, generation is now dispatched on an all-island basis. As a result, power flows are now permitted on the cross border circuits in analysis carried out for the TSYS. Despite this, however, only the performance of the transmission system in NI is considered.

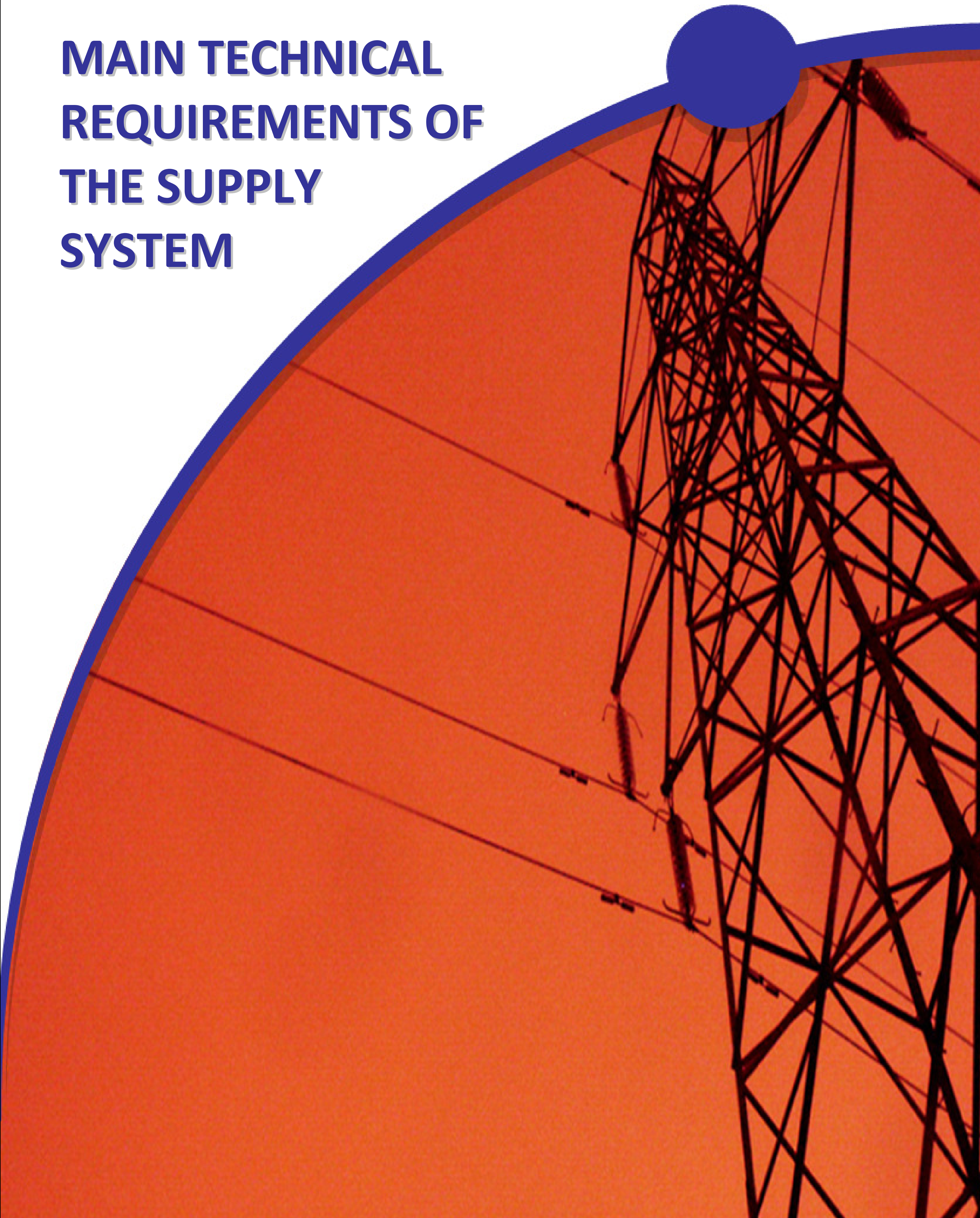
1.4 CHANGES SINCE THE LAST STATEMENT

The major changes to the network highlighted since the last TSYS include

- An increased number of wind farm power stations.
- The introduction of the SEM.
- Generation dispatch carried out on an all-island basis.
- The NI generation portfolio.
- New planned 400kV connection with RoI.

2

MAIN TECHNICAL REQUIREMENTS OF THE SUPPLY SYSTEM



2 MAIN TECHNICAL REQUIREMENTS OF THE SUPPLY SYSTEM

It is important for customers proposing to connect to the transmission system to be aware that there are technical requirements and standards to which the system is developed and operated.

The development and operation of the transmission system must be managed to provide safe, secure and economic supplies of electricity at a satisfactory level of quality.

2.1 SECURITY AND PLANNING STANDARDS

The ability to supply customers during circuit outages is governed by the Security and Planning Standard P2/5, as amended on the 7th August 1992. The standard is complex but generally requires that the main transmission system will continue to supply all customers in the event of a single unexpected event during the winter. In other seasons, the system should supply all or a defined percentage of load for an unexpected event during the maintenance of another circuit. The standard applies increasing security requirements as the demand increases. In Section 9 of this Statement, a tower failure at 275kV is considered to be a single event, i.e. the outage of two 275kV circuits on the same tower. This is to ensure that the system does not suffer catastrophic failure.

2.2 ELECTRICITY SUPPLY REGULATIONS (NORTHERN IRELAND)

The two most important technical characteristics that determine the quality of supply are frequency and voltage. The Electricity Supply Regulations (Northern Ireland) 1991 set out the statutory obligations in relation to both frequency and voltage.

2.2.1 FREQUENCY

The declared frequency is 50Hz, and is normally controlled within the range 49.8Hz to 50.2Hz.

Balancing generation and demand maintains the frequency within the above range. The all island system is not synchronously interconnected with the UK and greater European network, and thus remains an ‘island system’; as a result, the loss of a large generating unit could cause the frequency to fall below 49.5Hz for a few seconds. In such circumstances some system load may be shed automatically to assist in recovery of the frequency.

The NI Transmission System is connected to the RoI via a 275kV double circuit between Louth and Tandragee, and two power flow controlled 110kV circuits. These increase the inertia of the system, reducing the impact of the loss of a large generating unit in NI. Nevertheless, the loss of generation may, in some circumstances, still result in under-frequency load shedding.

SONI has negotiated with Moyle Interconnector Ltd and National Grid Electricity Transmission (NGET) to use the Moyle interconnector to contract for the provision of spinning reserve. This was introduced in 2007 to provide a reliable source of reserve and complement reserve that had been provided by conventional generation.

2.2.2 VOLTAGE

The voltage variation permitted by the Electricity Supply Regulations (Northern Ireland) 1991 on the NI transmission system is ±10% at the terminal of a customer. The permitted step voltage changes are specified in the Transmission and Distribution System Security Planning Standards (PLM-ST-9). The permitted step voltage changes are described below:

- For a secured single circuit outage: not greater than 6%.
- For a secured double circuit outage: not greater than 10%.

For both conditions, the 110kV voltage at BSPs should not drop below 90%.

The voltage at any point on the system is determined by the reactive power output of the generating plant, the tap position of each generator transformer and system transformer, the electrical characteristics of the system, the level of load and its power factor. Voltage control is affected by providing automatic control of the generator output voltage, altering transformer tap positions and the switching of shunt reactors or capacitors. These operational measures do not compromise the security standards imposed by the SONI licence.

2.3 GRID CODE REQUIREMENTS

The main technical conditions to be met by users of the system are outlined in the SONI Grid Code. The Code sets out the principles governing SONI's relationship with users of the system. The Code specifies procedures for both planning and operation and covers both normal and exceptional circumstances.

The main sections of the code are as follows:

- Planning Code
- Connection Conditions
- Operating Codes
- Scheduling and Dispatch Codes
- Data Registration Code
- General Conditions
- Metering Code

2.4 LICENCE (SYSTEM SECURITY AND PLANNING) STANDARDS

The system is planned in accordance with the document entitled 'Transmission and Distribution System Security and Planning Standards', which has been approved by Northern Ireland Authority for Utility Regulators (NIAUR). The relevant standards applicable to the NI Transmission System are described in **Table G.1** of this document.

The Regulators and the relevant government departments in NI and RoI, DETI and DCENR respectively, have placed an action on both NIE and EirGrid under the all-island Energy Market Development Framework issued in June 2004 to determine to what extent Grid Codes and Licence Standards can be harmonised within the two jurisdictions.

2.5 SYSTEM RELIABILITY, STABILITY AND QUALITY

The system is planned in accordance with the Licence Standards where particular consideration is given to avoiding potential problems due to forced circuit outages occurring during a planned circuit outage. The location and connection arrangement of power sources is very important in this context.

As well as considering the reliability of circuits and load flows following circuit outages (overload situations), it is necessary to consider the stability of the system. When proposals for new generation, demand connections or interconnection are being considered, it is necessary to investigate both transient stability (the resilience of the system to faults) and dynamic stability (the resilience of the system to generator trips or circuit switching).

System instability can usually be prevented by the application of enhanced protection and control systems. Instability can result in the following:

- Loss of synchronism between generators
- Consequential tripping of circuits
- Mismatched pockets of generation and load
- Possible plant damage

With regard to the relatively small size of the transmission system, it is also necessary to consider the adequacy of the response characteristics of generating units.

2.5.1 INCREASED PENETRATION OF WIND FARM POWER STATIONS

Wind power generators have characteristics which differ from those of conventional fossil fuel generators. As wind penetration increases SONI will face many challenges to manage the NI transmission in a safe, secure and reliable manner. These include:

a) The energy source is uncertain
b) The performance during and after faults may be difficult to control
c) The delivery of ancillary services may require attention
d) System inertia is reduced because large fossil fuel generators are not running and stability limits will change.

SONI is exploring ways to reduce the uncertainty in wind energy forecasting (e.g. Anemos[1] forecasting) and to help manage residual uncertainty and variability.

The SONI Grid Code has been modified to place duties on wind generators in relation to a) and b) above. It is likely that in order to facilitate high penetration of wind power, obligations will be required for wind generators to contribute to system inertia (see d) above).

Section 4.2.3 discusses the increase in wind farm power stations into the future.

[1] SONI is a participant in the Anemos project. This is a collaborative effort between wind developers, manufacturers, utilities and academia to develop system operator tools to better manage high levels of wind penetration

2.5.2 INTERCONNECTION WITH GREAT BRITAIN

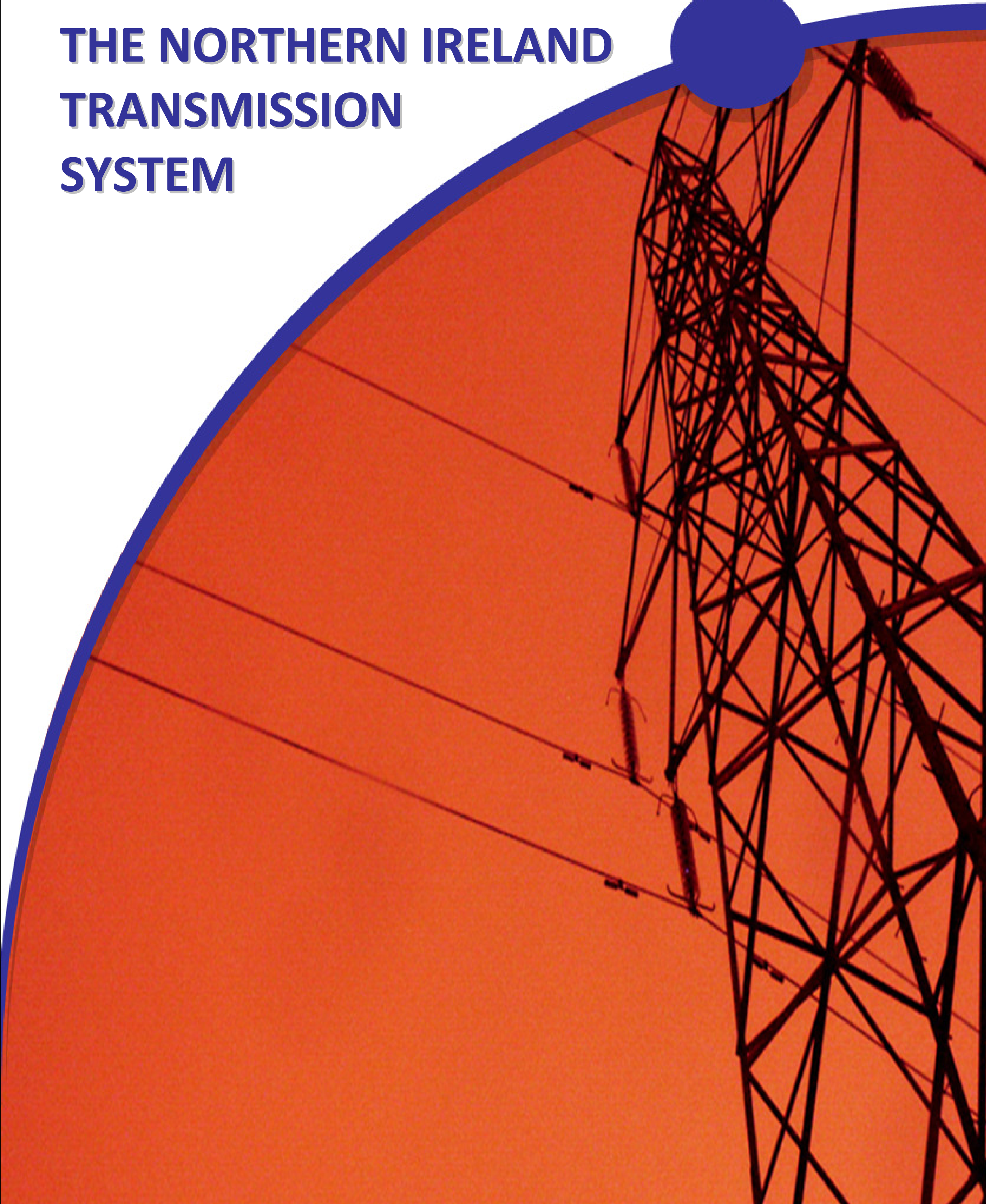
The 500MW HVDC link with Great Britain (GB) is described in **Section 3**.

HVDC links have an advantage over alternating current (ac) interconnection in that separate control of voltage and frequency can be maintained on each system. The power flow can be preset at a fixed value and in an emergency the link can provide additional support through its very rapid automatic response to system disturbances.

Where there are faults on the NI transmission system, effects are limited to a brief distortion of the HVDC 50Hz ac synchronous waveform in import mode. The rapid response means that the HVDC link can have a net stabilising effect on the island system in the event of generation loss. Nonetheless, in so far as it displaces rotating plant, the HVDC link reduces system inertia.

3

THE NORTHERN IRELAND TRANSMISSION SYSTEM



3 THE NORTHERN IRELAND TRANSMISSION SYSTEM

The purpose of this section is to describe the topology of the Northern Ireland (NI) transmission system. Large generation and demand connection projects tend to have long lead in times. It is therefore necessary to consider future planned network developments, which may alter the configuration of the system during the connection project. By the freeze date, SONI had not yet received a formal Transmission Investment Plan from Northern Ireland Electricity (NIE). NIE facilitated the production of this Transmission Seven Year Statement (TSYS) by providing network files for the seven year period covered by this TSYS. These network files contained projects expected to be delivered over the seven year period. NIE have advised whether the projects have received approval or are, as of yet, unapproved.

3.1 THE EXISTING SYSTEM

The NI transmission system comprises some 2,000 circuit kilometres of 275kV and 110kV overhead lines and cables. The backbone of the transmission network in NI was originally built to a high standard with the potential to deal with many years of load growth in NI. A geographic layout of the existing transmission system is shown in **Map B.1**.

3.2 CONNECTIONS WITH REPUBLIC OF IRELAND

3.2.1 275kV CONNECTIONS

The NI transmission system is connected to the Republic of Ireland (RoI) via a double circuit 275kV line between Tandragee and Louth, terminated in two paralleled 300MVA 275/220kV transformers on one circuit, and a 600MVA 275/220kV transformer on the other.

The physical firm capacity of the Tandragee-Louth cross-border circuits is assessed as the emergency overload rating of one circuit- 660MVA summer rating. However, the actual transfer capacity of the circuits is limited by other technical factors. Some of these include:

- the possibility of system separation that results from a forced outage of the circuits
- the risk of voltage instability

3.2.2 110kV CONNECTIONS

In addition to the main 275kV double circuit; there are two 110kV connections, as described below:

- Strabane-Letterkenny: single circuit 110kV line commissioned in March 1995.
- Enniskillen-Corraclassy: single circuit 110kV line- as above.

Until 2001 both circuits operated in a standby mode but were converted into permanent connections by the deployment of power flow controllers, rated at 125MW. The power flow controllers are normally adjusted close to 0MW transfer, but can be set to any desired flow to support either system during abnormal system operation. The systems are not considered stable in the absence of the 275kV Tandragee-Louth double circuit, and therefore the 110kV connections are automatically removed from service in the absence of both 275kV circuits. In the event of a severe outage, e.g. Coolkeeragh-Magherafelt 275kV double circuit, the power flow controllers allow immediate support from the healthy system, pending manual control action.

3.2.3 FUTURE CONNECTIONS

NIE and EirGrid (the TSO in RoI) are committed to establishing a new 400kV line between Turleenan in NI and Mid Cavan in RoI. The new circuit will increase the transfer capability between the two systems, resulting in higher, unconstrained flows. The total transfer capacity will be in the region of 1500MVA and is expected to be commissioned by 2012/13.

3.2.4 CONSTRAINTS

Currently, in the event of the loss of the existing 275kV double circuit connecting NI to RoI, the two 110kV connections are automatically switched out, to maintain system stability. As a result of this, system separation occurs. The potential impact of system separation results in constraints being applied on the amount of power that can be transferred between NI and RoI.

The Total Transfer Capacity (TTC) of the 275kV double circuit tie line is summarised in table 3.1 below. It should be noted that the amount of power that can be transferred also depends on the amount of reserve being carried in each jurisdiction.

DIRECTION	TOTAL TRANSFER CAPACITY
NI – RoI	**430 MW**
RoI – NI	**380 MW**

Table 3.1: Existing Constraints on 275kV Circuits

Once the 400kV circuit comes into operation, a second high capacity path will be provided in the event of a fault on the existing circuits. This will result in the constraints currently in existence on the 275kV double circuit being removed.

The map below in figure 3.1 shows the location of the connections with RoI.

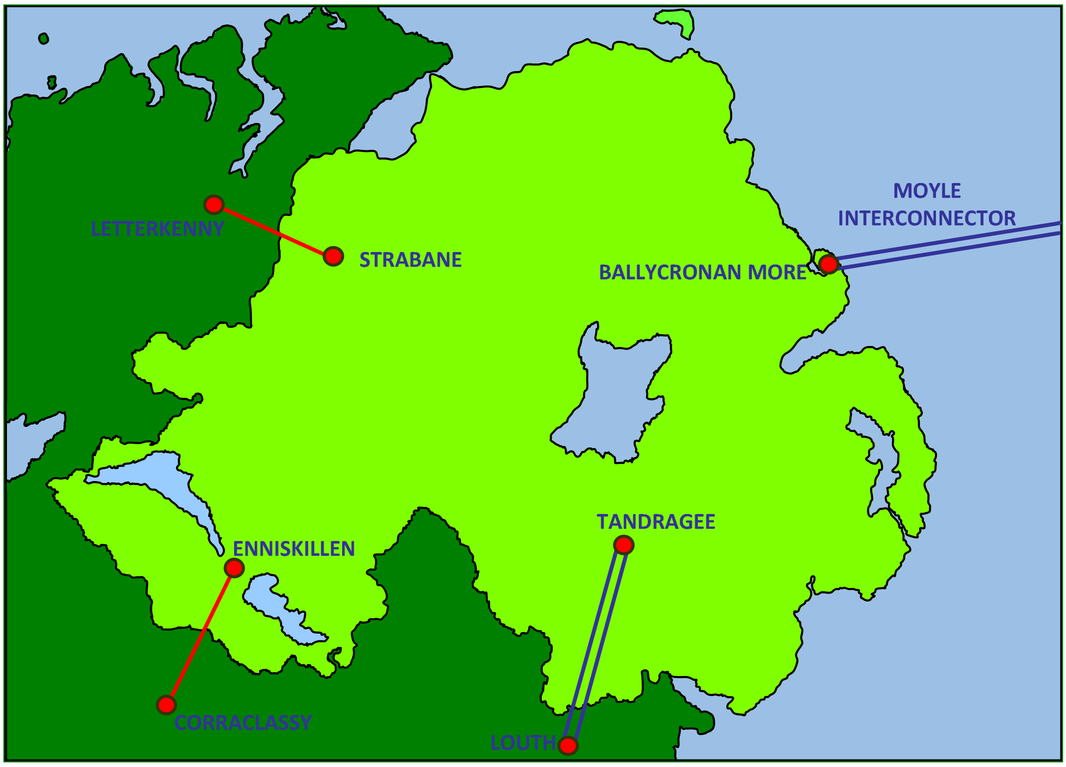


Figure 3.1: Existing Cross Border Circuits and Interconnection

3.3 INTERCONNECTION WITH GREAT BRITAIN

The Moyle interconnector commenced commercial operation in 2002. It is constructed as a dual monopole HVDC link with two coaxial undersea cables from Ballycronan More in Islandmagee, to Auchencrosh in Ayrshire, Scotland. The link has a physical installed capacity of 500MW; however, this is curtailed due to certain network limitations on both sides of the link. An emergency flow of up to 75MW is available should the frequency in NI drop below 49.6Hz. The convertor station at Ballycronan More is looped into one of the 275kV Ballylumford to Hannahstown circuits.

All interconnector capacity is auctioned by SONI in NI on behalf of Moyle Interconnector Limited (MIL). This capacity is purchased by market participants.

The map above in figure 3.1 shows the location of the Moyle interconnector.

Table 3.2 below details the available capacity of the Moyle interconnector.

DIRECTION	SUMMER	WINTER
GB – NI	410 MW	450 MW
NI - GB	80 MW	80 MW

Table 3.2: Existing Constraints on the Moyle Interconnector

3.4 APPROVED DEVELOPMENTS

As of the freeze date, system developments which have been approved by NIE for completion during the seven year period are detailed below.

3.4.1 TAMNAMORE 275/110kV SUBSTATION PHASE ONE

For phase one work, a new 275/110kV 240MVA Interbus Transformer (IBTX) is to be located close to the Tandragee - Magherafelt 275kV tower line and will supply Dungannon Bulk Supply Point (BSP) by a new 110kV circuit. Work is ongoing, and is expected to be complete by winter 2009/10.

3.4.2 BELFAST NORTH MAIN 110/33kV BSP

The BSP at Power Station West (PSW) is to be decommissioned and replaced with a new BSP at Whitla Street in North Belfast. The two 110kV cable circuits from Hannahstown to PSW are expected to be turned into Whitla Street which is planned to be equipped with 2 x 90MVA transformers and a new 33kV switchboard. The BSP is expected to be commissioned by autumn 2010.

3.4.3 SPRINGTOWN 110/33kV BSP

The existing 33kV circuits supplying the Springtown 33/11kV substation are approaching their thermal limits. The 33kV circuits will be upgraded to 110kV and a new 110kV BSP is planned to be established. It will be equipped with 2 x 90MVA transformers. Lenamore, Springtown and Strand Road are to be fed from this new BSP, in turn reducing the load at Coolkeeragh BSP. The BSP is anticipated be commissioned by winter 2009/10.

3.4.4 SLIEVE KIRK 110/33kV SUBSTATION

A new 110/33kV substation is to be established on a green-field site next to the proposed Slieve Kirk wind farm power station development. A new 110kV transmission line will be constructed and teed into an existing Coolkeeragh-Strabane ‘B’ 110kV line. The substation is planned to be commissioned by summer 2010.

3.4.5 400kV CONNECTION BETWEEN TURLEENAN AND MID CAVAN (RoI)

A new connection between NI and RoI is currently planned to be established by winter 2012. It is proposed that the circuit will connect into the NI transmission system at a new 275/400kV substation at Turleenan. Present plans indicate the circuit will be a single 400kV overhead tower line circuit, with initial capacity of circa 1000MW. With additional transformation capacity, this will increase to 1500MW. Once this connection is established, the constraints on the existing Tandragee-Louth 275kV double circuit (see **Section 3.2**) will be removed.

3.5 UNAPPROVED DEVELOPMENTS

This section contains developments that, at the time of the data freeze, are unapproved. These projects have come about mainly to allow the network to accommodate wind farm generation into the future. Typically, these developments would not be included in the analysis in the TSYS, due to their unapproved status. However, as a result of the large forecasted increases in wind farm generation over the seven years covered by this TSYS, and the publication of government renewable energy targets, it has been decided to include these projects in the analysis, using provisional completion dates provided by NIE.

3.5.1 TAMNAMORE 275/110kV SUBSTATION PHASE TWO

The second, and final, phase of this scheme involves the installation of a second 275/110kV 240MVA IBTX. This will be accompanied by 110kV circuit reconfiguration. The existing 110kV circuits, from Dungannon to Omagh and Dungannon to Drumnakelly, will now be connected to Tamnamore, rather than Dungannon. Dungannon BSP will be connected to Tamnamore by two 110kV circuits. The work is provisionally scheduled to be complete by winter 2011/12.

3.5.2 OMAGH – DUNGANNON CIRCUITS

At present, there are two 110kV circuits running between Dungannon and Omagh. They both have a winter rating of 124MVA. With the large amount of renewable generation scheduled to connect in the area around Omagh, these circuits will be uprated to a winter rating of 210MVA. In line with Tamnamore Phase Two (see **Section 3.5.1**), these circuits will also connect into Tamnamore substation, rather than Dungannon.

Along with the uprating of the two existing circuits, a third Tamnamore - Omagh circuit will be constructed, also with a winter rating of 210MVA. All of this work is provisionally scheduled to be complete by winter 2011/12.

In the interim, NIE are planning to establish a Dynamic Line Rating (DLR) on the Omagh – Dungannon circuits. The TSO would not view these as satisfactory longer-term solutions, and as a result, delays to the planned upgrades in this region could have a large impact on system security.

3.5.3 SECOND COLERAINE – KELLS 110kV CIRCUIT

In light of the large amount of renewable generation scheduled to connect in the region around Coleraine, a second 110kV circuit is planned to be constructed between Coleraine and Kells substations. It will have a winter rating of 210MVA. This circuit is provisionally scheduled to be complete by winter 2011/12.

3.5.4 MISCELLANEOUS PROJECTS

Works have been identified to replace assets and address load flow issues during the period between winter 2009/10 and autumn 2013, for example, schemes such as transformer replacement. For the purposes of this TSYS, certain projects have been assumed as being approved. These projects are described in the tables below:

TRANSFORMER REPLACEMENT

SUBSTATION	TRANSFORMERS		DATE
	REMOVED	ADDED	
BALLYMENA	2 X 45MVA	2 X 90MVA	WINTER 2009/10
WARINGSTOWN	2 X 45MVA	2 X 90MVA	WINTER 2009/10
ANTRIM	4 X 22.5MVA	2 X 90MVA	AUTUMN 2010
CARNMONEY	2 X 30MVA, 1 X 60MVA	2 X 90MVA	WINTER 2011/12
KNOCK	2 X 60MVA	2 X 90MVA	WINTER 2011/12
DONEGALL	1 X 45MVA	1 X 90MVA	WINTER 2012/13

Table 3.3: Miscellaneous Projects- 110/33kV Transformer Changes

Further information on the changes in table 3.3 can be found in **Appendix A.5**.

SUBSTATION	YEAR	IBTX CHANGES
CASTLEREAGH	WINTER 2009/10	REPLACEMENT OF IBTX 1
HANNAHSTOWN	WINTER 2010/11	INSTALLATION OF THIRD IBTX
HANNAHSTOWN	WINTER 2011/12	REPLACEMENT OF IBTX 1
CASTLEREAGH	WINTER 2011/12	INSTALLATION OF FOURTH IBTX
HANNAHSTOWN	WINTER 2012/13	REPLACEMENT OF IBTX 2

Table 3.4: Miscellaneous Projects- IBTX Transformer Changes

Further information on the changes in table 3.4 can be found in **Appendix A.7**.

3.6 SPECIAL PROTECTION SCHEMES

Special protection schemes monitor the network and take automatic action to minimise network problems when unexpected events occur. For example, the schemes may detect low network voltages, circuit overloads, or circuit tripping, and eliminate network problems by automatically reconfiguring the network, disconnecting demand or changing the output of generation. The design of individual schemes determines how they effect network operation in specific parts of the network listed below.

The TSO would not view special protection schemes as satisfactory long term solutions, as they could have a negative impact on system security in place of upgrades to the transmission system.

3.6.1 110kV CIRCUIT PROTECTION SCHEME: TANDRAGEE-DRUMNAKELLY

Under certain 110kV circuit outage scenarios the Tandragee to Drumnakelly circuits can become significantly overloaded. To relieve this situation, a special protection scheme has been installed to automatically reconfigure the network, and in extreme circumstances, disconnect load.

3.6.2 COOLKEERAGH UNDER-VOLTAGE SCHEME

At heavy load times, when there is insufficient operational generation at Coolkeeragh, the network in the North West may be subject to low voltage conditions following a forced outage on either:

- The Coolkeeragh – Magherafelt 275kV double circuit
- Both 275/110kV IBTXs at Coolkeeragh

To relieve this situation, a special protection scheme has been installed to automatically shed load in the North West.

3.6.3 NORTH WEST GENERATION CURTAILMENT SCHEME

If generation in the North West is operating at high output at times of low NI demand, and an outage of the 275kV double circuit between Coolkeeragh and Magherafelt occurs, the local 110kV circuits could overload.

Special protection schemes have been installed to take automatic remedial actions to remove sustained overloading of the transmission network. Under these rare circumstances, the output of the CCGT at Coolkeeragh will be reduced to 160MW. In addition, a special protection scheme monitoring for overloads on the 110kV circuits between Omagh and Dungannon will automatically reduce the output of Slieve Divena windfarm (30MW).

3.6.4 MOYLE LOW FREQUENCY RESCUE FLOW

If the frequency of the NI system falls below 49.6Hz, the Moyle interconnector provides a rescue flow of 50MW. If the frequency continues to fall, at 49.5Hz a further 25MW is provided. As the frequency recovers, the rescue flow is stopped once the frequency rises above 49.8Hz.

3.6.5 MOYLE RUNBACK SCHEME

When power is being exported to RoI via the North-South tie-line, there would be a surplus of generation in NI if the tie-line was lost. In the event of the loss of the tie-line, there is a runback scheme to reduce the Moyle import. This scheme depends on both the level of transfer on the North-South tie-line, and the amount of Centrally Dispatched Generation on in NI. At present, the maximum amount that the Moyle import can be runback by is 300MW.

3.6.6 BALLYLUMFORD GENERATION TRIPPING SCHEME

At times of maximum generation in the Islandmagee area, under certain outage conditions, circuits exiting the Ballylumford 275kV node can become overloaded. As a result, a SPS exists at Ballylumford, whereby either B5 or B6 can be tripped to prevent such overloads.

3.7 TRANSMISSION SYSTEM DATA

Detailed network information is described below, and corresponding data is provided in tables in Appendix A.

3.7.1 BUSBAR DATA

The data for the base year 2008/09 is given in Table A.1. The data comprises the node definition, voltage, active and reactive load.

3.7.2 CIRCUIT CAPACITIES AND PARAMETERS

The continuous thermal rating of a circuit is the maximum power flow that can be passed through the circuit on a continuous basis. On overhead lines, the circuit rating ensures that conductor sag does not infringe statutory clearances and that circuit damage is avoided. The thermal rating varies for each season of the year due to the differing impact of climatic conditions on equipment performance.

The data for the base year 2008/09 is given in Table A.2, and comprises of the identification information, resistance, reactance, susceptance and seasonal continuous ratings of overhead line and cable circuits. Table A.3 provides the data for changes to the system over the seven year period covered by this TSYS. There may be instances where protection system characteristics produce a further limitation.

3.7.3 TRANSFORMER DATA

BSP, cross-border connections and generator transformer data for the base year 2008/09 is provided in Table A.4. The data comprises of the transformer upper and lower tapping ratios, the number of tap steps, resistance, reactance and ratings. The ratings are maximum continuous values and do not allow for short-term enhancement. Table A.5 indicates transformers that will be added over the seven year period covered by this TSYS.

3.7.4 INTERBUS TRANSFORMER DATA

The interbus transformer data is displayed in Table A.6. This comprises the transformer upper and lower tapping ratios, the number of tap steps, winding resistance/reactance and rating information. Interbus transformers to be added to the system over the seven year period covered by this TSYS are indicated in Tables A.7 and A.8.

3.7.5 SHUNT DATA

Table A.9 indicates the location, voltage level and the magnitude of installed fixed capacitance. The operation of this equipment will be variable and dependent on network operating conditions, configuration etc. Table A.10 describes the location, voltage level and magnitude of installed fixed reactive support.

4

GENERATION

4 GENERATION

This section provides details of the generators connected to the transmission system, projections for any future generation connections and details of smaller capacity generators embedded in the distribution system.

The expected increase in wind farm power station capacity will have a large impact on the operation and planning of the transmission system in NI in the next seven year period. It is important to understand the NI generation portfolio and how system operating characteristics are likely to change in the period covered by this Transmission Seven Year Statement (TSYS).

For a detailed generation adequacy analysis, SONI publish the Seven Year Generation Capacity Statement. The most recent publication, covering the years 2009-2015, is available on the SONI website, www.soni.ltd.uk.

4.1 CONVENTIONAL GENERATION CAPACITY

4.1.1 CAPACITY CONTRACTED TO NIE THROUGH POWER PURCHASING AGREEMENTS

Plant contracted to Northern Ireland Electricity (NIE) via their Power Procurement Business (PPB) under pre-vesting contracts, or contracts negotiated thereafter, totals 1718MW, measured as output capacity at generator terminals. Details of capacity and contract information for individual generators can be seen in tables C.1 and C.2.

The contracts contain expiry dates, though the Northern Ireland Authority for Utility Regulation (NIAUR) may cancel contracts at earlier cancellation dates. The Power Purchasing Agreements (PPA) or Generating Unit Agreements (GUA) cover availability, operating characteristics, payments, metering etc. These Agreements cover matters such as outage planning, emissions and fuel stocks. PPB pays a Transmission Use of System (TUoS) to SONI.

4.1.2 INDEPENDENT MARKET PARTICIPANTS GENERATION CAPACITY

NIAUR has a duty to promote competition in the generation and supply of electricity. Competition in wholesale electricity trading, in line with the EU IME Directive (concerning common rules for the internal market in electricity 2003/54/EC), was introduced in July 1999. The Moyle interconnector, Coolkeeragh CCGT and G5 and G6 at Ballylumford are currently the main facilitators of Independent Market Participants (IMP) capacity. Table C.2 provides a complete list of contracted and IPP generators connected to the NI transmission system.

Each generator wishing to participate in the Single Electricity Market (SEM) must enter into a System Support Services Agreement (SSSA) with SONI. This agreement can covers items such as black start, operating characteristics, outage planning and the provision of system support services. IMPs also pay a Transmission Use of System (TUoS) to SONI.

4.1.3 PLANNED CONNECTIONS OF GENERATION PLANT

At the time of the data freeze, a new 440MW CCGT at Kilroot is expected to be connected by the end of 2013.

4.1.4 ASSUMED RETIREMENT OF GENERATION PLANT

It has been assumed by SONI that, due to environmental constraints introduced by EU legislation, Ballylumford G5 and G6 will be decommissioned by 2014.

4.1.5 GENERATION MIX

The chart below in figure 4.1 shows all existing and planned generation over the next seven year period. Superimposed onto the chart is the demand predicted for the next seven years. The demand forecast is described in detail in **Section 5.4**. The demand forecast scenario taken from **Section 5.4** and used in figure 4.1 is the realistic scenario.

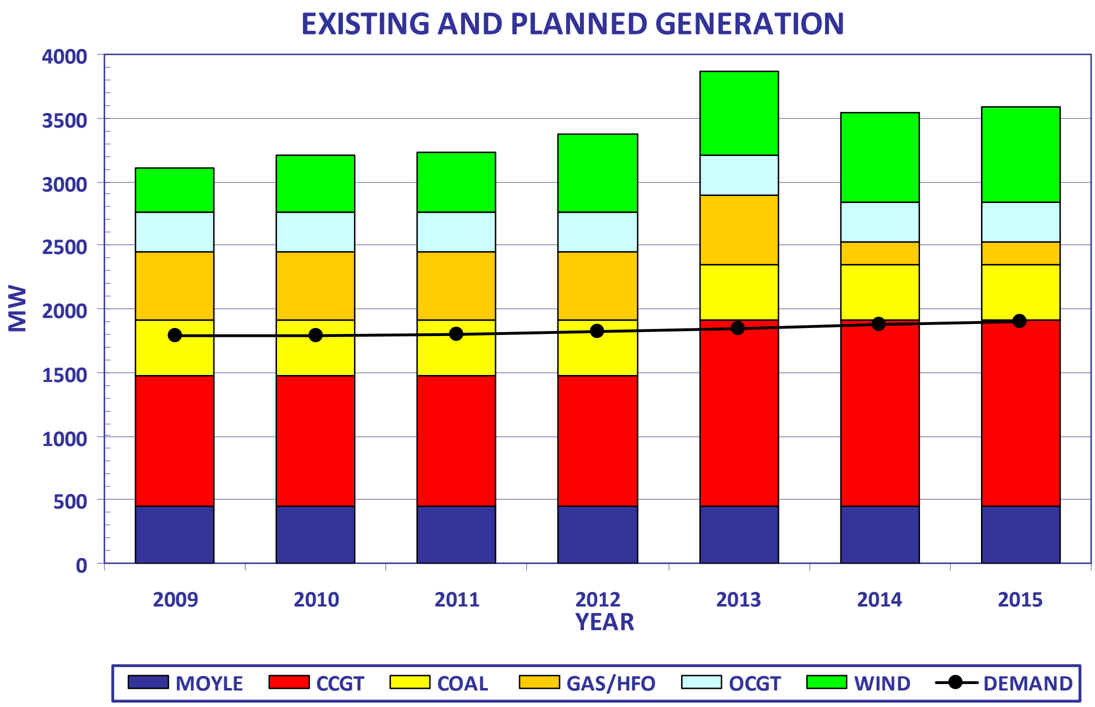


Figure 4.1: Existing and Planned Generation 2009-2015

Figure 4.1 shows a surplus of generation in relation to the demand. However, factors such as economic dispatch, wind variability, reserve requirements and actual interconnector flows are not taken into account. For example, if Moyle and wind generation is removed from the stack in any particular year, margins become much tighter for the TSO to manage. There is an increase in CCGT capacity, which offsets a reduction in Gas/HFO generation in 2014. The chart also shows the large increases in wind generation expected over the next seven years, and this is described in more detail in **Section 4.2**.

4.2 RENEWABLE GENERATION

4.2.1 NON FOSSIL FUEL OBLIGATION CAPACITY

Under the Non Fossil Fuel Obligation (NFFO), NIE signed contracts for approximately 15MW Declared Net Capacity (DNC) of Non Fossil Fuel Plant on 1 April 1994 (NFFO1) and 3MW DNC a short period later (NFFO2). The commissioned schemes are shown in table C.3. Contracts will expire from 31 March 2009 for NFFO1 and between April 2012 and August 2013 for NFFO2. For the purposes of this TSYS, it is assumed that all the plant will continue to remain available as renewable IPP plant.

4.2.2 ADDITIONAL RENEWABLE GENERATION

The wind power generation schemes that are already connected to the NI network, and schemes approved for development at the time of the data freeze, are listed in table C.4. Wind power generating units are generally connected to the distribution network (33kV and 11kV), and network analysis/design takes into consideration the variability of this source of energy. Figure 4.2 shows the locations of existing and committed wind farms at the various 110kV Bulk Supply Points (BSPs) they feed into, up to 2015/16.

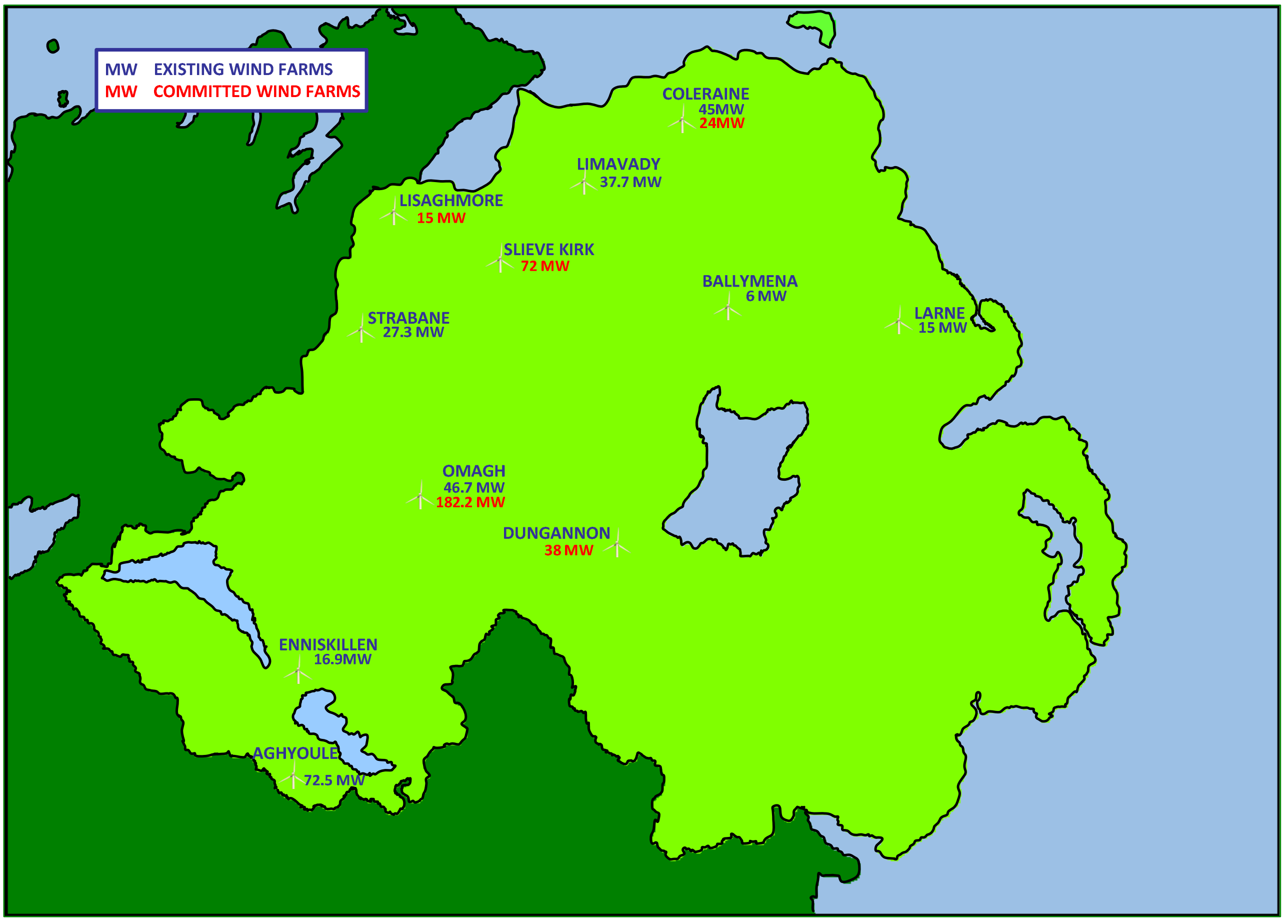


Figure 4.2: Existing and Committed Wind Farms

4.2.3 RENEWABLE GENERATION- THE FUTURE

The Draft Strategic Energy Framework (SEF) 2009 for NI states that 40% of all electrical energy in NI should come from renewable sources by the year 2020. Currently SONI, along with NIE and EirGrid, are planning for this 40% target to be met by the year 2020. This equates to about 1800MW of renewable generation in NI. The map below in figure 4.3 uses information from the list of wind applications in the planning service to demonstrate roughly where this generation may be located.

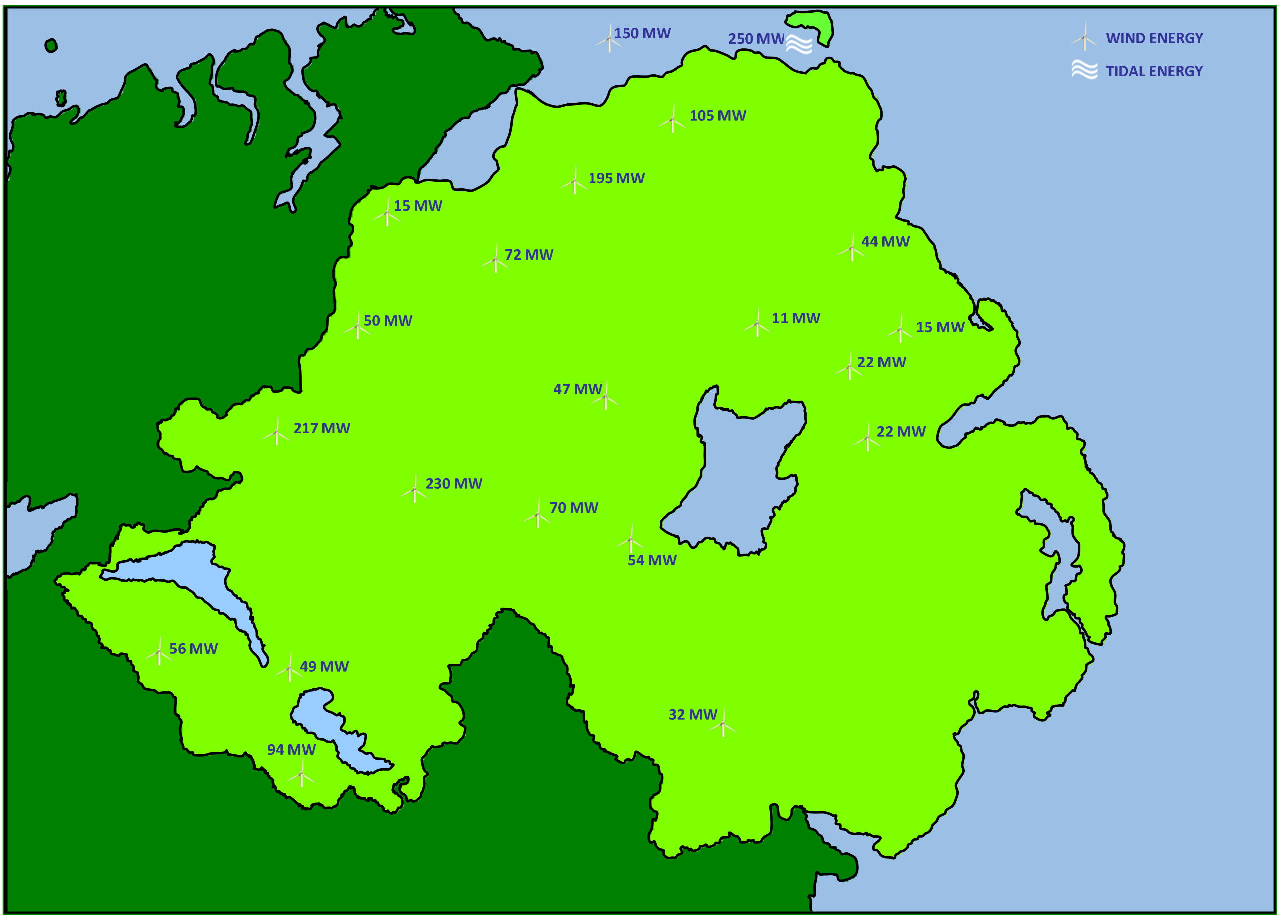


Figure 4.3: Potential Renewable Generation in 2020

As can be seen from figure 4.3, the majority of the renewable connections are in the Northern and Western regions of NI. This coincides with some of the weakest areas of the existing transmission network. It is therefore clear that to meet these ambitious renewable targets, improvements will have to be made to the transmission network in these areas.

4.3 CUSTOMER PRIVATE GENERATION

A number of customers have been reducing energy consumption at times of peak demand by load shifting or by running private generation. SONI has tended to view this generation as non-permanent due to a number of factors:

- The operation of this plant is not as reliable as conventional contracted plant
- Variable generation costs, e.g. diesel and hire charges
- Variable tariff price signals

Based on the 2008/09 winter, generation of this type is estimated to total 100MW. This is a reduction compared to previous years, where figures of 140MW were anticipated. SONI monitors the impact of private generation on an annual basis.

4.4 GENERATION OPERATION

The scheduling and dispatch of generation is now undertaken on an all-island basis to meet the requirements of the SEM. Generators submit bids and technical offer data into the market, until 10:00 hours on the day before dispatch (day-1). These bids nominate the output value which the generator can achieve, and the price. The technical offer data contains information such as running times and output limitations etc. All bids and data are collected and submitted to the market system. A program called Reserve Constrained Unit Commitment (RCUC) then creates a generation operation schedule for the following day. A merit order of generators is established so that if a generating unit is suddenly outaged, or requires an output reduction, it is known what unit(s) can be called on to meet demand.

4.5 SPINNING RESERVE

The 275/220kV Tandragee - Louth Tie Line enables the NI system to be operated with a minimum of three generating units. When isolated, the NI system operates with a minimum of four generating units. The generating units in NI must carry spinning reserve of a minimum of 50MW. The Moyle Interconnector carries 73.5MW of static reserve, meaning that in NI there will always be a minimum of 123.5MW of reserve. For a sudden loss of generation the balance is restored by shedding load via a low frequency selective tripping scheme. Should one generating unit trip the remaining three provide the spinning reserve cover as above and load shedding may take place.

The 275/220kV Tandragee - Louth tie line enables spinning reserve to be shared between the NI and RoI systems. Since the introduction of the SEM, the total combined system spinning reserve requirement is based on 81% of the largest island infeed. The allocation of sharing spinning reserve is kept under review to maintain an optimal economic and secure operation of the combined systems.

5

DEMAND

5 DEMAND

This section of the Transmission Seven Year Statement (TSYS) describes the base demand data upon which the analysis in this TSYS is based. It describes in detail the overall system, profiles, load duration and the load at individual Bulk Supply Points (BSP). In the final section, **Section 5.5**, BSP demands are compared to substation firm capacities to establish demand connection opportunities.

5.1 SYSTEM MAXIMUM DEMAND

The System Maximum Demand (SMD) data is based upon totalised data from power stations, interconnectors, renewable generation and customer private generators.

Temperature has been found to have the greatest effect on demand compared with other meteorological factors. Temperature correction in the form of an Average Cold Spell (ACS) analysis is necessary to remove the demand variation caused by temperature, thus enabling the underlying demand growth rate to be determined more accurately.

In 2008, the global economy experienced a rapid weakening. Northern Ireland (NI) officially entered recession, along with the rest of the UK, in the fourth quarter of 2008. The year 2009 is forecast to be a bleak one, with consumer spending decreasing and the economy set to shrink by up to 2%; indeed, the earliest signs of recovery are not forecast until the middle of 2010. Clearly, these difficult conditions will have an impact on the SMD forecast.

This 2009-2015 TSYS would usually have based the SMD forecast on data up to and including the 2007/08 winter period. In light of the current economic conditions, SONI decided to include data up to and including the 2008/09 winter period.

The actual 2007/08 NI system peak demand was **1884.1MW**, whereas the actual 2008/09 system peak demand was **1824.8MW**. These values consisted of:

GENERATION TYPE	MW	
	2007/08	2008/09
Centrally Dispatched Generating Units	**1704.7**	**1529.7**
Renewable Generation	**39.4**	**195.1**
Customer Private Generation	**140**	**100**
Total	**1884.1**	**1824.8**

Table 5.1: NI 2007/08 and 2008/09 System Maximum Demand

- The 2007/08 figure occurred on Wednesday 9th January between 17.00 and 17.30hrs. When adjusted to ACS conditions, the peak demand was determined to be **1905MW**.

- The 2008/09 figure occurred on Thursday 29th January between 17.00 and 17.30hrs. When adjusted to ACS conditions, the peak demand was determined to be **1831MW**.

It should be noted that the contribution from customer private generation was analysed during the period between these two sets of analysis, and was found to be considerably lower than had been estimated previously. As a result, the 2007/08 SMD figure is probably lower than that which had been calculated, and could be as much as 40MW higher than the actual figure.

The generated SMD profiles for 2007/08 and 2008/09, including renewable generation, are shown in the demand profile in figure 5.1. This maximum demand is as a result of coincidental customer usage patterns, e.g. domestic cooking load and lighting load. The profile does not include the demand that was suppressed by customer private generation.

The graph clearly shows a reduction in demand in 2008/09 when compared to 2007/08. At the peak time period of between 17.00 and 17:30, the peak values are reasonably close; however, there is a clear reduction in the demand in 2008/09 over the 24 hour profile period. This is as a result of reduced industrial activity and customers being more stringent with their electricity use given the large increases in electricity prices in NI in 2008.

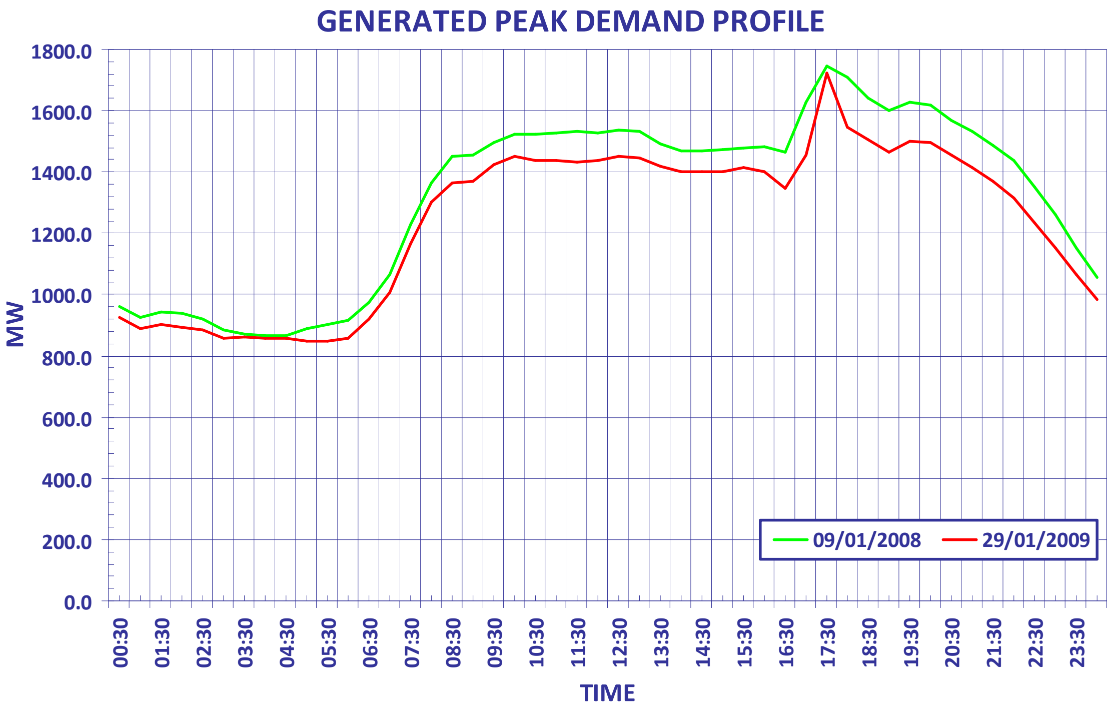


Figure 5.1: Generated Peak Demand Profile for 2007/08 and 2008/09

5.2 DEMAND PROFILES

The graph below in figure 5.2 shows daily demand profiles of days of maximum and minimum demand for different seasons of the year.

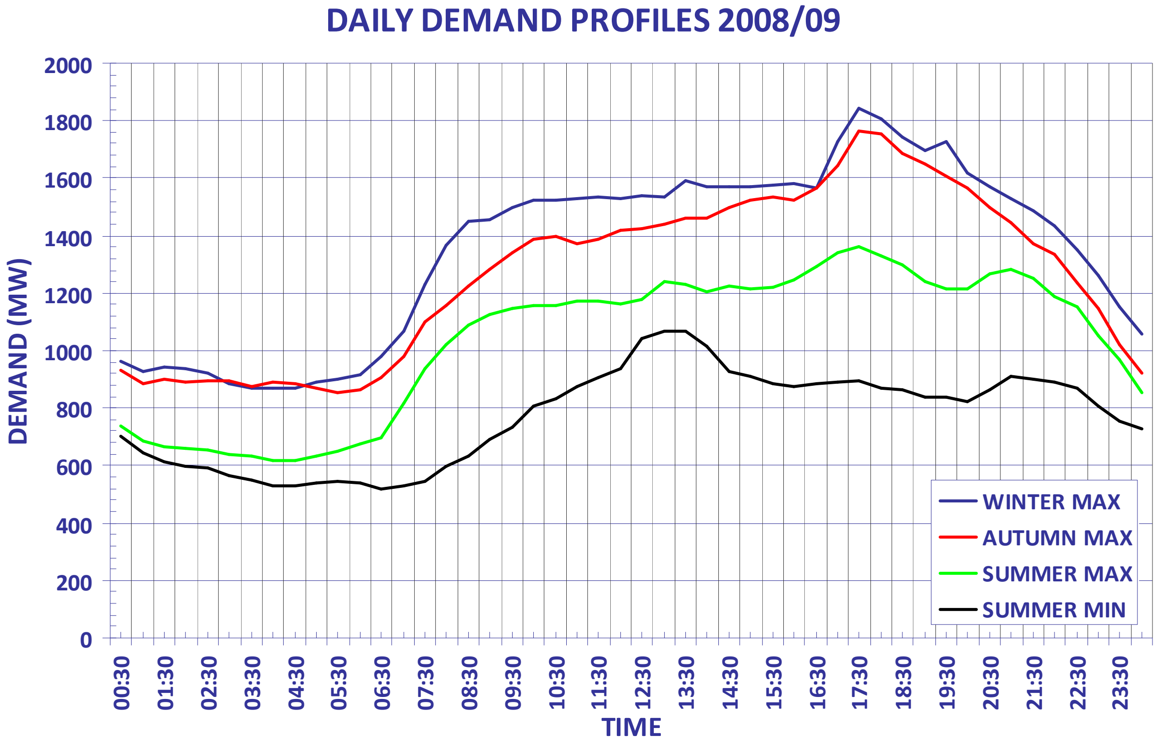


Figure 5.2: Daily Demand Profiles for 2008/09

5.1.1 WINTER AND AUTUMN

As can be seen, the night-time loads during autumn and winter are higher than in summer, as a result of increased use of time switched heating overnight. Between the hours of 6:30 and 9:00 there is a sharp rise to reflect the build up to the working day, before demand flattens out until the evening time peak. It is noticeable that the day of the autumn peak demand fell on a school holiday- this is reflected in the more gradual rise between 6:30 and 10:30.

The time of peak demand for both profiles occurs at 17:30 due to the onset of the lighting load and the increased domestic tea-time load. In recent years the difference between the autumn and winter peaks has narrowed; indeed, on this occasion they are 100MW apart.

5.1.2 SUMMER

The summer maximum demand profile follows a similar profile to that of the winter maximum. The major differences are that it is less 'peaky' with a reduced load factor, generally reduced levels of demand, and the later onset of the lighting load, at 21:00.

The time of summer minimum demand occurred at 06.30am on the 13th of July 2008. The day of summer minimum demand fell on a Sunday. This is reflected in the fact that the time of peak demand is around 13:00, due to the increased lunchtime cooking load. As with summer maximum, the effects of the lighting load can be seen at the later time of 21:00. The summer minimum time period is increasingly important for network planning, as reduced load levels can result in excess distributed load generation. In 2008/09, the demand is around 30% of winter peak.

5.3 LOAD DURATION CURVE

Figure 5.3 shows the NI load duration curve for 2008/09. The curve shows the percentage of time in the year that a particular demand value was exceeded. For example, demand exceeded 1000MW for more than 56% of the time.

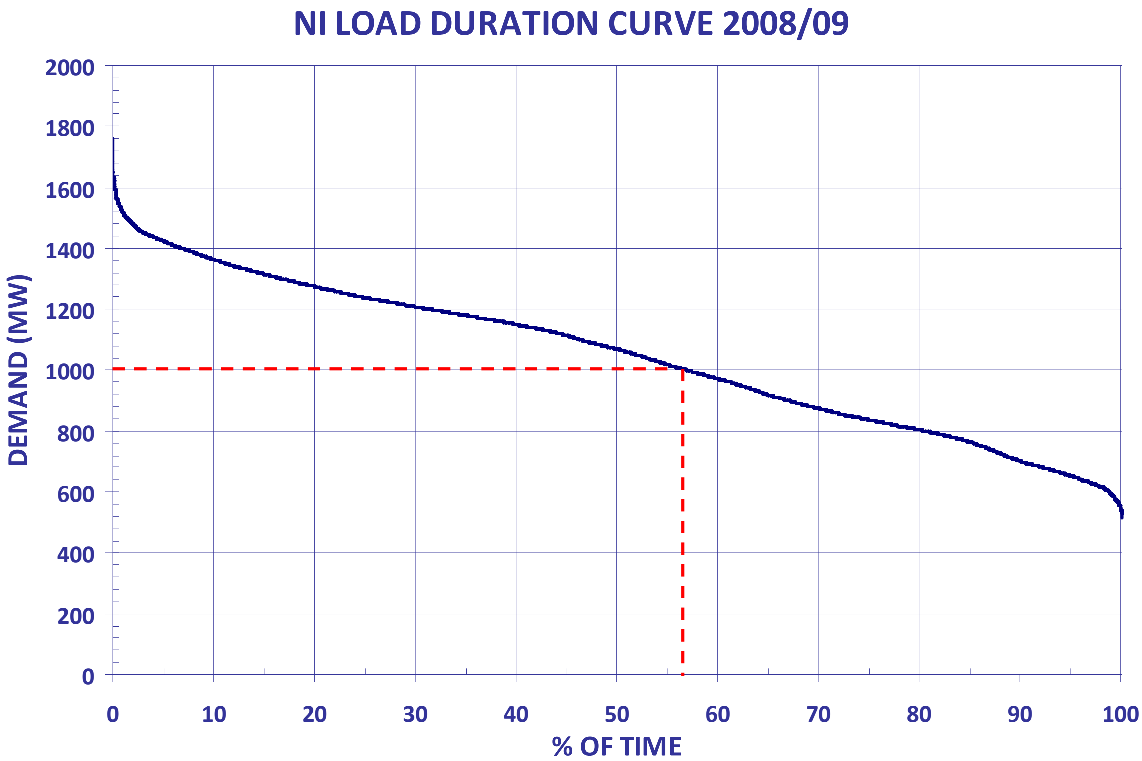


Figure 5.3: Load Duration Curve 2008/09

5.4 SYSTEM MAXIMUM DEMAND FORECAST

The graph below in figure 5.4 plots the historic system peak demands for the past 36 years. The red line on the graph is a trend line, highlighting the average growth in peak demand over the 36 year period. The graph shows that for the last 7 years, peak demand has been above average; however, for 2008/09, the peak demand plot takes a sharp decline below the trend line.

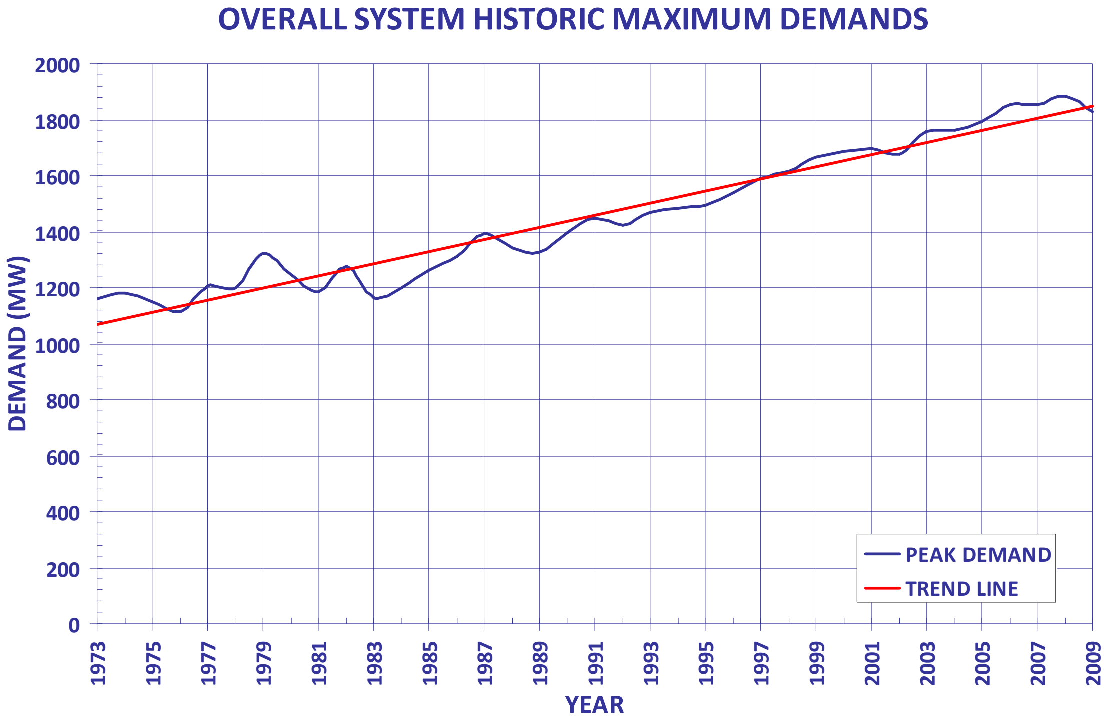


Figure 5.4: System Historic Peak Demand Profile

The sharp decline in peak demand in 2008/09, coupled with the continued uncertainty as to the length and severity of the current economic crisis, makes predicting future demand very difficult. The general opinion amongst economists is that the economic decline will flatten out in 2010. After this, predictions become more varied. As a result, SONI have forecast three scenarios, which could happen over the forthcoming seven year period. These scenarios are detailed briefly below:

- A **realistic** scenario, where the reduction in peak demand in 2008/09 continues into 2009/10. It then levels off, in consensus with the current general opinion, before making a slow recovery.
- An **optimistic** scenario, where the economy recovers more quickly than expected, as a result of the various stimulus measures being taken by governments. Economic growth would therefore be quicker than in the realistic scenario.
- A **pessimistic** scenario, where the economic decline continues into 2010, with the earliest signs of recovery not occurring until 2012 at the earliest.

Table 5.2 shows the seven year load forecasts for each of the three scenarios described above. All three of the load forecasts are corrected for ACS conditions. Figure 5.5 plots these three scenarios on a graph, and also shows the peak demands from 2000/01 onwards.

SCENARIO	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
REALISTIC	1793	1793	1802	1820	1847	1875	1903
PESSIMISTIC	1774	1765	1772	1785	1798	1818	1840
OPTIMISTIC	1831	1840	1859	1886	1920	1955	1990

Table 5.2: Seven Year Peak Demand Forecast

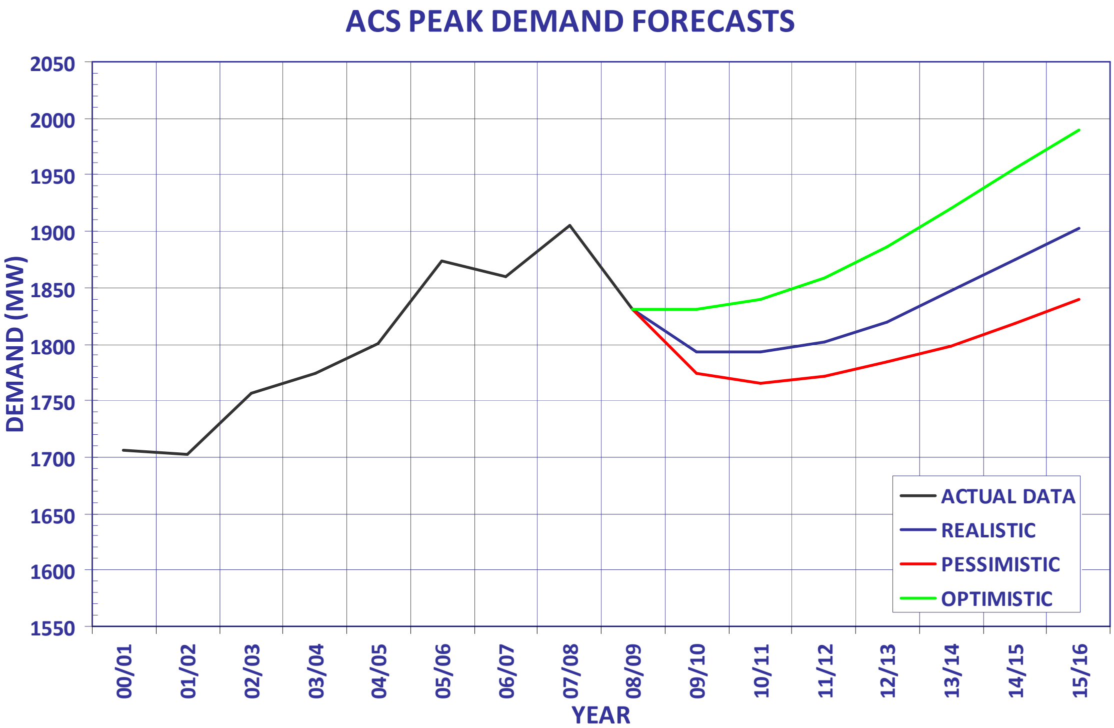


Figure 5.5: Three ACS corrected peak demand forecast scenarios

Throughout this TSYS, SONI will be using the **realistic** demand scenario, as most economists believe that this is the most likely scenario to occur.

5.5 110/33kV BULK SUPPLY POINT DEMAND

The BSP demand forecasts are provided by Northern Ireland Electricity (NIE) and are adjusted to align with the overall system ACS forecasts. These demand forecasts are based on localised demand trends at individual nodal level. Consideration is given to future block load transfers from one BSP to another. Tables and information relating to demand forecasts are contained in **Appendix D**.

The BSP total installed transformer capacity, substation firm capacity and predicted demands are given in **Table D.1**. Table D.1 presents the winter peak demand forecast, in MVA, at each substation, based on a single circuit outage. The firm capacity is generally based on the loss of one infeed to the substation, and is the capability of the remaining circuit. The geographical location and connectivity of the BSPs can be determined from **Maps B.1** and **B.2**. Table D.1 highlights a number of BSPs where the firm has been, or will be, exceeded. These substations are:

- Aghyoule
- Antrim
- Ballymena Rural
- Dungannon
- Lisburn
- Knock
- Limavady
- Strabane
- Waringstown

NIE have provided a description of how the overloads will be managed, e.g. new transformer capacity, load transfer etc. These are detailed in **Appendix D.2**. From our analysis, several substations appear to have no current plans in place to remove the overload. These substations are:

- Dungannon
- Lisburn
- Strabane

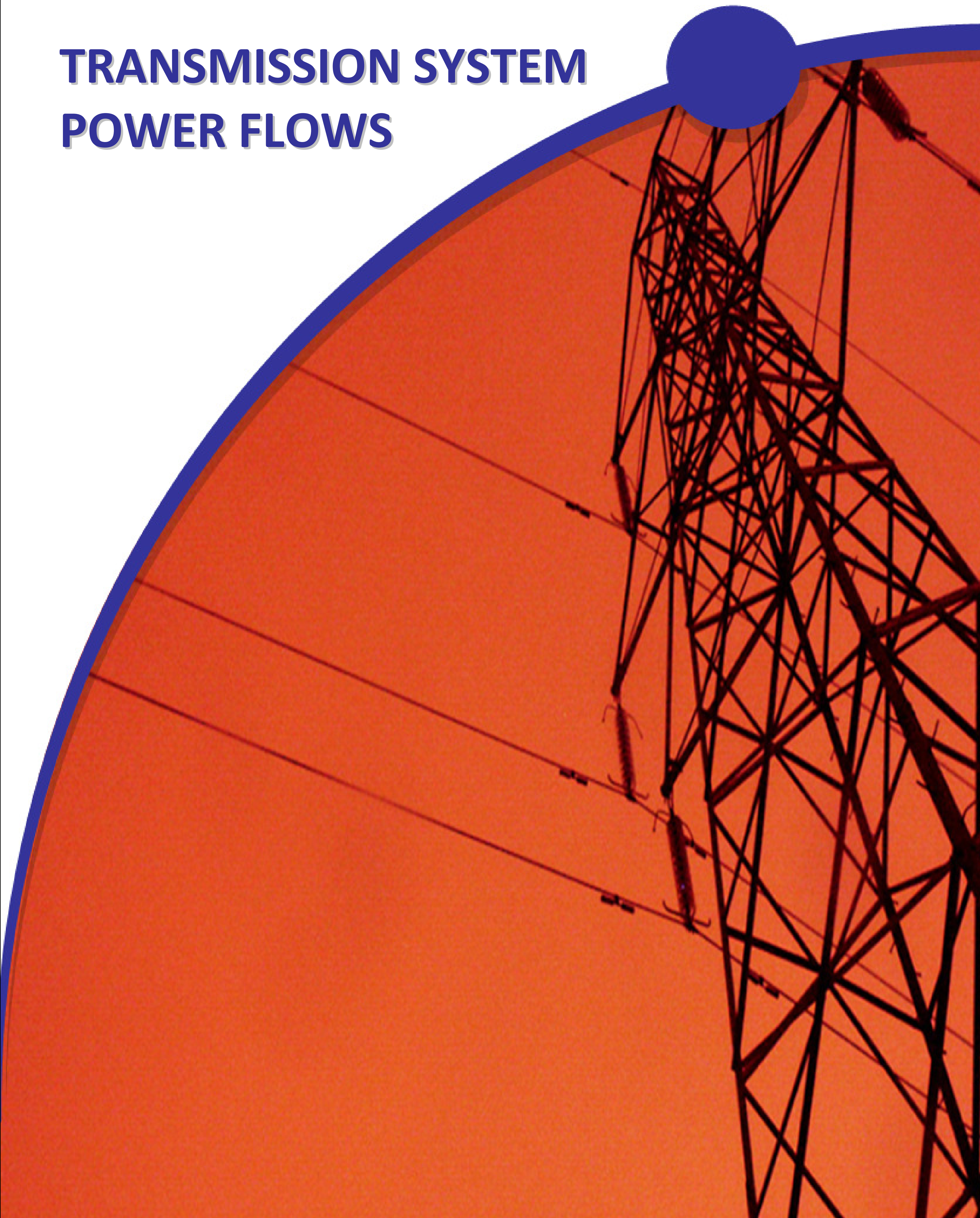
Discussions will be held with NIE to progress these issues.

Table D.2 indicates available capacity at each BSP. This table follows on from Table D.1, and is therefore again based upon the winter peak load, in MVA, under a single circuit outage. The table is drafted on the basis of not extending load shedding. The purpose of this table is to assist network users in assessing connection opportunities. It will be necessary to carry out further detailed analysis depending on the magnitude and type of load to be connected, to establish if a connection is viable.

Tables D.3, **D.4** and **D.5** present the demand forecast for the next seven years for Winter Maximum, Summer Maximum and Summer Minimum conditions respectively in terms of the MW loading at the BSP. The power factor for a single circuit outage at each BSP is also shown.

6

TRANSMISSION SYSTEM POWER FLOWS



6 TRANSMISSION SYSTEM POWER FLOWS

The power flows are represented on schematic diagrams of the Northern Ireland (NI) transmission system, and can be found in **Appendix H**. They are the method by which results of load flow analysis are best displayed. They provide a broad view of the system as it develops over the seven year period and also display seasonal loading conditions. The power flows are an important guide when assessing system capacity and possible locations for connections.

It is important to stress that the power flows represent system normal conditions. The power system is designed to cope with the higher thermal loading experienced under abnormal outage conditions.

6.1 INTRODUCTION TO THE POWER FLOWS

The previous sections have described the background to the NI transmission system and the manner in which it is designed and operated. This section of the report deals with the results of system studies for the forthcoming seven year period.

Power flows are provided for the NI transmission system for the years 2010/11, 2012/13 and 2015/16. The power flows display network voltages for all system 275, 110 and 33kV busbars, the flow of active and reactive power on circuits and the active and reactive load at all Bulk Supply Points (BSP).

The power flows are displayed in schematic diagram format in a series of figures in **Appendix H.**

In any one year, the power flows on the NI transmission system vary on a seasonal basis, with varying demand and a changing generation profile. To give an appreciation of the effect of these different load and generation combinations, this Transmission Seven Year Statement (TSYS) considers three representative seasonal power flows for each of the years above. The seasons and load conditions are:

- Winter peak load condition,
- Summer peak load condition,
- Summer minimum load condition.

The power flow studies represent normal system conditions with no transmission outages as a result of a fault or for maintenance. Some transmission circuits are normally run open, for example, to avoid overloads or reduce fault levels. The effect of fault or maintenance outages is assessed in **Section 8** - ‘Transmission System Capability’.

The changes to the transmission system used in the power flow models are those approved projects in **Section 3.4**, and unapproved but expected reinforcements described in **Section 3.5**. It is important to note that if projects are not completed as planned, then there may be system security issues, and certain circuits may be overloaded.

Generation dispatches were prepared on an all island basis, with power flows across the existing 275kV and planned 400kV connections allowed. This is in contrast to previous TSYS, where there were no transfers across any of the connections. As is common practice, reactive power transfers across the tie-lines are kept to a minimum. The 110kV connections with RoI are assumed to run with zero power transfer in line with current normal operational practices.

The Moyle interconnector is operating throughout the period covered by this TSYS. In line with what has been observed flowing on Moyle throughout the last year, the following assumptions have been used in this section:

TIME	SCENARIO	POWER FLOW (GB-NI)
DAY	WINTER MAX SUMMER MAX	240MW
NIGHT	SUMMER MIN	150MW

Table 6.1: Moyle Assumed Flows

It should be noted that much larger imports at night have been seen since the freeze date, which could lead to operational difficulties of the system during times of low demand.

Another significant change compared to previous TSYS is the increased penetration of wind. In all power flows, from H1 to H9, wind is running at 30% of installed capacity. In addition, in the final year of study- 2015/16- wind is increased to 100% of capacity for each season. The resulting power flows are provided in H10 to H12. Details on wind farm locations and capacities can be found in **Appendix C.4**.

6.2 POWER FLOWS FOR 2010/11

The three power flows presented for 2010/11 can be found in **Appendix H** and are as follows:

- Figure H1: Summer Maximum, 2010
- Figure H2: Summer Minimum, 2010
- Figure H3: Winter Maximum, 2010/11

Changes to the transmission system in these power flows compared to previous TSYS include:

- The addition of the new 40MW OCGTs at Kilroot
- The inclusion of Aghyoule BSP and associated circuits at both 110kV and 33kV level.
- The reconfiguration of Power Station West BSP to Belfast North Main BSP in the winter season
- Increased levels of wind

A notable feature of the power flows are the reduced East-West flows, compared to previous statements. In particular, there are now larger flows towards Magherafelt on the Coolkeeragh-Magherafelt 275kV double circuit, and reduced flows from Kells to Coleraine and from Dungannon to Omagh on the 110kV circuits. This is mostly as a result of the increased wind generation in the Northern and Western regions, meeting the local demand and reducing reliance on power being

transferred from the generation nodes in the East of the country. Other factors include the lower levels of demand predicted in this TSYS, in light of the current economic situation.
A notable feature of the Winter Maximum power flow is the import of roughly 120MW from the Republic of Ireland (RoI). Towards the end of the year, two new CCGT plant are scheduled to commence operation in RoI. They will therefore be high merit order plant (see **Section 4.4**) and, coupled with the increased amount of wind generation, will displace some of the older, less efficient plant in NI. This results in an import of power from RoI.

Overall, busbar voltages in 2010/11 tend to be similar to those in the final year of study in the 2003/04 TSYS.

6.3 POWER FLOWS FOR 2012/13

The three power flows presented for 2012/13 can be found in **Appendix H** and are as follows:

- Figure H4: Summer Maximum, 2012
- Figure H5: Summer Minimum, 2012
- Figure H6: Winter Maximum, 2012/13

The three significant, unapproved projects to accommodate the increased levels of wind, as described in **Section 3.5**, are included. In brief, these are:

- The completion of Tamnamore substation
- Uprating existing Omagh-Tamnamore 110kV circuits, and construction of a third circuit
- The second Coleraine-Kells 110kV circuit

The completion of Tamnamore substation results in the Drumnakelly to Tamnamore 110kV circuits being run open, as can be seen in the power flow diagrams.

Other changes include the new IBTXs at Castlereagh (as can be seen from the diagrams, only three out of the four IBTXs will be in service at any one time) and at Hannahstown, and the replacing of the three existing transformers at Carnmoney with two new 90MVA ones.

The most significant change, however, is the introduction of the new 400kV connection with RoI in winter 2012/13, and the associated new 400/275kV substation at Turleenan. It is interesting to note that there is a circulating power flow on the connections with RoI (power is being imported into NI across the 400kV connection and exported to RoI across the 275kV connections). In the winter 2012/13 scenario, 130MW is imported to Turleenan, while 150MW is being exported from Tandragee, resulting in an overall power transfer of circa 20MW from NI to RoI.

The effect of the increased wind penetration can be seen in the lowering of busbar voltages at wind generation nodes. For example, the Omagh 110kV busbar voltage is 0.989p.u. in winter 2012/13, compared to 1.004p.u. in winter 2010/11.

6.4 POWER FLOWS FOR 2015/16

The three power flows presented for 2015/16 can be found in **Appendix H** and are as follows:

- Figure H7: Summer Maximum, 2015
- Figure H8: Summer Minimum, 2015
- Figure H9: Winter Maximum, 2015/16

The most significant development is the introduction of the new CCGT plant at Kilroot. Along with this, B5 and B6 at Ballylumford are no longer assumed to be in use, due to EU legislation on emissions. The CCGT at Kilroot is assumed to be high level merit order plant, and its inclusion results in power being exported to RoI, as opposed to the imports seen in winter 2010.

At times of minimum demand in NI, there is a need for at least three generating units to be dispatched at all times (see **Section 4.5**). It has been suggested that with the completion of the 400kV connection with RoI, this rule can be relaxed to a minimum of two generating units. Without detailed analysis, however, in this TSYS, the summer minimum case in 2015 has still been dispatched with three machines. System studies have shown that these machines must include a Coolkeeragh machine and a Kilroot machine.

In all cases, circulating power flows can again be seen on the connections with RoI. Busbar voltages tend to be similar to those in the year 2012/13.

At the freeze date, information provided by NIE detailing committed renewable generation connections was available up until 2012/13. Beyond this date, no firm connection information was available from NIE, and therefore further increases in wind generation are not included in the power flows for 2015/16. This is reflected in the power flows emanating from the West of NI, e.g. power flows of 160MW and 150MW are seen in 2012/13 and 2015/16 respectively on the Coolkeeragh-Magherafelt double circuit. A similar effect can be seen on the Omagh-Tamnamore 110kV circuits.

In all power flows H1 to H9, transmission loadings remain within circuit ratings. Under certain contingencies, overloads can be seen; this is investigated in **Section 8** - Transmission System Capability.

6.5 POWER FLOWS FOR 2015/16 WITH MAXIMUM WIND

To highlight the effects of significant wind generation on the NI transmission system, it has been decided to also include power flows which include the maximum wind generation expected in 2015/16.

The three power flows presented for the maximum wind studies in 2015/16 can be found in **Appendix H** and are as follows:

- Figure H10: Summer Maximum, 2015
- Figure H11: Summer Minimum, 2015
- Figure H12: Winter Maximum, 2015/16

To help accommodate this wind, the Moyle flow is reduced from the assumptions stated in table 6.1. In Winter and Summer Maximum power flows, the Moyle import is 100MW, while in the Summer Minimum power flow, it is assumed to be exporting 80MW to GB. Wind in RoI has been dispatched at 30%.

An important addition to these high wind power flows is a SVC of circa 100MVAr to support voltages in the wind generation rich western region of NI. This can be seen at Strabane 110kV busbar. It must be stressed that this is just an assumed addition, and as of yet there are no definite plans from NIE to install reactive support. However, the results of these power flows indicate that reactive support is highly likely to be required as the wind penetration increases.

It is clear that the large amount of wind generation in NI, particularly in the Northern and Western regions of the country, has caused a significant flow of power from West to East.

This is particularly noticeable on the three Omagh-Tamnamore 110kV circuits, and the Kells-Coleraine 110kV circuits. Power flows can be seen flowing from both Omagh and Coleraine 33kV distribution systems onto the 110kV transmission network.

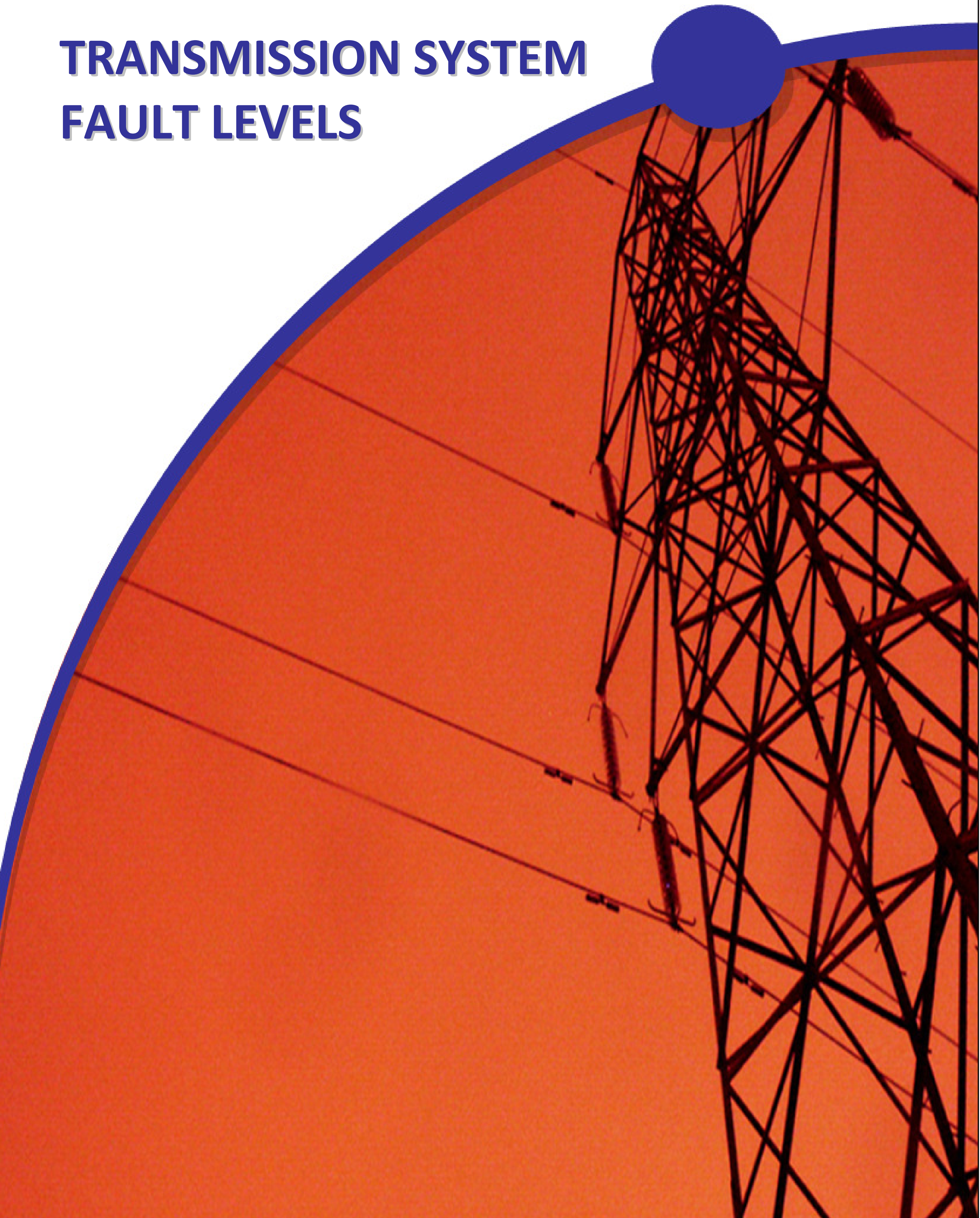
A similar effect can be seen on the Coolkeeragh-Magherafelt 275kV double circuit, where much larger power flows are being exported from Coolkeeragh 275kV node.

The wind generation at Aghyoule and Enniskillen is also meeting the entire demand in that region, resulting in negligible power flows on 110kV Omagh-Enniskillen circuits.

Several local and system wide technical issues may arise from high penetration levels of wind farm power stations. As is discussed in **Section 4.2.3**, there are ambitious renewable generation targets being set for NI; how all of this extra generation will be connected and accommodated is currently under investigation by SONI, NIE and EirGrid.

7

TRANSMISSION SYSTEM FAULT LEVELS



7 TRANSMISSION SYSTEM FAULT LEVELS

This section presents a summary of the results of the fault level analysis carried out on the Northern Ireland (NI) transmission system. **Appendix E** contains a detailed description of the fault level calculation methodology, the generation dispatches and the detailed results. The purpose of this analysis is to identify fault levels at individual transmission nodes, and to compare these with the relevant equipment ratings. As generation sources are connected to the network, fault levels rise. Thus, this section provides a guide to potential network users of where equipment ratings are approaching their rated limits.

7.1 INTRODUCTION TO FAULT LEVEL RESULTS

Three-phase and single-phase to earth fault levels have been calculated for the following years and seasons, on an all-island transmission network model:

- Winter Max 2010/11
- Summer Min 2010
- Winter Max 2015/16
- Summer Min 2015

Only the NI transmission nodes are published in this Transmission Seven Year Statement (TSYS), though the analysis is based on an all-island model as both the NI and Republic of Ireland (RoI) systems will contribute to fault levels in either jurisdiction.

Winter peak and summer minimum demand situations have been studied, as they should be indicative of the full range of anticipated fault levels. Two years have been considered for study; 2010/11 highlights issues with the current network, while 2015/16 considers a future network with additional expected 400kV interconnection and generation levels etc.

In this section we will attempt to summarise the results and consider the areas where specific issues arise and need to be addressed by Northern Ireland Electricity (NIE), the asset owner.

7.2 WINTER RESULTS

The generation dispatches used for the fault level analysis can be found in **Appendix E**. During times of winter maximum demand, any generator not dispatched has still been modelled as remaining connected to the transmission system, albeit at a 0MW level of generation. This ensures that the most onerous short circuit current is calculated for all nodes on the NI transmission system, as all generators are contributing to the fault level. Renewable generation has been dispatched at 10% to enable all larger conventional plant to be dispatched, while still ensuring there is contribution to the fault level from renewable generation sources.

The maps in figures 7.1 and 7.2 summarise the results of the fault level analysis carried out for Winter Maximum 2010/11 and Winter Maximum 2015/16. Substations where the fault level exceeds 80% of the rating are highlighted in **yellow** and substations where 90% of the rating is exceeded are highlighted in **orange**. Substations where the fault level rating is exceeded are shown in **red**.

The 80% and 90% of fault level rating values should act as a trigger for further detailed analysis by NIE, as although short circuit duties at a node could be approaching the rating of the installed switchgear, the switchgear may still not be overstressed for one or more of the following reasons:

- The topology of the substation is such that the switchgear is not subjected to the full fault current from all of the infeeds connected to that node.
- Temporary risk mitigation measures could be in place, such as reconfiguration of the network or generation redispatch, to maintain fault levels at acceptable limits
- Modifications to switchgear, e.g. uprating of equipment, are already in hand that will remove the overstressing in the near future.

Results for Winter Maximum fault level studies for both 2010/11 and 2015/16 are discussed in sections 7.3 and 7.4.

7.3 WINTER 2010/11 RESULTS

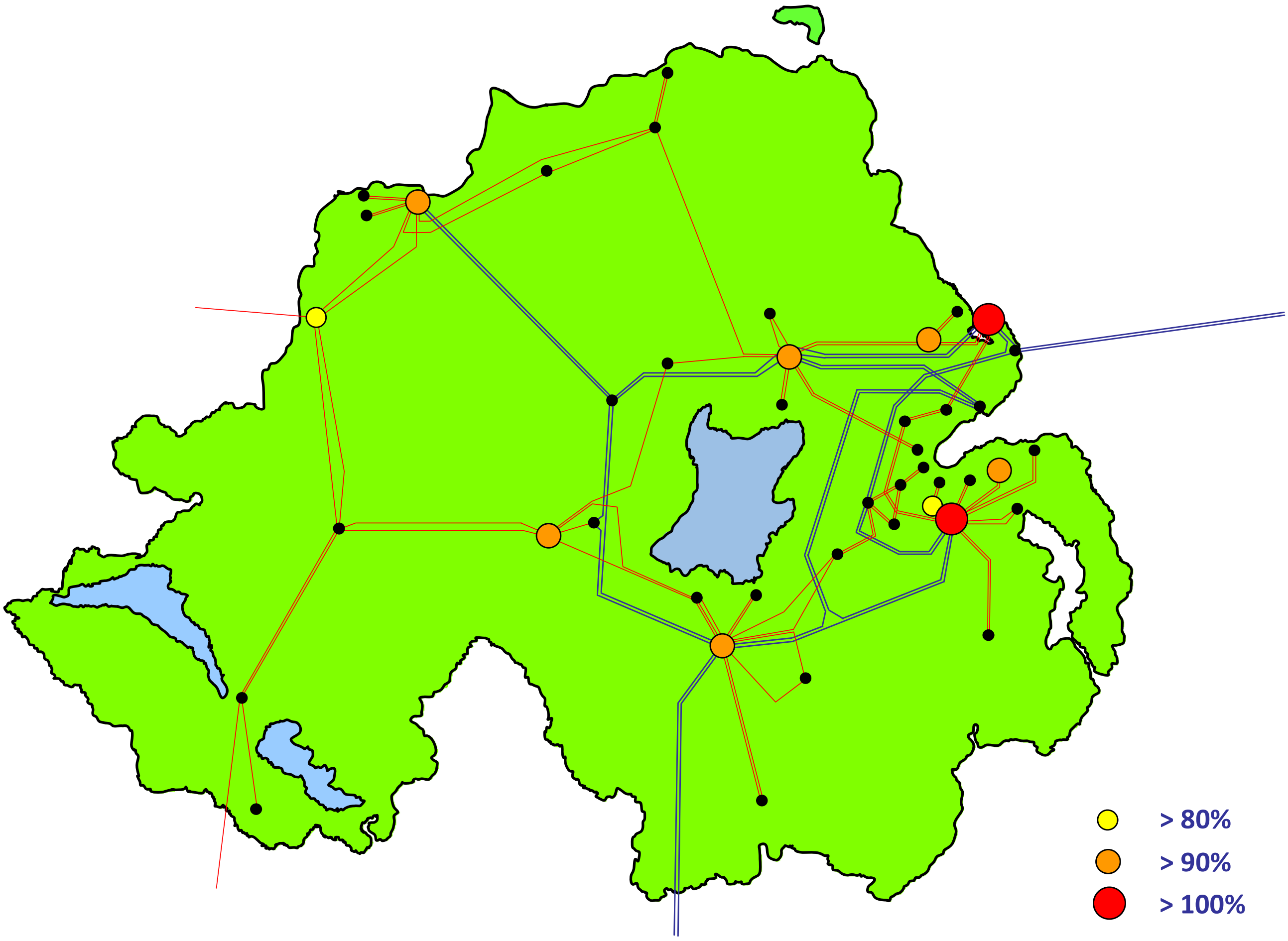


Figure 7.1: Winter Max 2010/11 Fault Levels

The map in figure 7.1 indicates that a significant number of 110kV transmission nodes in NI experience short circuit currents in excess of 80% of their rated capability. In some cases, transmission nodes experience fault levels in excess of 100% of their rated capability, e.g. Ballylumford and Castlereagh 110kV nodes. Table 7.1 below provides a list of all nodes where the fault level is approaching or has exceeded the rating.

% OF RATING	NODE	kV
>100	BALLYLUMFORD	110
	CASTLEREAGH	110
>90	BALLYLUMFORD	275
	BALLYVALLAGH	110
	COOLKEERAGH	110
	DUNGANNON	110
	KELLS	110
	KNOCK	110
	TANDRAGEE	110

Table 7.1: 2010/11 Nodes Approaching or Exceeding Rating

These are particularly geographically widespread, from Coolkeeragh in the North-West, to Castlereagh in the East of the province.

Where NIE have plans in place to uprate equipment they are discussed in **Sections 7.3.1** and **7.3.2** below. At the time of publishing, this is the best information available to SONI. In the interim risk mitigation measures have been employed by SONI, e.g. circuit reconfiguration.

7.3.1 SUBSTATIONS WHERE THE RATING HAS BEEN EXCEEDED

BALLYLUMFORD 110kV

The fault levels at the 110kV node for both three-phase and single-phase faults exceed the substation ratings. This occurs under maximum generation conditions and under normal network conditions when both of the 275/110kV interbus transformers (IBTXs) are in service. The substation is programmed to be replaced with a new 110kV GIS switchboard, with work commencing in 2011/12. In the interim, SONI usually manages this risk by operating with one IBTX out of service, which reduces the fault level below the equipment rating. In some instances, reconfiguration of the 110kV network around Ballylumford is also used to manage fault levels.

CASTLEREAGH 110kV

The 2006/07 TSYS stated an 110kV rating of 31.5kA, based on the fault level capability of the circuit breakers. This TSYS now takes account of the disconnectors which have a certified rating of 26.3kA. With all available generation in service, the fault level of 26.49kA is marginally in excess of the disconnector rating. The 110kV substation is presently being rebuilt with the disconnectors scheduled for replacement with 40kA equipment within the next three years.

7.3.2 SUBSTATIONS WHERE THE FAULT LEVEL IS WITHIN 5% OF THE RATING

DUNGANNON 110kV

Fault levels at Dungannon 110kV node are within 5% of the substation ratings. The relevant Dungannon Main 110kV equipment is programmed to either be removed from the system or refurbished with 40kA equipment.

KELLS 110kV

The fault level at Kells 110kV node is approaching the substation rating, being within 3% of the rated value. The Kells 110kV double bus is scheduled to be replaced with 40kA switchgear.

KNOCK 110kV

Fault levels at Knock are within 5% of substation ratings.

7.3.3 CONCLUSIONS

This analysis indicates that fault levels are particularly high at a number of nodes geographically spread across NI. Any potential generation connections will require careful and detailed fault level analysis to determine the impact on 275kV and 110kV plant and equipment ratings across the NI transmission network. Plans are in place at Ballylumford, Castlereagh, Dungannon and Kells to uprate substation ratings

7.4 WINTER 2015/16 RESULTS

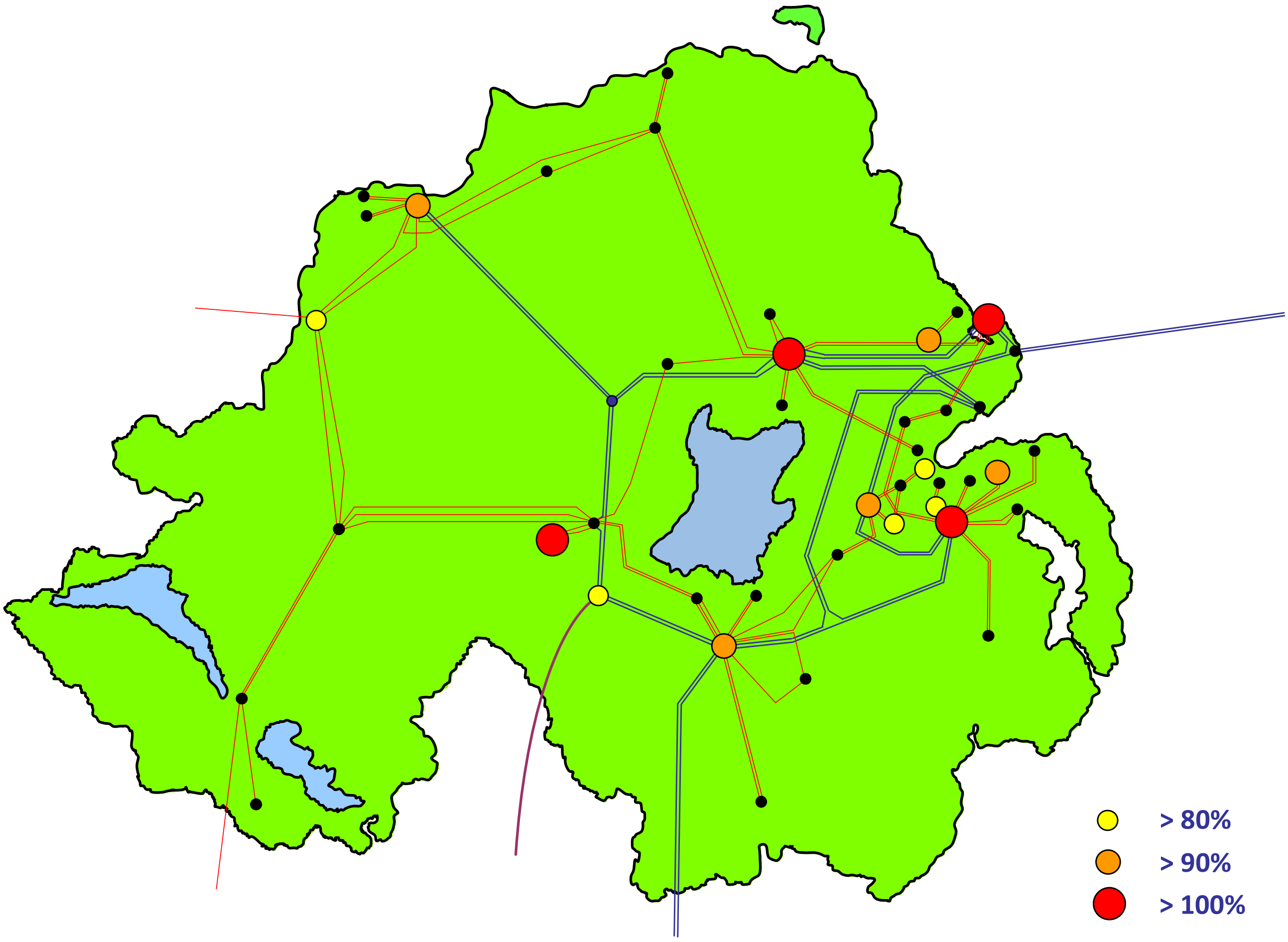


Figure 7.3: Winter Max 2015/16 Fault Levels

As can be seen from Figure 7.3, by 2015/16 there will be a total of four substations which experience higher fault levels than their rated capability. Table 7.2 below provides a list of all nodes where the fault level is approaching or has exceeded the rating.

% OF RATING	NODES	kV
>100	BALLYLUMFORD	110
	CASTLEREAGH	110
	DUNGANNON	110
	KELLS	110
>90	BALLYVALLAGH	110
	COOLKEERAGH	110
	HANNAHSTOWN	110
	KNOCK	110
	TANDRAGEE	110

Table 7.2: 2015/16 Nodes Approaching or Exceeding Rating

Most of these nodes are located in the East of the country, around the main generation sources and load centres, and are explained in more detail below. Where NIE have plans in place to uprate equipment they are discussed in **Section 7.4.1** below. At the time of publishing, this is the best information available to SONI.

7.4.1 SUBSTATIONS WHERE THE RATING HAS BEEN EXCEEDED

BALLYLUMFORD 110kV

As can be seen in **Tables E.2** and **E.4**, the fault levels at Ballylumford 110kV node in 2010 and 2015 are very similar. This is because, despite the loss of short circuit current contributions from B5 and B6, which are assumed to be decommissioned, there are increased contributions from the new CCGT at Kilroot and from wind generation. Whilst **Table E.4** details the present rating, it is planned that, by 2015, the switchgear will be replaced with 40kA equipment.

CASTLEREAGH 110kV

The addition of a fourth IBTX at Castlereagh would increase the short circuit current for a single-phase fault well above the substation's disconnector rating of 26.2kA rating, if all four IBTXs are in service. It is proposed, however, that only three out of the four IBTXs will be in service at any point in time, in effect, allowing the existing IBTXs to be taken out of service without a reduction in transformer capacity. Despite this, the fault level at Castlereagh still exceeds the rating of the disconnectors; however, it is planned that, by 2015, the disconnectors will have been replaced.

DUNGANNON 110kV

Table E.4 indicates that the fault level at Dungannon 110kV node could exceed the switchgear rating by 2015. This is as a result of the increased wind generation in the region and the second IBTX at Tamnamore. As discussed previously, the Dungannon Main 110kV equipment will either be removed from the system, or refurbished with 40kA equipment. It should be noted that if this work is not completed in a timely manner, it will lead to severe system operational repercussions.

KELLS 110kV

Both three-phase and single-phase fault levels will be exceeded at the Kells 110kV node in 2015. This will result principally from increased contributions from wind, particularly from Ballymena, from the proposed new Kilroot CCGT. The Kells 110kV double bus is scheduled to be replaced with 40kA switchgear by this time.

7.4.2 SUBSTATIONS WHERE THE FAULT LEVEL IS WITHIN 5% OF THE RATING

BALLYVALLAGH 110kV

Fault levels at Ballyvallagh 110kV substation are over 96% of the substation assigned rating.

COOLKEERAGH 110kV

Fault levels at Coolkeeragh 110kV substation are approaching 97% of the substation assigned rating.

HANNAHSTOWN 110kV

Fault levels at Hannahstown 110kV substation are at 96% of the substation assigned rating.

KNOCK 110kV

Fault levels at Knock are at 99% of substation ratings.

TANDRAGEE 110kV

At Tandragee, high fault levels are seen at the 110kV substation for a single-phase fault, where the fault level is at almost 99% of the rating. Tandragee 110kV substation is to be refurbished, with work due to commence in 2010/11.

7.4.3 CONCLUSIONS

As expected, fault levels have generally risen by 2015/16, due to factors including demand growth, increased wind, and the new 400kV tie line with the RoI. However, with the decommissioning of B5 and B6 at Ballylumford, the fault levels at the 275kV substation have dropped by circa 10%.

NIE have in place plans to uprate equipment at Ballylumford, Castlereagh, Dungannon and Kells by 2015/16, as equipment margins are reduced. Potential generation connections will require careful analysis to determine the impact in the NI transmission system.

7.5 SUMMER MINIMUM RESULTS

Summer minimum analysis is included in this TSYS for the first time, to facilitate connection studies to the network for protection settings. These results are indicative and care should be taken as lower fault levels may be experienced under certain network configurations- e.g. circuits out for maintenance. Additionally, detailed studies may be required to accurately determine minimum fault levels under these conditions.

7.6 COMPARISON WITH PREVIOUS STATEMENTS

Table 7.3 below compares the results of the Winter 2010/11 analysis from this TSYS with the Winter 2006/07 analysis from the previous Statement (2003/04 – 2009/10). In the table, the fault levels for all transmission nodes at each voltage level are averaged, to allow comparisons to be made.

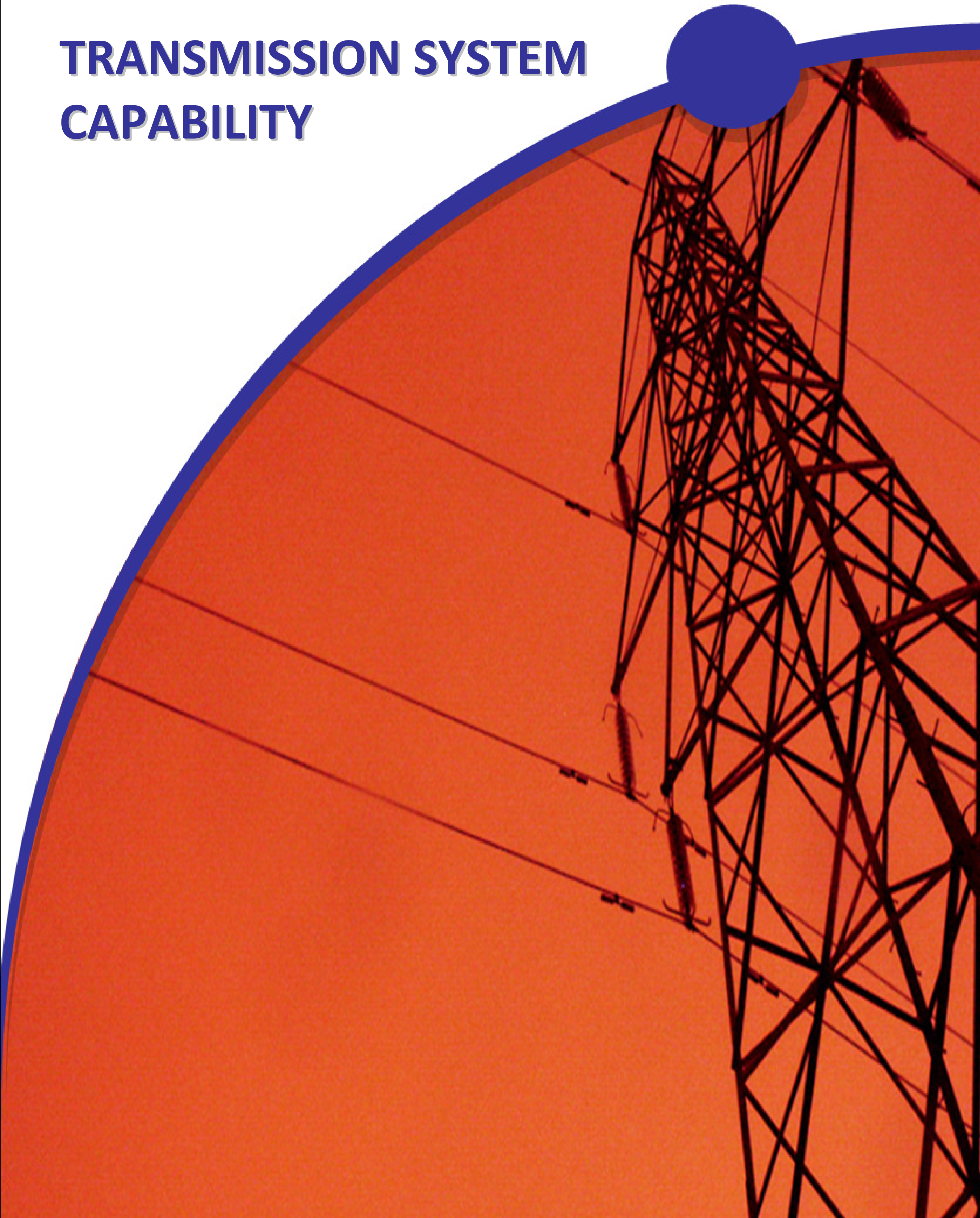
FAULT TYPE	kV	2006	2010	CHANGE
THREE PHASE	**275**	14.64	17.92	**+22%**
	110	11.26	12.69	**+15%**
SINGLE PHASE TO EARTH	**275**	16.13	18.62	**+16%**
	110	12.69	14.04	**+10%**

Table 7.3: Comparison of Average Fault Levels with Previous Statement

- The fault levels have clearly risen since the last Statement, in particular, for three phase faults. The main contributing factor is the use of G74 methodology in the analysis. **Appendix E** explains this methodology in detail, but key techniques include:
    - Contribution to the fault level from the load.
    - Contribution from power station auxiliaries.
- Other factors contributing to the rise in fault levels include:
    - Contribution to the fault level from embedded generation.
    - Increased demand.
- Separate analysis has shown that in 2006/07, single phase faults at nodes were 10-13% higher than the three phase faults at the same node. In 2010/11, this has changed to a difference of circa 5%, and this is as a result of the use of G74 analysis in this TSYS.

8

TRANSMISSION SYSTEM CAPABILITY



8 TRANSMISSION SYSTEM CAPABILITY

This section of the Transmission Seven Year Statement (TSYS) presents the results of the transmission system capability analysis. This enables potential users to assess those parts of the system which can accommodate new generation connections and the ability of the transmission system to transport additional electrical power. Using the results, the capability of each transmission node on the system to connect generation is shown.

This section contains a high level presentation and analysis of the results. A detailed description of the assumptions and methodology used in the analysis can be found in **Appendix F**. These results are indicative and are based on steady state analysis. Detailed studies considering dynamic stability, fault level analyses etc. are necessary prior to a connection offer being issued.

8.1 RESULTS

The results of the 275/110/33kV capability studies are presented in the following sections. It should be noted that, for all studies, reactive support of circa 100MVAr was required in the North West area. In the study files, this was achieved by use of a SVC. The high wind levels in the region have the effect of absorbing reactive power and lowering voltages; under contingencies, these voltages would fall outside acceptable limits. There may be a requirement in the future for both the TSO and the DSO to consider alternative wind farm voltage operating schemes. Without this reactive support, incremental capacities in the region would be minimal. As technical solutions do not require lengthy planning/construction timelines, this analysis assumes that the necessary reactive support will be achieved and will not act as an obstacle for potential system users. This is also discussed in the results of the power flows in **Section 6.5**.

The results also assume that the following reinforcements have been completed by 2015/16:

- Tamnamore Phase 2
- Coleraine to Kells 110kV circuit 2
- Omagh to Tamnamore 110kV circuit 3
- New 400kV tie line with the Republic of Ireland (RoI)

Without these developments being achieved by 2015/16, the capacity results will not be as accurate.

The system is tested for three scenarios where the new generation is absorbed by either the existing Northern Ireland (NI) load, the RoI load, or the load in Great Britain (GB). The results are displayed in the results tables below. The maximum generation that can be accepted based on these scenarios is also listed in the tables, in the right hand column.

8.1.1 RESULTS AT 275kV

Table 8.1 below contains the results for the analysis at 275kV nodes, for the year 2015/16. The table shows the capability for power transfers on the transmission system resulting from the connection of new generation at a 275kV node.

It should be noted that these results are based on individual studies of each node, and do not assess the cumulative effect of the addition of new generation to the transmission system.

275kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
BALLYLUMFORD	60	A1	40	A2	>400	-	**40**
CASTLEREAGH	>400	-	320	A3	>400	-	**320**
COOLKEERAGH	0	A4	0	A4	0	A4	**0**
HANNAHSTOWN	>400	-	300	A3	>400	-	**300**
KELLS	>400	-	>400	-	>400	-	**>400**
KILROOT	>400	-	>400	-	>400	-	**>400**
MAGHERAFELT	>400	-	>400	-	>400	-	**>400**
MOYLE	60	A1	40	A2	>400	-	**40**
TAMNAMORE	120	A5	120	A5	120	A5	**120**
TANDRAGEE	>400	-	>400	-	>400	-	**>400**
TURLEENAN	>400	-	>400	-	>400	-	**>400**

Table 8.1: Capability Results for 275kV

The table contains notes which cross reference with a corresponding table in **Appendix F**, which lists the network constraint limiting the maximum power transfer, and the contingency that caused the constraint.

8.1.2 RESULTS AT 110kV AND 33kV

This section looks at the ability of the 110kV stations to accept the connection of smaller generation stations. For this TSYS, all 110kV stations on the NI transmission system were examined for the year 2015/16. The results are displayed in Table 8.2 on the following page. Since renewable generation in NI is predominantly connected at 33kV level, an analysis of all 33kV nodes at Bulk Supply Points (BSP) is also included. These results are displayed in Table 8.3.

It must be stressed that these results assess the ability to connect generation at each individual node. It is only assessing the capability of the local network and assets. These results do not assess the cumulative effect on the interconnected all-island transmission system or the operational limitations that may limit the total amount of wind connected to the system at any time.

As with the previous section, the notes in Tables 8.2 and 8.3 cross reference with corresponding tables in **Appendix F**. These tables provide information on the constraints and contingency that limits the capability at each 110kV or 33kV station.

Any new generation connections would require further detailed connection studies, taking into consideration all other existing and planned generation connections, to determine the cumulative impact on the all-island transmission system.

110kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
AGHYOULE	0	B1	0	B1	0	B1	**0**
ANTRIM	80	R	80	R	80	R	**80**
BALLYLUMFORD	40	B2	40	B2	40	B2	**40**
BALLYMENA	120	R	120	R	140	R	**120**
BALLYNAHINCH	80	R	80	R	80	R	**80**
BALLYVALLAGH	140	B3	140	B3	160	B3	**140**
BANBRIDGE	80	R	80	R	80	R	**80**
BELFAST CENTRAL	160	B4	160	B4	160	B4	**160**
BELFAST NORTH MAIN	100	B5	100	B5	100	B5	**100**
CARNMONEY	80	B6	80	B6	80	B6	**80**
CASTLEREAGH	>400	-	320	B7	>400	-	**320**
COLERAINE	80	B8	100	B8	80	B8	**80**
COOLKEERAGH	0	B9	0	B9	0	B9	**0**
CREAGH	60	B10	60	B10	60	B10	**60**
CREGAGH	160	R	160	R	160	R	**160**
DONEGALL N	180	R	180	R	180	R	**180**
DONEGALL S	60	R	60	R	60	R	**60**
DRUMNAKELLY	80	B11	80	B11	80	B11	**80**
DUNGANNON	120	B12	100	B12	100	B12	**100**
EDEN	60	B13	40	B13	60	B13	**40**
ENNISKILLEN	40	B14	60	B14	60	B14	**40**
FINAGHY	160	B15	160	B15	160	B15	**160**
GLENGORMLEY	60	R	60	R	60	R	**60**
HANNAHSTOWN	300	B7	200	B7	320	B7	**200**
KELLS	220	B16	240	B16	240	B16	**220**
KNOCK	80	R	80	R	80	R	**80**
LARNE	60	R	60	R	60	R	**60**
LIMAVADY	20	B9	20	B9	20	B9	**20**
LISAGHMORE	0	B9	0	B9	0	B9	**0**
LISBURN	180	B17	180	B17	180	B17	**180**
LOGUESTOWN	80	R	80	R	80	R	**80**
NEWRY	80	R	80	R	80	R	**80**
NEWTOWNARDS	120	R	120	R	120	R	**120**
OMAGH	0	N	0	N	0	N	**0**
RATHGAEL	80	R	80	R	80	R	**80**
ROSEBANK	120	R	120	R	120	R	**120**
SPRINGTOWN	0	B9	0	B9	0	B9	**0**
STRABANE	40	B18	40	B18	40	B18	**40**
TAMNAMORE	120	B12	100	B12	100	B12	**100**
TANDRAGEE	>400	-	>400	-	>400	-	**>400**
WARINGSTOWN	120	R	120	R	120	R	**120**

Table 8.2: Capability Results for 110kV

33kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
AGHYOULE	0	C1	0	C1	0	C1	**0**
ANTRIM	80	T	80	T	80	T	**80**
BALLYMENA	100	T	100	T	100	T	**100**
BALLYNAHINCH	100	T	100	T	100	T	**100**
BANBRIDGE	80	T	80	T	80	T	**80**
BELFAST CENTRAL	160	T	160	T	160	T	**160**
BELFAST NORTH MAIN	160	T	160	T	160	T	**160**
CARNMONEY	100	T	100	T	100	T	**100**
COLERAINE	0	N	0	N	0	N	**0**
COOLKEERAGH	0	C2	0	C2	0	C2	**0**
CREAGH	60	C3	100	C3	60	C3	**60**
CREGAGH	100	T	100	T	100	T	**100**
DONEGALL N	120	T	120	T	120	T	**120**
DONEGALL S	60	T	60	T	60	T	**60**
DRUMNAKELLY	40	C4	40	C4	40	C4	**40**
DUNGANNON	60	T	60	T	60	T	**60**
EDEN	60	T	60	T	60	T	**60**
ENNISKILLEN	40	C5	40	C5	60	C5	**40**
FINAGHY	40	T	40	T	40	T	**40**
GLENGORMLEY	20	T	20	T	20	T	**20**
KNOCK	80	T	80	T	80	T	**80**
LARNE	40	T	40	T	40	T	**40**
LIMAVADY	20	C2	20	C2	20	C2	**20**
LISAGHMORE	0	C2	0	C2	0	C2	**0**
LISBURN	120	T	120	T	120	T	**120**
LOGUESTOWN	60	T	60	T	60	T	**60**
NEWRY	100	T	100	T	100	T	**100**
NEWTOWNARDS	80	T	80	T	80	T	**80**
OMAGH	0	N	0	N	0	N	**0**
RATHGAEL	100	T	100	T	100	T	**100**
ROSEBANK	120	T	120	T	120	T	**120**
SPRINGTOWN	0	C2	0	C2	0	C2	**0**
STRABANE	20	T	20	T	20	T	**20**
WARINGSTOWN	120	T	120	T	120	T	**120**

Table 8.3: Capability Results for 33kV

The analysis at 33kV stations assumes the potential new generator is connected directly to the 33kV busbars within the substation. It does not assess the capability of the 33kV network to accommodate generation. This will require additional detailed connection studies by NIE, the asset owner. In general, 33kV limitations tend to be caused by transformer capacity limits within the station.

8.2 DISCUSSION OF RESULTS

8.2.1 RESULTS AT 275kV

ISLANDMAGEE (BALLYLUMFORD AND MOYLE)

The 275kV capability analysis highlights the limited incremental capacity available at Ballylumford and Moyle 275kV substations. The maximum generation capacity available is 40MW; this is despite the fact units B5 and B6 are decommissioned due to E.U. emission targets. The loss of the Hannahstown-Ballylumford/Moyle 275kV circuits leads to thermal overloads on the Ballylumford-Kells 275kV circuit. In addition, the loss of the Ballylumford-Kells/Magherafelt 275kV circuits leads to overloads on the 110kV circuits out of Ballylumford. Considerable voltage stability issues also arise- SONI believe the system is close to the margin of voltage collapse for these critical outages. Studies suggest the system requires in excess of 100MVArs of reactive compensation. Under outage conditions a number of generators approach their reactive power limits, and results are sensitive to North-south exports, generation dispatch and the amount of wind generation.

BELFAST (CASTLEREAGH AND HANNAHSTOWN)

Both Castlereagh and Hannahstown 275kV substations have restricted generation capacity of circa 300MW. When power is transferred to RoI, the loss of the Castlereagh-Tandragee/Kilroot 275kV circuits causes overloads on the Hannahstown-Lisburn 110kV circuits.

TAMNAMORE

When a maintenance-trip occurs on the Tamnamore-Magherafelt and Tamnamore-Turleenan 275kV circuits, there is restricted generation capacity as the 110kV network is the only available means of exporting the generation. It is possible to accept 120MW before overloads occur on the Drumnakelly-Tandragee 110kV circuits.

COOLKEERAGH

Even with additional capacity on the new Kells-Coleraine and Omagh-Tamnamore 110kV circuits, with the expected levels of wind generation detailed in **Appendix C**, this node is saturated as a generation source. The critical outage is the loss of the Coolkeeragh-Magherafelt 275kV double circuit. When this outage occurs, heavy overloads appear on the underlying 110kV network. Considerable transmission capacity is required to evacuate the existing generation and the expected renewable energy in the North- West. When generation is not operational in the North-West, there is a risk of voltage collapse. Indeed, a low voltage load shedding scheme is in place to avoid voltage collapse during Coolkeeragh-Magherafelt outage conditions (see **Section 3.6.2**).

8.2.2 RESULTS AT 110kV AND 33kV

In the 2003 TSYS there was approximately 60MW of wind generation capacity connected to the NI distribution system. In the 2010 base year of this report this figure has rapidly grown to circa 310MW and is expected to increase further to 600MW by 2015/16. This figure, however, is dependent on key transmission assets (detailed in **Appendix F.1.3**) being achieved by NIE. The vast majority of this generation capacity is located to the West and North-West of NI. It is not surprising, therefore, that 110kV and 33kV substations in this region have little or no spare generation capacity available by 2015/16.

To the East of the province, however, this trend is reversed, with minimal renewable generation penetration. Instead, the amount of generation capacity is dependent on the thermal rating of circuits and transformers which supply the substations. The load at the substation is also a factor- the higher the local load, the greater the ability to absorb generation capacity. In general, it is the summer minimum case, with low loads and reduced circuit ratings that limits the generation capacity available.

Each 110kV and 33kV node must be considered individually to determine its individual characteristics and the resulting maximum generation capacity. Radially fed 110/33kV substations will be limited by the loss of a single circuit or transformer, and the constraint will be the remaining healthy circuit. Interconnected 110kV substations have a variety of critical outages which limit the generation capacity. These are listed in **Appendix F.3.2**.

8.3 SUMMARY OF RESULTS

Islandmagee is an important generation source, with Moyle and Ballylumford providing over 1300MW of electrical power in 2015/16. As in previous TSYS, these capability studies highlight the node is now saturated as a generation source. Thermal capacity limitations and voltage stability issues would require resolution. To maintain voltage stability, the TSO is presently forced to dispatch must-run plant at Coolkeeragh and Kilroot. These problems are exacerbated as wind levels and North-South exports both increase.

These studies are based on an assumed automatic tripping scheme being installed on the 110kV circuits out of Ballylumford, in particular the Carnmoney-Castlereagh and Ballyvallagh-Kells circuits. Without this scheme in place, there would be little or no capacity at many major 275kV nodes. This requirement was identified in the 2003 TSYS.

Generation capacity is limited to circa 300MW at Castlereagh and Hannahstown 275kV substations in Belfast. The main constraint is the thermal overloads of the Hannahstown-Lisburn 110kV circuits. The 2003 SYS had suggested reconfiguration of these circuits.

The major change that has occurred in recent years is the increased wind penetration, particularly in the North-West of NI. SONI is concerned that even with the planned reinforcements of Kells-Coleraine and Omagh-Tamnamore being in place by 2015/16, there remains limited transmission capacity beyond this date for further renewable generation connections in the North-West. Coolkeeragh still remains a generation saturated node, with no spare capacity. The Coolkeeragh runback scheme (see **Section 3.6.3** and **Appendix F.2.6**) is essential in enabling the further connection of renewable generation in the North-West region. It should be noted that neither Coolkeeragh itself, nor any nodes fed from Coolkeeragh, were tested with the runback schemed employed.

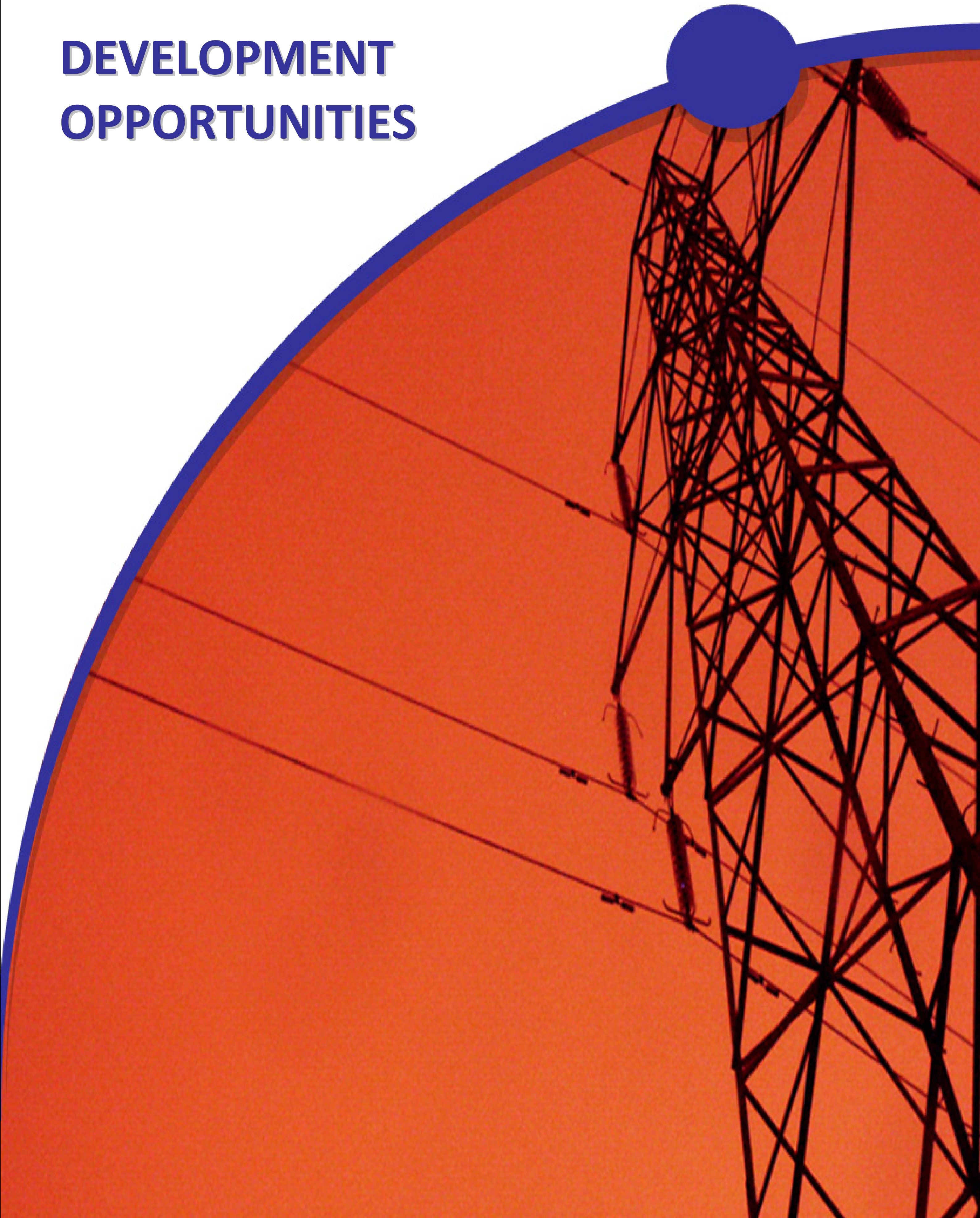
The 2009 Draft Strategic Energy Framework presents a target of 40% of all energy to be provided from renewable sources by the year 2020 (for further information, see **Section 4.2.3**). A Strategic Energy Assessment, carried out by DETI, in combination with on-shore renewable planning applications and connection information from NIE, indicate that there is in excess of 1800MW of renewable generation capacity in NI, much of it located in the North-West region. Without significant strategic investment in transmission capacity, network constraints will rise and it will not be possible to meet the 40% target. Both SONI and EirGrid are currently performing all-island studies to consider management and operational challenges in delivering such a target.

8.4 CONCLUSIONS

The NI transmission system was originally built to a high standard in the 1960s and 1970s. Since that time, it has experienced four decades of growth, increased interconnection with GB and RoI, widely distributed renewable generation and the introduction of the Single Electricity Market (SEM). SONI is required to operate the transmission system whilst meeting a wide range of operational demands. The resulting market flows and changing conditions have increased the thermal capacity issues and caused stability problems. Substantial investment is now required in the short to medium term to support market mechanisms, meet government and E.U. renewables targets and prevent thermal and voltage related problems identified in these generation capability studies.

9

DEVELOPMENT OPPORTUNITIES



9 DEVELOPMENT OPPORTUNITIES

When SONI receives either generation or demand related connection enquiries, there are a wide range of technical assessments necessary in advance of offering a connection proposal to the potential transmission system user. Detailed connection studies are required which take into consideration the full impact on fault level, transient stability and dynamic stability. The development must also meet the technical connection requirements set out in the Northern Ireland (NI) Grid Code. The potential capacities identified in these capability studies are only indicative. The general information provided in this report may be used as a guide only, and must be followed by analysis using detailed plant models provided by potential network users.

9.1 GENERATION OPPORTUNITIES

Opportunity is largely based upon the size and location of the connecting generation plant. The results of the capability analysis indicate that, for 2015/16, there are several locations on the transmission network where a large 400MW generator could connect without the need for reinforcements.

Generation capability is displayed geographically in figures 9.1 to 9.3. More detailed maps and schematics containing full substation names etc. can be found in **Appendix B**.

9.1.1 GENERATION OPPORTUNITIES AT 275kV

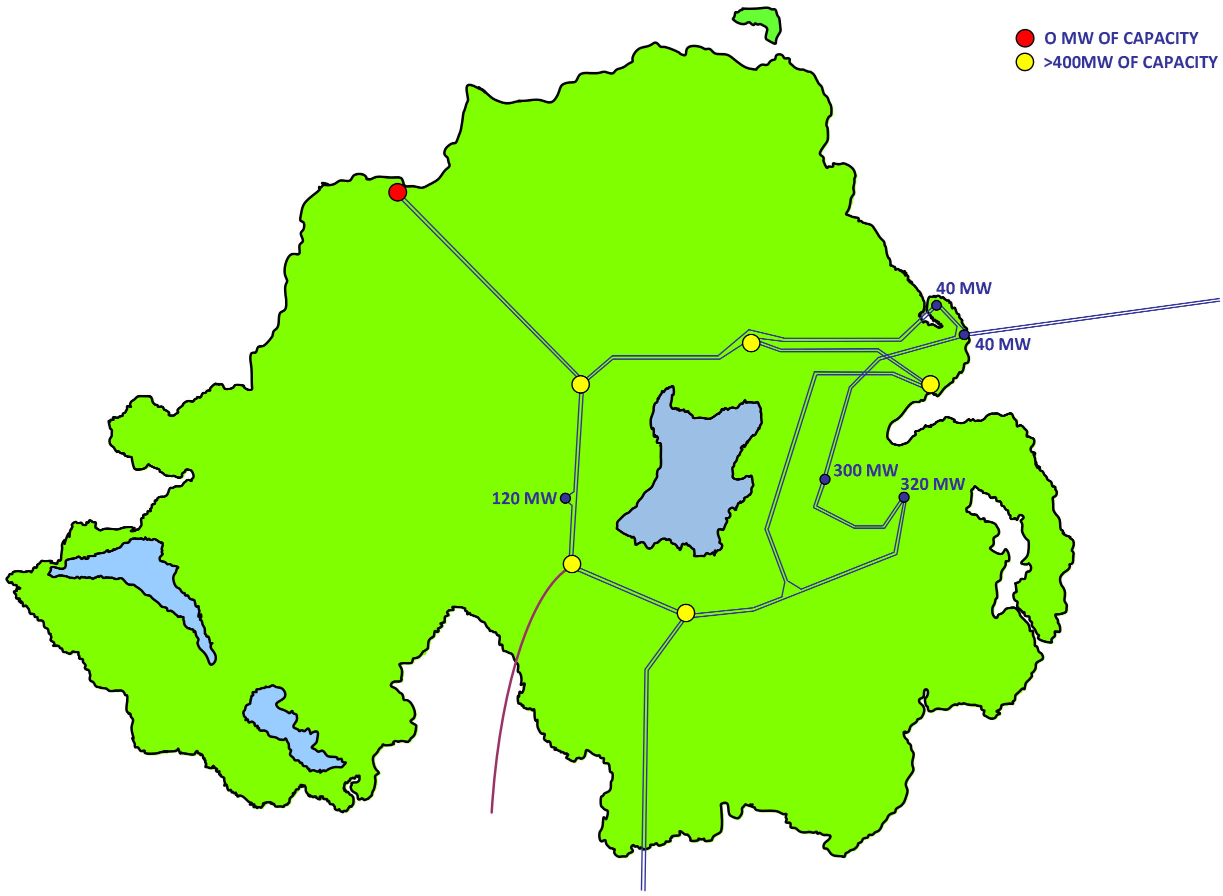


Figure 9.1: Generation Opportunities at 275kV

The results of the capability analysis in this Transmission Seven Year Statement (TSYS) are displayed in figure 9.1 above. They show that spare capacity for the connection of a new large generator exists at several locations on the grid in 2015/16. Tandragee, Kells, Kilroot and Magherafelt 275kV substations, as well as the new 275kV substation at Turleenan, could accommodate a 400MW generator.

Generation connections at other 275kV locations would likely require varying degrees of transmission network reinforcement to enable them to connect. As has been noted in previous Statements, the Islandmagee area is saturated as a generation source, as is the node at Coolkeeragh. This is still the case in this TSYS, and no new generation could be connected at any of these nodes without significant reinforcements to the transmission system. At Tamnamore, only 120MW can be accommodated under the current network configuration. This could be increased, however, if the second 275kV circuit was diverted into the substation.

Large generation sources make considerable contributions to fault level. As fault levels increase, the margins available have generally reduced on the transmission system, and detailed analysis is required for all such potential development.

9.1.2 GENERATION OPPORTUNITIES AT 110kV

Connection of smaller generators would take place at 110kV. Currently, the largest unit connected at 110kV is circa 150MW. In the capability studies, the connection of up to 200MW of generation at each node was investigated. The results are shown below in Figure 9.2.

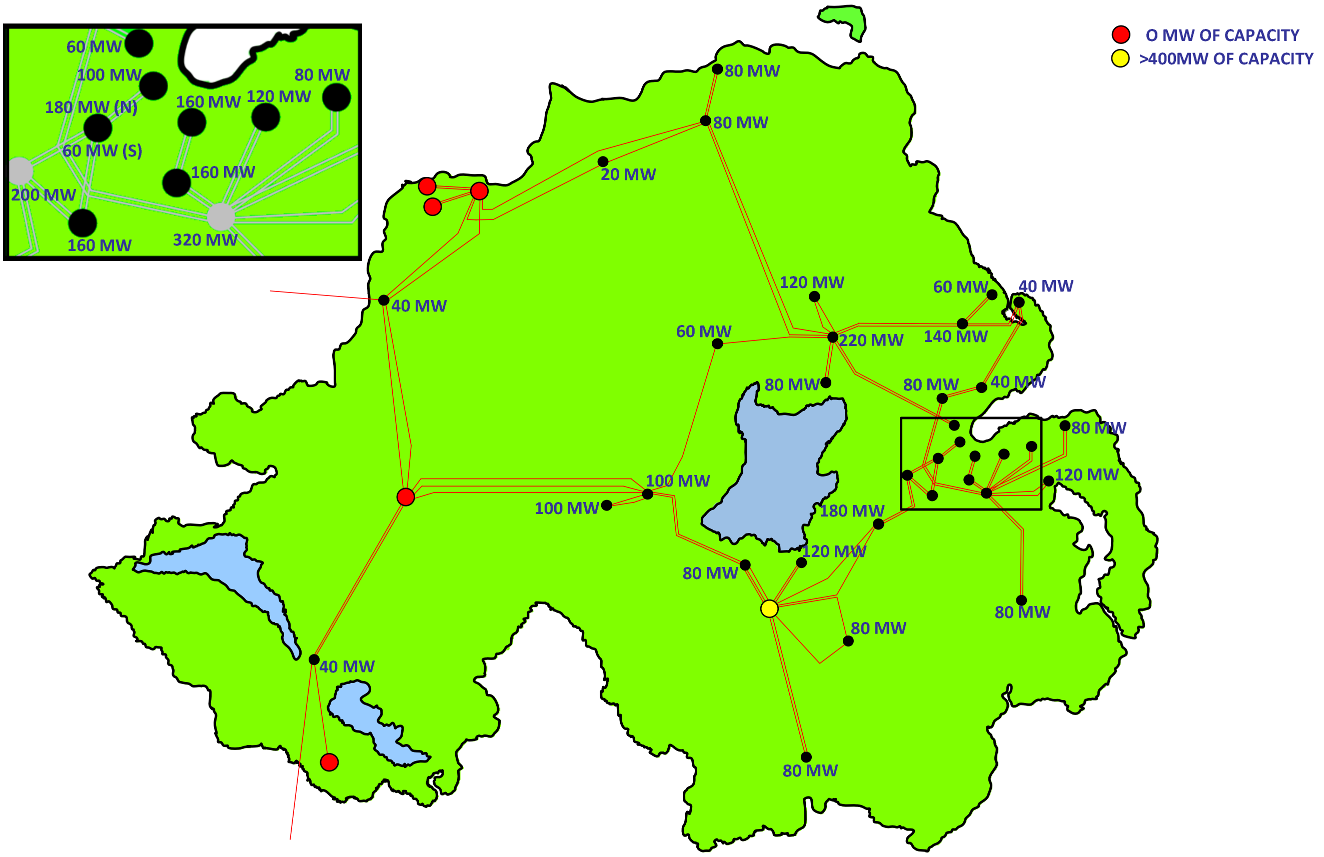


Figure 9.2: Generation Opportunities at 110kV

Figure 9.2 shows that opportunities for new generation in the west of the country are very limited. In particular, the 110kV nodes at Coolkeeragh and Omagh can not accommodate any new generation. This is despite the additional 110kV circuits between Kells-Coleraine and Omagh-Tamnamore. Initial studies suggest it may be possible to connect an additional 100MW of wind to the 600MW in 2015/16 before thermal capacity issues arise in the North-West region.

Towards the East of the country, opportunities for generation become more substantial. In particular, both Tandragee and Castlereagh 110kV nodes are shown to be able to accept generation above 300MW in size. The magnitude of generation capability varies depending on the local load, the number of circuits at the node and the rating of the transmission circuit equipment. For example, it is only possible to accommodate 60MW at Creagh 110kV substation, while Kells 110kV can accommodate 220MW.

It should be noted that opportunities are not cumulative, and if a new generator agrees to connect at a particular node, then it will have an impact on the capabilities of many other nodes on the transmission system.

9.1.2 GENERATION OPPORTUNITIES AT 33kV

At present in NI, renewable generation has connected at 33kV. Therefore, in this TSYS, SONI has also analysed the capability of the transmission system to accept new generation at 33kV level, connected to the transmission system via 110/33kV Bulk Supply Points (BSP). The results are presented in Figure 9.3 below.

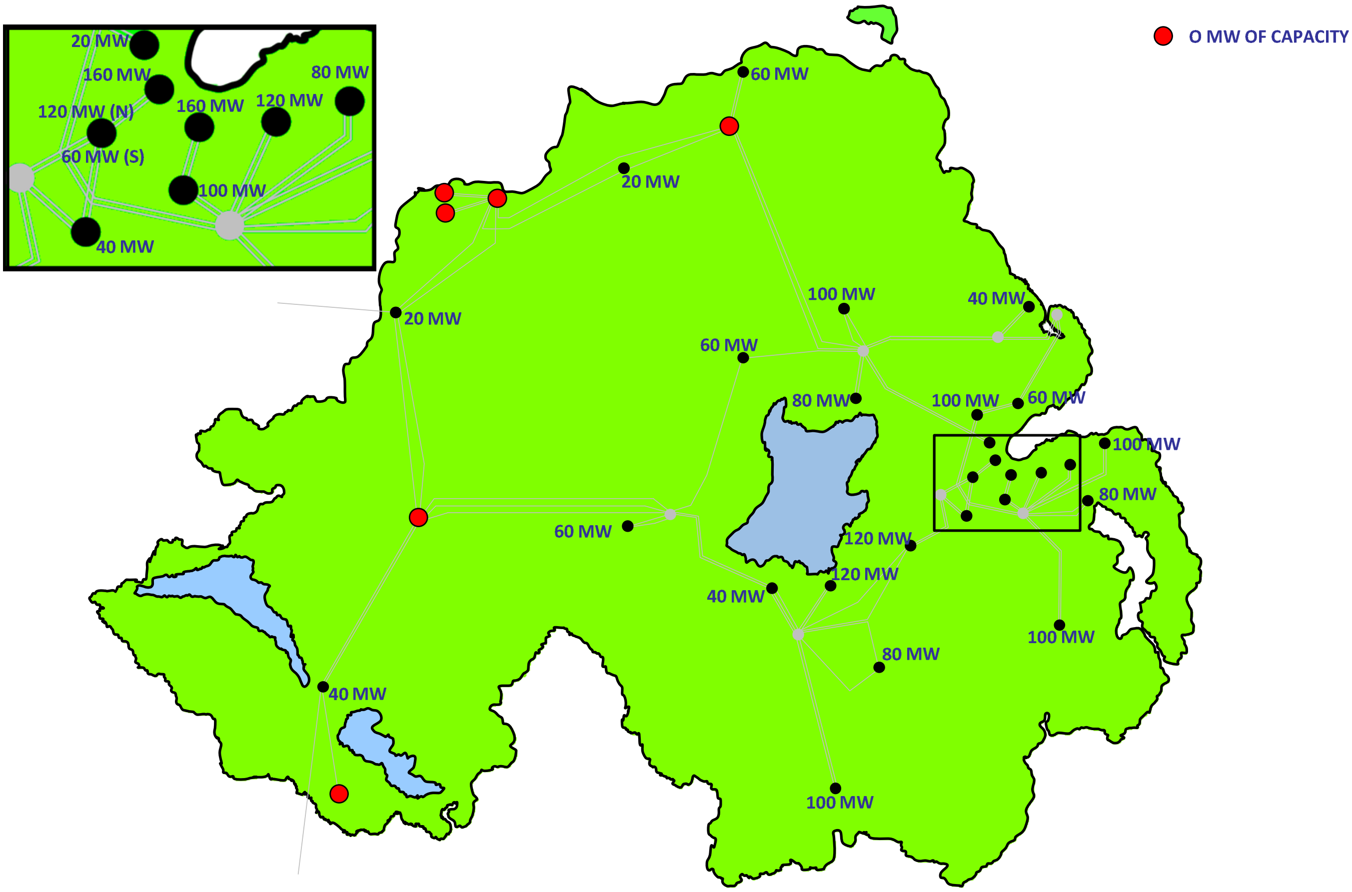


Figure 9.3: Generation Opportunities at 33kV

The results in figure 9.3 are broadly comparable to those in figure 9.2. Generation capabilities at 33kV level may be reduced if 110/33kV transformer capacity limits power transfers onto the 110kV system.

9.1.3 CONCLUSIONS

The transmission network in NI was originally built to a high standard, with many years of capacity, but the effects of over 40 years of load growth are starting to stress capability.

Both the Islandmagee area, and the node at Coolkeeragh, cannot accept further generation capacity without major reinforcement.

The large amount of renewable generation in the North West area not only severely limits the capability for new generation in that region, but also affects the stability of the system. For all studies, a SVC was required in the North Western region to maintain voltage levels within the required standards. It should also be noted that the capabilities shown in this area are very much dependent on the installation of the planned 110kV reinforcements. Without these, the entire North Western area will also be generation saturated by 2015/16, and likely before.

The best opportunities for new generation are to be found at transmission nodes on the 275kV system.

It should, of course, be noted that the results presented are merely indicative. Other factors that would affect the overall capability of a node to accept new generation include:

- Existing fault levels at the node.
- Possible delays in network reinforcements.
- Changes in demand profile due to economic conditions and customer behaviour.
- Delays in the connection of planned generation.

9.2 DEMAND OPPORTUNITIES

Over the last two decades NI has seen load growth, averaging around 2% per year, until the recent global economic downturn. By 2011/12, SONI expect a return to this trend (as discussed in **Section 5.4**). The NI transmission system has coped well with this gradual incremental increase year on year. The generation capability studies highlight a number of circuits that are increasingly stressed under certain generator dispatch and outage scenarios. If the network is to continue to accept additional load growth, and transit/export power, then investment is required to provide additional thermal capacity and voltage support on the NI network.

Currently, all NI customers are connected to the distribution system at 33kV level or below. The largest customer demand is currently around 20MW. The transmission system could cope with continued small scale customer connections at 33kV and below, but the cumulative impact on the transmission system must be carefully monitored. **Appendix D** provides tables detailing the available connection capacity at all 110/33kV nodes. A comparison is made between substation firm capacity and expected load growth.

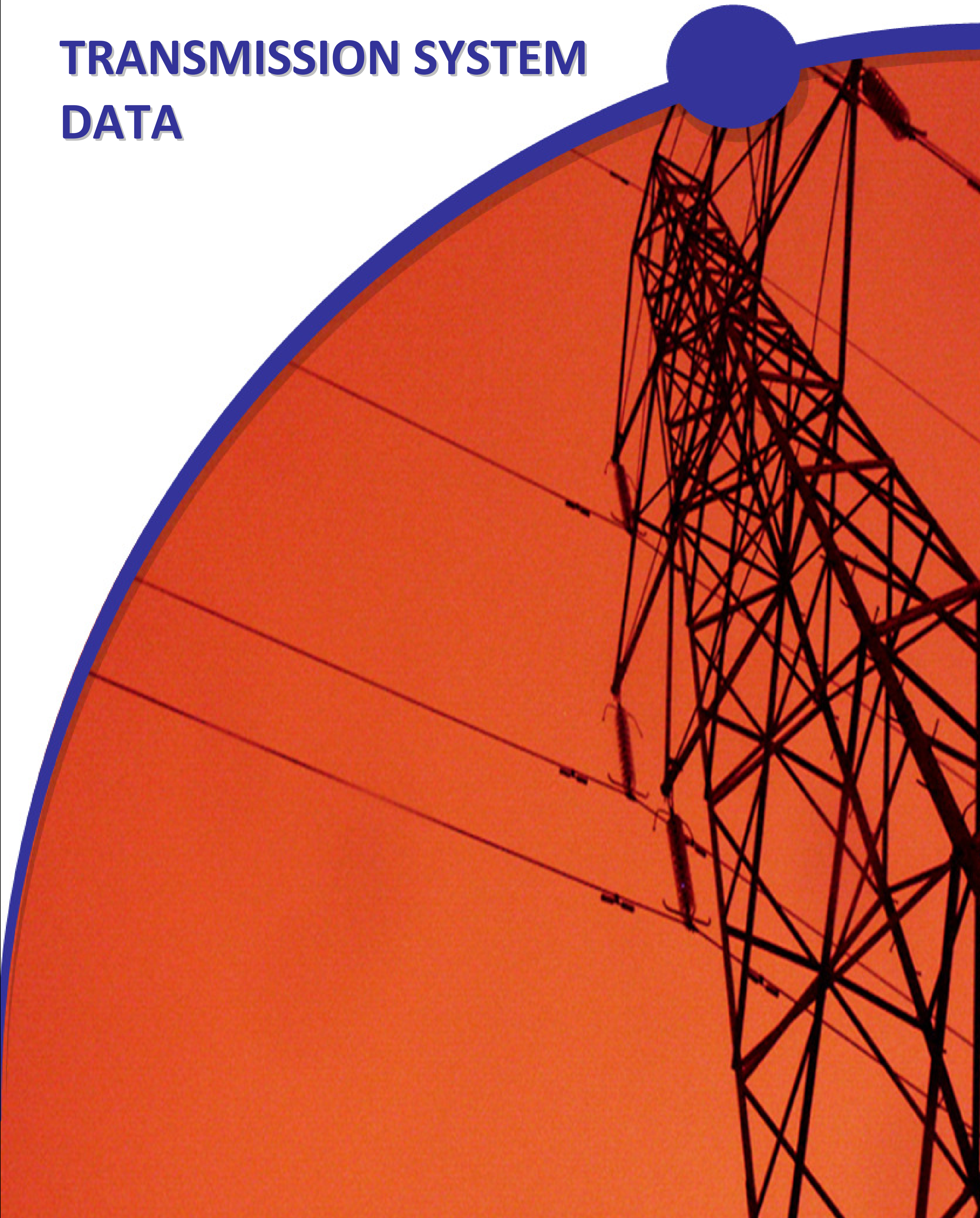
In general, the connection of additional load assists the process of connecting local variable distributed generation. The difficulty for network planning is that the system must be able to maintain supplies to customers when renewable generation sources are not generating- for example, wind generation on a calm day.

Large bulk transmission connections in excess of 50MW will require careful study to determine their impact. Large 275kV connections at major power sources such as Ballylumford, Moyle, Coolkeeragh and Kilroot could be connected without major 275kV upgrading. However, large connections in the North-West area, or in Belfast, could require substantial additional reactive power support to ensure voltage stability for critical 275kV contingencies.

The 110kV network is much more heavily loaded in comparison to the 275kV network. Therefore, large connections to the 110kV system would be much more likely to require network reinforcement when compared to the 275kV backbone.

APPENDIX A

TRANSMISSION SYSTEM DATA



APPENDIX A TRANSMISSION SYSTEM DATA

The following is a list of tables contained in this section:

TABLE A.1: BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (Mvar)
1981	CORRACL	ESB PLANT	110		
3522	LOUTH		220		
3581	LETRKENY		110		
35231	LOUTH5 A		275		
35232	LOUTH5 B		275		
60101	COLE_WIND3	WIND FARMS	33		
60102	BAME_WIND3		33		
60103	ENNK_WIND3		33		
60104	LARN_WIND3		33		
60105	OMAH_WIND3		33		
60106	STRA_WIND3		33		
60107	LIMA_WIND3		33		
60108	AGHY_WIND3		33		
60109	DUNG_WIND3		33		
60110	ANTR_WIND3		33		
60111	BNCH_WIND3		33		
60112	BANB_WIND3		33		
60113	CREA_WIND3		33		
60114	DRUM_WIND3		33		
60115	LSMR_WIND3		33		
60116	LOGE_WIND3		33		
60117	NEWY_WIND3		33		
60118	WARN_WIND3		33		
69031	TERM_T1	AGHYOULE	33		
69032	TERM_T2		33		
69110	AGHY1-		110		
69130	AGHY3-		33	13.18	4.33
69131	GORT3-		33	13.18	4.33
69132	DYLN3-		33	3.07	1.01
69133	DYLN3C		33		
70011	ANTR1A	ANTRIM	110		
70012	ANTR1B		110		
70030	ANTR3-		33	43.61	14.33
70504	BAFDG4	BALLYLUMFORD	15	13.65	4.55
70505	BAFDG5		15		
70506	BAFDG6		15		
70507	BAFDG7		11		
70508	BAFDG8		11		
70510	BAFD1-		110	6.83	2.28
70513	BAFD_GA		15	3.41	1.14

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (Mvar)
70514	BAFD_GB	BALLYLUMFORD	15	3.41	1.14
70515	BAFD_GC		18	3.41	1.14
70516	BAFD_GD		15	3.41	1.14
70520	BAFD2-		275		
70561	BAFD6P		22		
70562	BAFD6Q		22		
70571	BAFD7P		22		
70572	BAFD7Q		22		
71011	BAME1A	BALLYMENA	110		
71012	BAME1B		110		
71031	BAME3R		33	47.84	15.72
71032	BAME3T		33	49.67	16.32
71511	BANB1A	BANBRIDGE	110		
71512	BANB1B		110		
71530	BANB3-		33	42.83	14.08
72010	BAVA1-	BALLYVALLAGH	110		
72511	BNCH1A	BALLYNAHINCH	110		
72512	BNCH1B		110		
72530	BNCH3-		33	58.02	19.07
73521	CACO2A		275		
73522	CACO2B		275		
74011	CARN1A	CARNMONEY	110		
74012	CARN1B		110		
74030	CARN3-		33	30.14	9.91
74511	CAST1A	CASTLEREAGH	110		
74512	CAST1B		110		
74520	CAST2-		275		
74561	CAST6P		22		
74562	CAST6Q		22		
74563	CAST6R		22		
74571	CAST7P		22		
74572	CAST7Q		22		
74573	CAST7R		22		
74711	CENT1A	BELFAST CENTRAL	110		
74712	CENT1B		110		
74730	CENT3-		33	64.43	21.18
75010	COLE1-	COLERAINE	110		
75011	COLE1C		110		
75030	COLE3-		33	49.71	16.34
75508	COOLG8-	COOLKEERAGH	11		
75510	COOL1-		110		
75514	COOL1C		110		
75515	COOLST-		11.8	3.41	1.14

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (Mvar)
75516	COOLGT-	COOLKEERAGH	16	5.69	1.9
75520	COOL2-		275		
75530	COOL3-		33	25.24	8.3
75561	COOL6P		22		
75562	COOL6Q		22		
75571	COOL7P		22		
75572	COOL7Q		22		
75810	CREA1-	CREAGH	110		
75830	CREA3-		33	26.33	8.66
75911	CREC1A		110		
75912	CREC1B		110		
76011	CREG1A	CREGAGH	110		
76012	CREG1B		110		
76031	CREG3A		33	22.42	7.39
76032	CREG3B		33	12.13	3.99
76511	DONE1C	DONEGAL	110		
76512	DONE1B		110		
76513	DONE1D		110		
76514	DONE1A		110		
76531	DONE3AS		33	52.03	17.1
76532	DONE3N		33	52.04	17.11
76533	DONE3BS		33	8.38	2.76
77010	DRUM1-	DRUMNAKELLY	110		
77030	DRUM3-		33	89.3	29.35
77510	DUNG1-	DUNGANNON	110		
77530	DUNG3-		33	101.2	33.26
78030	DUNM3-	DUNMURRAY	33	23.59	7.75
78511	EDEN1A	EDEN	110		
78512	EDEN1B		110		
78530	EDEN3-		33	31.84	10.46
79010	ENNK1_	ENNISKILLEN	110		
79015	ENNKPFA		110		
79016	ENNKPFB		110		
79030	ENNK3-		33	75.34	24.76
80011	FINY1A	FINAGHY	110		
80012	FINY1B		110		
80030	FINY3-		33	37.84	12.44
80511	GLEN1A	GLENGORMLEY	110		
80512	GLEN1B		110		
80531	GLEN3A		33	19.93	6.55
80532	GLEN3B		33	10.79	3.55
81010	HANA1A	HANNAHSTOWN	110		
81020	HANA2A		275		

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (Mvar)
81061	HANA6P	HANNAHSTOWN	22		
81062	HANA6Q		22		
81071	HANA7P		22		
81072	HANA7Q		22		
81510	KELS1-	KELLS	110		
81520	KELS2-		275		
81561	KELS6P		22		
81562	KELS6Q		22		
81571	KELS7P		22		
81572	KELS7Q		22		
82001	KILRG1-	KILROOT	17	13.65	4.55
82002	KILRG2-		17	13.65	4.55
82011	KPS_AUX1		11		
82012	KPS_AUX2		11		
82020	KILR2-		275		
82511	KNCK1A	KNOCK	110		
82512	KNCK1B		110		
82530	KNCK3-		33	55.58	18.27
83011	LARN1A	LARNE	110		
83012	LARN1B		110		
83030	LARN3-		33	44.22	14.53
83510	LIMA1-	LIMAVADY	110		
83530	LIMA3-		33	39.78	13.07
84011	LISB1A	LISBURN	110		
84012	LISB1B		110		
84030	LISB3-		33	73.48	24.15
84411	LSMR1A	LISAGHMORE	110		
84412	LSMR1B		110		
84430	LSMR3-		33	39.78	13.07
84511	LOGE1A	LOGUESTOWN	110		
84512	LOGE1B		110		
84530	LOGE3-		33	73.48	24.15
85020	MAGF2-	MAGHERAFELT	275		
86030	MOUN3-	MOUNTPOTTINGER	33	32.22	10.59
86220	MOYL2-	MOYLE	275		
86221	SCOT2-		275		
86311	NARD1A	NEWTOWNARDS	110		
86312	NARD1B		110		
86330	NARD3-		33	38.35	12.61
86511	NEWY1A	NEWRY	110		
86512	NEWY1B		110		
86530	NEWY3-		33	34.23	11.25
87011	NORF1A	NORFILL	110		

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (Mvar)
87012	NORF1B	NORFILL	110		
87510	OMAH1-	OMAGH	110		
87530	OMAH3-		33	40.69	13.37
88011	RATH1A	RATHGAEL	110		
88012	RATH1B		110		
88030	RATH3-		33	86.93	28.57
88511	ROSE1A	ROSEBANK	110		
88512	ROSE1B		110		
88530	ROSE3-		33	52.93	17.4
89030	SKEG3-	SKEGONEILL	33	27.07	8.9
89510	STRA1-	STRABANE	110		
89515	STRPFCA		110		
89516	STRPFCB		110		
89530	STRA3-		33	35.07	11.53
90011	TAND1A	TANDRAGEE	110		
90012	TAND1B		110		
90020	TAND2-		275		
90061	TAND6P		22		
90062	TAND6Q		22		
90063	TAND6R		22		
90071	TAND7P		22		
90072	TAND7Q		22		
90073	TAND7R		22		
90310	TAMN1-	TAMNAMORE	110		
90320	TAMN2-		275		
90361	TAMN6P		22		
90371	TAMN7P		22		
90511	WARN1A	WARINGSTOWN	110		
90512	WARN1B		110		
90530	WARN3-		33	71.43	23.48
91011	WEST1A	POWER STATION WEST	110		
91012	WEST1B		110		
91031	WEST3A		33		
91032	WEST3B		33		

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
CORRACL	ENNKPFB	1	0.04720	0.10680	0.01020	105	100	90
LETRKENY	STRPFCB	1	0.03498	0.07926	0.00759	126	115	106
LOUTH5 A	LOUTH5 B	1	0.00000	0.00010	0.00000	1000	1000	1000
LOUTH5 A	TAND2-	1	0.00240	0.02110	0.12690	881	820	710
LOUTH5 B	TAND2-	2	0.00240	0.02110	0.12690	881	820	710
COLE_WIND3	COLE3-	1	0.00000	0.00010	0.00000	0	0	0
BAME_WIND3	BAME3R	1	0.00000	0.00010	0.00000	0	0	0
ENNK_WIND3	ENNK3-	1	0.00000	0.00010	0.00000	0	0	0
LARN_WIND3	LARN3-	1	0.00000	0.00010	0.00000	0	0	0
OMAH_WIND3	OMAH3-	1	0.00000	0.00010	0.00000	0	0	0
STRA_WIND3	STRA3-	1	0.00000	0.00010	0.00000	0	0	0
LIMA_WIND3	LIMA3-	1	0.00000	0.00010	0.00000	0	0	0
AGHY_WIND3	AGHY3-	1	0.00000	0.00010	0.00000	1000	1000	1000
DUNG_WIND3	DUNG3-	1	0.00000	0.00010	0.00000	0	0	0
ANTR_WIND3	ANTR3-	1	0.00000	0.00010	0.00000	0	0	0
BNCH_WIND3	BNCH3-	1	0.00000	0.00010	0.00000	0	0	0
BANB_WIND3	BANB3-	1	0.00000	0.00010	0.00000	0	0	0
CREA_WIND3	CREA3-	1	0.00000	0.00010	0.00000	0	0	0
DRUM_WIND3	DRUM3-	1	0.00000	0.00010	0.00000	0	0	0
LSMR_WIND3	LSMR3-	1	0.00000	0.00010	0.00000	0	0	0
LOGE_WIND3	LOGE3-	1	0.00000	0.00010	0.00000	0	0	0
NEWY_WIND3	NEWY3-	1	0.00000	0.00010	0.00000	0	0	0
WARN_WIND3	WARN3-	1	0.00000	0.00010	0.00000	0	0	0
TERM_T1	DYLN3-	1	0.30140	0.75351	0.00097	30	30	30
TERM_T1	ENNK3-	1	0.06514	0.09471	0.00007	20	20	20
TERM_T2	DYLN3-	1	0.23436	0.58590	0.00075	30	30	30
TERM_T2	ENNK3-	1	0.16314	0.23719	0.00017	20	20	20
AGHY1-	ENNK1_	1	0.03918	0.10365	0.00994	124	119	109
AGHY3-	GORT3-	1	0.04361	0.09640	0.00170	30	30	30
AGHY3-	GORT3-	2	0.04361	0.09640	0.00170	30	30	30
AGHY3-	DYLN3-	1	0.04361	0.09640	0.00170	30	30	30
AGHY3-	DYLN3-	2	0.04361	0.09640	0.00170	30	30	30
DYLN3-	DYLN3C	1	0.00000	0.00010	0.00000	0	0	0
ANTR1A	KELS1-	1	0.01162	0.02940	0.00310	103	95	82
ANTR1A	NORF1A	1	0.00080	0.00080	0.00770	84	76	76
ANTR1B	KELS1-	1	0.01162	0.02940	0.00310	103	95	82
ANTR1B	NORF1B	1	0.00080	0.00080	0.00770	84	76	76
BAFD1-	BAVA1-	1	0.02259	0.05760	0.00610	103	95	82
BAFD1-	BAVA1-	2	0.02259	0.05760	0.00610	103	95	82
BAFD1-	EDEN1A	1	0.02280	0.05350	0.00480	86	80	69

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
BAFD1-	EDEN1B	1	0.02280	0.05270	0.00480	87	81	70
BAFD2-	HANA2A	2	0.00004	0.00034	0.00201	881	820	710
BAFD2-	KELS2-	1	0.00170	0.01500	0.09040	881	820	710
BAFD2-	MAGF2-	1	0.00320	0.02860	0.17200	881	820	710
BAFD2-	MOYL2-	1	0.00010	0.00130	0.00810	881	820	710
BAFD6P	BAFD7P	1	0.00000	0.00010	0.00000	0	0	0
BAFD6Q	BAFD7Q	1	0.00000	0.00010	0.00000	0	0	0
BAME1A	KELS1-	1	0.01306	0.03455	0.00332	124	119	109
BAME1B	KELS1-	1	0.01502	0.03973	0.00381	124	119	109
BANB1A	TAND1A	1	0.02403	0.06239	0.00622	103	103	82
BANB1B	TAND1A	1	0.01855	0.04902	0.00471	103	103	82
BAVA1-	KELS1-	1	0.02769	0.07300	0.00705	124	119	109
BAVA1-	KELS1-	2	0.02651	0.06989	0.00675	124	119	109
BAVA1-	LARN1A	1	0.00720	0.02340	0.00250	113	96	80
BAVA1-	LARN1B	1	0.00720	0.02340	0.00250	113	96	80
BNCH1A	CAST1B	1	0.02769	0.07132	0.00722	103	95	82
BNCH1B	CAST1B	1	0.02769	0.07132	0.00722	103	95	82
CACO2A	COOL2-	1	0.00010	0.00010	0.02280	837	761	761
CACO2A	MAGF2-	1	0.00670	0.02400	0.14950	513	513	412
CACO2B	COOL2-	1	0.00010	0.00010	0.01930	837	761	761
CACO2B	MAGF2-	1	0.00670	0.02400	0.14950	513	513	412
CARN1A	CAST1A	1	0.03710	0.08690	0.00780	87	80	69
CARN1A	EDEN1A	1	0.01870	0.04390	0.00400	86	80	69
CARN1B	CAST1A	1	0.03710	0.08570	0.00780	87	80	69
CARN1B	EDEN1B	1	0.01870	0.04330	0.00400	87	81	70
CARN3-	GLEN3B	1	0.03510	0.02070	0.00330	17.1	17.1	17.1
CARN3-	GLEN3B	2	0.03510	0.02070	0.00330	17.1	17.1	17.1
CAST1A	CAST1B	1	0.00000	0.00010	0.00000	1000	1000	1000
CAST1A	CAST1B	2	0.00000	0.00010	0.00000	1000	1000	1000
CAST1A	ROSE1A	1	0.00100	0.00180	0.02545	128	117	117
CAST1A	ROSE1B	1	0.00100	0.00180	0.02545	128	117	117
CAST1B	CREG1A	1	0.00120	0.00360	0.06080	145	132	132
CAST1B	CREG1B	1	0.00120	0.00360	0.06080	145	132	132
CAST1B	KNCK1A	1	0.00520	0.00440	0.04370	73	66	66
CAST1B	KNCK1B	1	0.00520	0.00440	0.04370	73	66	66
CAST1B	NARD1A	1	0.01516	0.04027	0.07135	124	119	109
CAST1B	NARD1B	1	0.01770	0.04614	0.07049	124	119	109
CAST1B	RATH1A	1	0.02468	0.06300	0.00660	103	95	82
CAST1B	RATH1B	1	0.02468	0.06300	0.00660	103	95	82
CAST2-	HANA2A	1	0.00090	0.00780	0.05060	881	820	710
CAST2-	HANA2A	2	0.00090	0.00790	0.05060	881	820	710
CAST2-	KILR2-	1	0.00340	0.02940	0.17810	881	820	710
CAST2-	TAND2-	1	0.00230	0.01910	0.12350	881	820	710

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
CAST6P	CAST7P	1	0.00000	0.00010	0.00000	0	0	0
CAST6Q	CAST7Q	1	0.00000	0.00010	0.00000	0	0	0
CAST6R	CAST7R	1	0.00000	0.00010	0.00000	0	0	0
CENT1A	CREG1A	1	0.00111	0.00462	0.02222	145	144	144
CENT1B	CREG1B	1	0.00111	0.00462	0.02222	145	144	144
CENT3-	MOUN3-	1	0.01290	0.26890	0.00300	30	30	30
CENT3-	MOUN3-	2	0.01290	0.26890	0.00300	30	30	30
CENT3-	WEST3A	1	0.01300	0.26699	0.00400	33	30	30
CENT3-	WEST3A	2	0.01245	0.26627	0.00400	33	30	30
CENT3-	WEST3B	1	0.01925	0.26296	0.00400	33	30	30
CENT3-	WEST3B	2	0.01171	0.26530	0.00400	33	30	30
COLE1-	COLE1C	1	0.00000	0.00010	0.00000	0	0	0
COLE1-	COOL1-	1	0.06030	0.15390	0.01610	103	95	82
COLE1-	KELS1-	1	0.07010	0.20080	0.01980	124	119	109
COLE1-	LIMA1-	1	0.02430	0.06410	0.00610	103	95	82
COLE1-	LOGE1A	1	0.01040	0.02700	0.00280	103	95	82
COLE1-	LOGE1B	1	0.01040	0.02700	0.00280	103	95	82
COOL1-	COOL1C	1	0.00000	0.00010	0.00000	0	0	0
COOL1-	LIMA1-	1	0.03850	0.10110	0.00980	103	95	82
COOL1-	LSMR1A	1	0.01175	0.03028	0.00307	103	95	82
COOL1-	LSMR1B	1	0.01175	0.03028	0.00307	103	95	82
COOL1-	STRA1-	1	0.01800	0.05170	0.01690	166	158	144
COOL1-	STRA1-	2	0.01820	0.07860	0.00840	166	158	144
COOL6P	COOL7P	1	0.00000	0.00010	0.00000	0	0	0
COOL6Q	COOL7Q	1	0.00000	0.00010	0.00000	0	0	0
CREA1-	CREC1A	1	0.00023	0.00088	0.00614	144	144	144
CREA1-	CREC1B	1	0.00023	0.00088	0.00614	144	144	144
CREC1A	KELS1-	1	0.02912	0.07589	0.00751	103	95	82
CREC1B	DUNG1-	1	0.04727	0.12489	0.01733	103	95	82
CREG3A	CREG3B	1	0.00000	0.00010	0.00000	1000	1000	1000
CREG3A	MOUN3-	1	0.00670	0.01190	0.00620	46	46	46
CREG3A	MOUN3-	2	0.00670	0.01190	0.00620	46	46	46
CREG3B	KNCK3-	1	0.02000	0.03000	0.00400	33	30	30
CREG3B	KNCK3-	2	0.02000	0.03000	0.00400	33	30	30
DONE1C	HANA1A	1	0.00170	0.00470	0.14550	158	144	144
DONE1C	WEST1A	1	0.00570	0.00550	0.06320	82	75	75
DONE1B	HANA1A	1	0.00170	0.00470	0.14550	158	144	144
DONE1B	WEST1B	1	0.00560	0.00530	0.06090	82	75	75
DONE1D	FINY1B	1	0.00540	0.01240	0.00120	87	81	70
DONE1A	FINY1A	1	0.00540	0.01240	0.00120	86	80	69
DONE3AS	DONE3BS	1	0.00000	0.00010	0.00000	0	0	0
DONE3N	DONE3BS	1	0.00000	0.00100	0.00000	34.2	34.2	34.2
DONE3N	DONE3BS	2	0.00000	0.00100	0.00000	34.2	34.2	34.2

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
DRUM1-	DUNG1-	1	0.03330	0.08663	0.00860	103	95	82
DRUM1-	DUNG1-	2	0.03670	0.09520	0.00950	103	95	82
DRUM1-	TAND1A	1	0.00460	0.01480	0.00160	113	113	80
DRUM1-	TAND1A	2	0.00460	0.01480	0.00160	113	113	80
DRUM1-	TAND1A	3	0.00550	0.01520	0.00140	119	119	96
DUNG1-	OMAH1-	1	0.04715	0.12473	0.01197	124	119	109
DUNG1-	OMAH1-	2	0.05133	0.13578	0.01303	124	119	109
DUNG1-	TAMN1-	1	0.00387	0.01454	0.00630	166	158	144
DUNM3-	SKEG3-	1	0.01780	0.01200	0.00400	30.8	28	28
DUNM3-	SKEG3-	2	0.01350	0.01270	0.00550	34.4	31.3	31.3
DUNM3-	WEST3A	1	0.02120	0.27190	0.00300	33	33	30
DUNM3-	WEST3B	1	0.02030	0.27090	0.00300	33	33	30
ENNK1_	OMAH1-	1	0.02733	0.11337	0.01148	103	95	82
ENNK1_	OMAH1-	2	0.02733	0.11337	0.01148	103	95	82
FINY1A	HANA1A	1	0.00100	0.00300	0.05067	144	144	144
FINY1B	HANA1A	1	0.00100	0.00300	0.05067	144	144	144
GLEN1A	KELS1-	1	0.02733	0.06840	0.02854	90	82	82
GLEN1B	KELS1-	1	0.02733	0.06840	0.02854	90	82	82
GLEN3A	GLEN3B	1	0.00000	0.00010	0.00000	1000	1000	1000
HANA1A	LISB1A	1	0.01589	0.03781	0.00368	103	95	82
HANA1A	LISB1B	1	0.01291	0.03987	0.00358	100	93	80
HANA2A	MOYL2-	1	0.00200	0.01875	0.11181	881	820	710
HANA6P	HANA7P	1	0.00000	0.00010	0.00000	0	0	0
HANA6Q	HANA7Q	1	0.00000	0.00010	0.00000	0	0	0
KELS2-	KILR2-	1	0.00150	0.01280	0.07690	881	820	710
KELS2-	KILR2-	2	0.00150	0.01280	0.07690	881	820	710
KELS2-	MAGF2-	1	0.00150	0.01350	0.08140	881	820	710
KELS6P	KELS7P	1	0.00000	0.00010	0.00000	0	0	0
KELS6Q	KELS7Q	1	0.00000	0.00010	0.00000	0	0	0
KPS_AUX1	KPS_AUX2	1	0.00010	0.00010	0.00000	0	0	0
KILR2-	TAND2-	1	0.00410	0.03540	0.21490	881	820	710
LISB1A	TAND1A	1	0.03910	0.10850	0.01040	103	95	82
LISB1B	TAND1A	1	0.03370	0.10600	0.00940	100	93	80
MAGF2-	TAND2-	1	0.00260	0.02150	0.13950	881	820	710
MAGF2-	TAMN2-	1	0.00115	0.10700	0.06770	881	820	710
NEWY1A	TAND1A	1	0.03121	0.08040	0.00814	103	95	82
NEWY1B	TAND1A	1	0.03121	0.08040	0.00814	103	95	82
OMAH1-	STRA1-	1	0.04636	0.12265	0.01177	124	119	109
OMAH1-	STRA1-	2	0.04715	0.12469	0.01197	124	119	109
SKEG3-	WEST3A	1	0.02600	0.26760	0.00300	33	33	30
SKEG3-	WEST3B	1	0.01820	0.26880	0.00300	33	33	30
TAND1A	TAND1B	1	0.00000	0.00010	0.00000	1000	1000	1000
TAND1B	WARN1A	1	0.01280	0.04180	0.00440	113	96	80

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
TAND1B	WARN1B	1	0.01280	0.04180	0.00440	113	96	80
TAND2-	TAMN2-	1	0.00116	0.01089	0.06850	881	820	710
TAND6P	TAND7P	1	0.00000	0.00010	0.00000	0	0	0
TAND6Q	TAND7Q	1	0.00000	0.00010	0.00000	0	0	0
TAND6R	TAND7R	1	0.00000	0.00010	0.00000	0	0	0
TAMN6P	TAMN7P	1	0.00000	0.00010	0.00000	0	0	0
WEST3A	WEST3B	1	0.00400	0.21260	0.00000	38	38	38

TABLE A.3: BRANCH DATA CHANGES

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
WINTER 2009/10 CIRCUITS ADDED								
COOL1-	SPRN1A-	1	0.01072	0.02872	0.01210	103	103	103
COOL1-	SPRN1B-	1	0.01072	0.02872	0.01210	103	103	103
SUMMER 2010 CIRCUITS ADDED								
COOL1-	SKIRK_T	1	0.00910	0.03930	0.00420	166	158	144
SKIRK1	SKIRK_T	1	0.00784	0.02004	0.00206	103	95	82
SKIRK_T	STRA1-	1	0.00910	0.03930	0.00420	166	158	144
SUMMER 2010 CIRCUITS DELETED								
COOL1-	STRA1-	2	0.01820	0.07860	0.00840	166	158	144
WINTER 2010/11 CIRCUITS ADDED								
BFNM1A	DONE1C	1	0.00570	0.00550	0.06320	75	75	75
BFNM1B	DONE1B	1	0.00560	0.00530	0.06090	75	75	75
BFNM3-	CENT3-	1	0.01300	0.01699	0.00400	30	30	30
BFNM3-	CENT3-	2	0.01245	0.01627	0.00400	30	30	30
BFNM3-	CENT3-	3	0.01925	0.01296	0.00400	30	30	30
BFNM3-	CENT3-	4	0.01171	0.01530	0.00400	30	30	30
BFNM3-	DUNM3-	1	0.02120	0.02190	0.00300	33	33	33
BFNM3-	DUNM3-	2	0.02030	0.02090	0.00300	33	33	33
BFNM3-	SKEG3-	1	0.02600	0.01760	0.00300	33	33	33
BFNM3-	SKEG3-	2	0.01820	0.01880	0.00300	33	33	33
WINTER 2010/11 CIRCUITS DELETED								
CENT3-	WEST3A	1	0.01300	0.26699	0.00400	30	30	30
CENT3-	WEST3A	2	0.01245	0.26627	0.00400	30	30	30
CENT3-	WEST3B	1	0.01925	0.26296	0.00400	30	30	30
CENT3-	WEST3B	2	0.01171	0.26530	0.00400	30	30	30
DONE1C	WEST1A	1	0.00570	0.00550	0.06320	75	75	75
DONE1B	WEST1B	1	0.00560	0.00530	0.06090	75	75	75
DUNM3-	WEST3A	1	0.02120	0.27190	0.00300	33	33	30
DUNM3-	WEST3B	1	0.02030	0.27090	0.00300	33	33	30
SKEG3-	WEST3A	1	0.02600	0.26760	0.00300	33	33	30
SKEG3-	WEST3B	1	0.01820	0.26880	0.00300	33	33	30
WEST3A	WEST3B	1	0.00400	0.21260	0.00000	38	38	38
WINTER 2011/12 CIRCUITS ADDED								
CAST6S	CAST7S	1	0.00000	0.00010	0.00000	0	0	0
COLE1-	KELS1-	2	0.07010	0.20080	0.01980	210	200	190
CREC1B	TAMN1-	1	0.04727	0.12489	0.01733	103	95	82
DRUM1-	TAMN1-	1	0.02683	0.07203	0.01671	210	200	190
DRUM1-	TAMN1-	2	0.02654	0.07122	0.01751	210	200	190
DUNG1-	TAMN1-	2	0.00387	0.01454	0.00630	166	158	144
OMAH1-	TAMN1-	1	0.05603	0.14822	0.01422	210	200	190
OMAH1-	TAMN1-	2	0.05603	0.14822	0.01422	210	200	190

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
WINTER 2011/12 CIRCUITS ADDED								
OMAH1-	TAMN1-	3	0.05603	0.14822	0.01422	210	200	190
WINTER 2011/12 CIRCUITS DELETED								
CREC1B	DUNG1-	1	0.04727	0.12489	0.01733	103	95	82
DRUM1-	DUNG1-	1	0.03700	0.08600	0.00880	103	95	82
DRUM1-	DUNG1-	2	0.04080	0.09450	0.00970	103	95	82
DUNG1-	OMAH1-	1	0.05218	0.12421	0.01186	124	119	109
DUNG1-	OMAH1-	2	0.05832	0.13881	0.01325	124	119	109
WINTER 2012/13 CIRCUITS ADDED								
MIDCAVAN	TURLE4	1	0.00160	0.01830	0.41390	1713	1566	1424
MAGF2-	TURLE2	1	0.00174	0.01441	0.09347	881	820	710
TAND2-	TURLE2	1	0.00429	0.00355	0.02302	881	820	710
TAND2-	TURLE2	2	0.00086	0.00710	0.04604	881	820	710
TAMN2-	TURLE2	1	0.00871	0.00720	0.04673	881	820	710
WINTER 2012/13 CIRCUITS DELETED								
MAGF2-	TAND2-	1	0.00260	0.02150	0.13950	881	820	710
TAND2-	TAMN2-	1	0.01300	0.01075	0.06975	881	820	710

TABLE A.4: TRANSFORMER DATA

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NUMBER OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
LOUTH	220	LOUTH5 A	275	1	0.00000	0.03030	300	1.15700	0.85040	23
LOUTH	220	LOUTH5 A	275	2	0.00000	0.03030	300	1.15700	0.85040	23
LOUTH	220	LOUTH5 B	275	3	0.00000	0.01515	600	1.15700	0.85040	23
AGHY1-	110	AGHY3-	33	1	0.00372	0.24190	90	1.10000	0.80000	19
ANTR1A	110	ANTR3-	33	1	0.02680	0.44400	22.5	1.10000	0.90000	15
ANTR1A	110	ANTR3-	33	2	0.02680	0.44400	22.5	1.10000	0.90000	15
ANTR1B	110	ANTR3-	33	1	0.02680	0.44400	22.5	1.10000	0.90000	15
ANTR1B	110	ANTR3-	33	2	0.02680	0.44400	22.5	1.10000	0.90000	15
BAFDG4	15	BAFD2-	275	1	0.00120	0.07290	240	1.24800	1.02110	15
BAFDG5	15	BAFD2-	275	1	0.00120	0.07290	240	1.24800	1.02110	15
BAFDG6	15	BAFD2-	275	1	0.00120	0.07290	240	1.24800	1.02110	15
BAFDG7	11	BAFD1-	110	1	0.00680	0.20000	75	1.20000	0.98180	15
BAFDG8	11	BAFD1-	110	1	0.00680	0.20000	75	1.20000	0.98180	15
BAFD1-	110	BAFD_GD	15	1	0.00370	0.13259	135	1.17500	0.87500	25
BAFD_GA	15	BAFD2-	275	1	0.00230	0.08157	217	1.17090	0.86550	25
BAFD_GB	15	BAFD2-	275	1	0.00230	0.08157	217	1.17090	0.86550	25
BAFD_GC	18	BAFD2-	275	1	0.00200	0.07120	250	1.17090	0.86550	25
BAME1A	110	BAME3R	33	1	0.01320	0.23840	45	1.10000	0.80000	19
BAME1A	110	BAME3T	33	1	0.01160	0.27800	45	1.10000	0.80000	19
BAME1B	110	BAME3R	33	1	0.01320	0.23840	45	1.10000	0.80000	19
BAME1B	110	BAME3T	33	1	0.01160	0.27800	45	1.10000	0.80000	19
BANB1A	110	BANB3-	33	1	0.01680	0.41020	30	1.10000	0.90000	15
BANB1A	110	BANB3-	33	2	0.01680	0.41020	30	1.10000	0.90000	15
BANB1B	110	BANB3-	33	1	0.01680	0.41020	30	1.10000	0.90000	15
BANB1B	110	BANB3-	33	2	0.01680	0.41020	30	1.10000	0.90000	15
BNCH1A	110	BNCH3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
BNCH1B	110	BNCH3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
CARN1A	110	CARN3-	33	1	0.01110	0.28540	60	1.15000	0.85000	19
CARN1B	110	CARN3-	33	1	0.03060	0.59560	30	1.15000	0.85000	19
CARN1B	110	CARN3-	33	2	0.03060	0.59560	30	1.15000	0.85000	19
CENT1A	110	CENT3-	33	1	0.00600	0.24240	90	1.15000	0.85000	19
CENT1B	110	CENT3-	33	1	0.00600	0.24240	90	1.15000	0.85000	19
COLE1-	110	COLE3-	33	1	0.00740	0.25000	60	1.10000	0.80000	19
COLE1-	110	COLE3-	33	2	0.00740	0.25000	60	1.10000	0.80000	19
COOLG8-	11	COOL1-	110	1	0.00680	0.20000	75	1.20000	0.98180	15
COOL1-	110	COOLST-	12	1	0.00260	0.06340	200	1.20000	0.98180	15
COOL1-	110	COOL3-	33	1	0.00860	0.25560	90	1.10000	0.80000	19
COOL1-	110	COOL3-	33	2	0.00860	0.25560	90	1.10000	0.80000	19
COOLGT-	16	COOL2-	275	1	0.00150	0.04320	300	1.18700	0.97100	15

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NUMBER OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
CREA1-	110	CREA3-	33	1	0.01100	0.27400	60	1.10000	0.80000	19
CREA1-	110	CREA3-	33	2	0.01100	0.27400	60	1.10000	0.80000	19
CREG1A	110	CREG3A	33	1	0.01180	0.32000	75	1.15000	0.85000	19
CREG1B	110	CREG3A	33	1	0.01180	0.32000	75	1.15000	0.85000	19
DONE1C	110	DONE3N	33	1	0.00600	0.24240	90	1.15000	0.85000	19
DONE1B	110	DONE3N	33	1	0.02100	0.36700	60	1.15000	0.85000	19
DONE1D	110	DONE3AS	33	1	0.02100	0.36700	60	1.15000	0.85000	19
DONE1A	110	DONE3AS	33	1	0.02100	0.36700	60	1.15000	0.85000	19
DRUM1-	110	DRUM3-	33	1	0.00600	0.24240	90	1.10000	0.80000	19
DRUM1-	110	DRUM3-	33	2	0.00600	0.24240	90	1.10000	0.80000	19
DUNG1-	110	DUNG3-	33	1	0.00860	0.25820	90	1.10000	0.80000	19
DUNG1-	110	DUNG3-	33	2	0.00860	0.25820	90	1.10000	0.80000	19
EDEN1A	110	EDEN3-	33	1	0.01100	0.27400	45	1.10000	0.80000	19
EDEN1B	110	EDEN3-	33	1	0.01100	0.27400	45	1.10000	0.80000	19
ENNK1_	110	ENNKPFA	110	1	0.00197	0.02130	125	45.0000	-45.000	9999
ENNK1_	110	ENNK3-	33	1	0.01200	0.26600	45	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	2	0.01200	0.26600	45	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	3	0.00740	0.25000	60	1.10000	0.80000	19
ENNKPFA	110	ENNKPFB	110	1	0.00000	0.02130	125	1.22670	0.77390	35
FINY1A	110	FINY3-	33	1	0.00760	0.25330	45	1.10000	0.80000	19
FINY1B	110	FINY3-	33	1	0.00760	0.25330	45	1.10000	0.80000	19
GLEN1A	110	GLEN3A	33	1	0.01110	0.33800	60	1.15000	0.85000	19
KILRG1-	17	KPS_AUX1	11	1	0.01508	0.34728	40	1.01340	0.82915	17
KILRG1-	17	KILR2-	275	1	0.00070	0.04880	1000	1.22400	0.89020	19
KILRG2-	17	KPS_AUX2	11	1	0.01508	0.35287	40	1.01340	0.82915	17
KILRG2-	17	KILR2-	275	1	0.00070	0.04880	340	1.22400	0.89020	19
KNCK1A	110	KNCK3-	33	1	0.01200	0.33700	60	1.15000	0.85000	19
KNCK1B	110	KNCK3-	33	1	0.01200	0.33700	60	1.15000	0.85000	19
LARN1A	110	LARN3-	33	1	0.01160	0.27800	45	1.10000	0.90000	15
LARN1B	110	LARN3-	33	1	0.01160	0.27800	45	1.10000	0.90000	15
LIMA1-	110	LIMA3-	33	1	0.01240	0.27780	45	1.50000	0.51000	15
LIMA1-	110	LIMA3-	33	2	0.01240	0.27780	45	1.50000	0.51000	15
LISB1A	110	LISB3-	33	1	0.00860	0.25500	90	1.10000	0.80000	19
LISB1B	110	LISB3-	33	1	0.00860	0.25500	90	1.10000	0.80000	19
LSMR1A	110	LSMR3-	33	1	0.00760	0.25330	45	1.10000	0.80000	19
LSMR1B	110	LSMR3-	33	1	0.00760	0.25330	45	1.10000	0.80000	19
LOGE1A	110	LOGE3-	33	1	0.01260	0.28000	45	1.10000	0.80000	19
LOGE1B	110	LOGE3-	33	1	0.01260	0.28000	45	1.10000	0.80000	19
NARD1A	110	NARD3-	33	1	0.01000	0.25000	60	1.10000	0.80000	19
NARD1B	110	NARD3-	33	1	0.01000	0.25000	60	1.10000	0.80000	19
NEWY1A	110	NEWY3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
NEWY1B	110	NEWY3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NUMBER OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
OMAH1-	110	OMAH3-	33	1	0.00740	0.25000	60	1.10000	0.80000	19
OMAH1-	110	OMAH3-	33	2	0.00740	0.25000	60	1.10000	0.80000	19
RATH1A	110	RATH3-	33	1	0.00860	0.25540	90	1.10000	0.80000	19
RATH1B	110	RATH3-	33	1	0.00860	0.25540	90	1.10000	0.80000	19
ROSE1A	110	ROSE3-	33	1	0.00860	0.25540	90	1.10000	0.80000	19
ROSE1B	110	ROSE3-	33	1	0.00860	0.25540	90	1.10000	0.80000	19
STRA1-	110	STRPFCA	110	1	0.00197	0.02130	125	45.0000	-45.000	9999
STRA1-	110	STRA3-	33	1	0.00780	0.25000	45	1.10000	0.80000	19
STRA1-	110	STRA3-	33	2	0.00780	0.25000	45	1.10000	0.80000	19
STRPFCA	110	STRPFCB	110	1	0.00000	0.02130	125	1.22670	0.77390	35
WARN1A	110	WARN3-	33	1	0.01200	0.30000	45	1.10000	0.80000	19
WARN1B	110	WARN3-	33	1	0.01200	0.30000	45	1.10000	0.80000	19
WEST1A	110	WEST3A	33	1	0.00740	0.16700	75	1.15000	0.85000	19
WEST1B	110	WEST3B	33	1	0.00740	0.16700	75	1.15000	0.85000	19

TABLE A.5: TRANSFORMER DATA CHANGES

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NUMBER OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
SUMMER 2009 TRANSFORMERS ADDED										
KOCGT1	17	KILR2-	275	1	0.00680	0.20000	40	1.20000	0.98120	15
KOCGT2	17	KILR2-	275	1	0.00680	0.20000	40	1.20000	0.98120	15
WINTER 2009/10 TRANSFORMERS ADDED										
SPRN1A-	110	SPRN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
SPRN1B-	110	SPRN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WINTER 2009/10 TRANSFORMERS REPLACED										
BAME1A	110	BAME3R	33	1	0.00377	0.24190	90	1.10000	0.80000	19
BAME1B	110	BAME3R	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WARN1A	110	WARN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WARN1B	110	WARN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
AUTUMN 2010 TRANSFORMERS ADDED										
BFNM1A	110	BFNM3-	33	1	0.00740	0.16700	75	1.15000	0.85000	19
BFNM1B	110	BFNM3-	33	1	0.00740	0.16700	75	1.15000	0.85000	19
AUTUMN 2010 TRANSFORMERS DELETED										
WEST1A	110	WEST3A	33	1	0.00740	0.16700	75	1.15000	0.85000	19
WEST1B	110	WEST3B	33	1	0.00740	0.16700	75	1.15000	0.85000	19
ANTR1A	110	ANTR3-	33	2	0.02680	0.44400	22.5	1.10000	0.90000	15
ANTR1B	110	ANTR3-	33	2	0.02680	0.44400	22.5	1.10000	0.90000	15
AUTUMN 2010 TRANSFORMERS REPLACED										
ANTR1A	110	ANTR3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
ANTR1B	110	ANTR3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WINTER 2011/12 TRANSFORMERS ADDED										
CARN1A	110	CARN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
CARN1B	110	CARN3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WINTER 2011/12 TRANSFORMERS DELETED										
CARN1A	110	CARN3-	33	1	0.01110	0.28540	60	1.15000	0.85000	19
CARN1B	110	CARN3-	33	1	0.03060	0.59560	30	1.15000	0.85000	19
CARN1B	110	CARN3-	33	2	0.03060	0.59560	30	1.15000	0.85000	19
WINTER 2011/12 TRANSFORMERS REPLACED										
KNCK1A	110	KNCK3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
KNCK1B	110	KNCK3-	33	1	0.00377	0.24190	90	1.10000	0.80000	19
WINTER 2012/13 TRANSFORMERS ADDED										
KCCGT1	17	KILR2-	275	1	0.00070	0.04880	450	1.22400	0.89020	19
WINTER 2012/13 TRANSFORMERS REPLACED										
DONE1A	110	DONE3AS	33	1	0.00377	0.24190	90	1.10000	0.80000	19

TABLE A.6: 275/110kV INTERBUS TRANSFORMER DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100 MVA BASE						RATING IN MVA			OFF NOMINAL RATIO (PU)		NO. OF TAP
			W1-2		W2-3		W3-1							
			R	X	R	X	R	X	W1	W2	W3	UPPER	LOWER	
BAFD1-	BAFD2-	1	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
BAFD1-	BAFD2-	2	0.0018	0.0641	0.0018	0.2059	0.0000	0.1280	240	240	30	1.15	0.85	19
CAST1A	CAST2-	1	0.0014	0.0525	0.0014	0.1900	0.0000	0.1274	240	240	30	1.15	0.85	19
CAST1A	CAST2-	2	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
CAST1B	CAST2-	3	0.0018	0.0656	0.0018	0.2375	0.0000	0.1593	240	240	30	1.15	0.85	19
COOL1-	COOL2-	1	0.0018	0.0609	0.0018	0.1273	0.0000	0.0570	240	240	30	1.15	0.85	19
COOL1-	COOL2-	2	0.0018	0.0609	0.0018	0.1273	0.0000	0.0570	240	240	30	1.15	0.85	19
HANA1A	HANA2A	1	0.0018	0.0591	0.0018	0.1261	0.0000	0.0560	240	240	30	1.15	0.85	19
HANA1A	HANA2A	2	0.0018	0.0591	0.0018	0.1261	0.0000	0.0560	240	240	30	1.15	0.85	19
KELS1-	KELS2-	1	0.0018	0.0609	0.0018	0.1273	0.0000	0.0570	240	240	30	1.15	0.85	19
KELS1-	KELS2-	2	0.0018	0.0607	0.0018	0.1317	0.0000	0.0570	240	240	30	1.15	0.85	19
TAMN1-	TAMN2-	1	0.0018	0.0656	0.0018	0.2375	0.0000	0.1593	240	240	60	1.10	0.90	19
TAND1A	TAND2-	1	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
TAND1A	TAND2-	2	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
TAND1B	TAND2-	3	0.0018	0.0656	0.0018	0.2375	0.0000	0.1575	240	240	30	1.15	0.85	19

TABLE A.7: 275/110kV INTERBUS TRANSFORMER DATA CHANGES

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100 MVA BASE						RATING IN MVA			OFF NOMINAL RATIO (PU)		NO. OF TAP
			W1-2		W2-3		W3-1							
			R	X	R	X	R	X	W1	W2	W3	UPPER	LOWER	
WINTER 2009/10 INTERBUS TRANSFORMERS REPLACED														
CAST1A	CAST2-	1	0.0014	0.0525	0.0014	0.1900	0.0000	0.1274	240	240	60	1.15	0.85	19
WINTER 2010/11 INTERBUS TRANSFORMERS ADDED														
HANA1A	HANA2A	3	0.0014	0.0525	0.0014	0.1900	0.0000	0.1274	240	240	60	1.15	0.85	19
WINTER 2011/12 INTERBUS TRANSFORMERS ADDED														
CAST1B	CAST2-	4	0.0018	0.0656	0.0018	0.2375	0.0000	0.1593	240	240	60	1.15	0.85	19
TAMN1-	TAMN2-	2	0.0018	0.0656	0.0018	0.2375	0.0000	0.1593	240	240	60	1.10	0.90	19
WINTER 2012/13 INTERBUS TRANSFORMERS REPLACED														
HANA1A	HANA2A	1	0.0014	0.0525	0.0014	0.1900	0.0000	0.1274	240	240	60	1.15	0.85	19
HANA1A	HANA2A	2	0.0014	0.0525	0.0014	0.1900	0.0000	0.1274	240	240	60	1.15	0.85	19

TABLE A.8: 275/400kV INTERBUS TRANSFORMER DATA CHANGES

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100 MVA BASE						RATING IN MVA			OFF NOMINAL RATIO (PU)		NO. OF TAP
			W1-2		W2-3		W3-1							
			R	X	R	X	R	X	W1	W2	W3	UPPER	LOWER	
WINTER 2012/13 INTERBUS TRANSFORMERS ADDED														
TURLE2	TURLE4	1	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	500	500	60	1.1	0.9	23
TURLE2	TURLE4	2	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	500	500	60	1.1	0.9	23
TURLE2	TURLE4	3	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	500	500	60	1.1	0.9	23

TABLE A.9: CAPACITANCE DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	LOAD (MVAr)
74571	CAST7P	CASTLEREAGH	22	25
74572	CAST7Q	CASTLEREAGH	22	25
74573	CAST7R	CASTLEREAGH	22	25
75011	COLE1C	COLERAINE	110	48
75514	COOL1C	COOLKEERAGH	110	40
79030	ENNK3-	ENNISKILLEN	30	24
86220	MOYLE2-	MOYLE	275	236
90071	TAND7P	TANDRAGEE	22	25
90073	TAND7R	TANDRAGEE	22	25

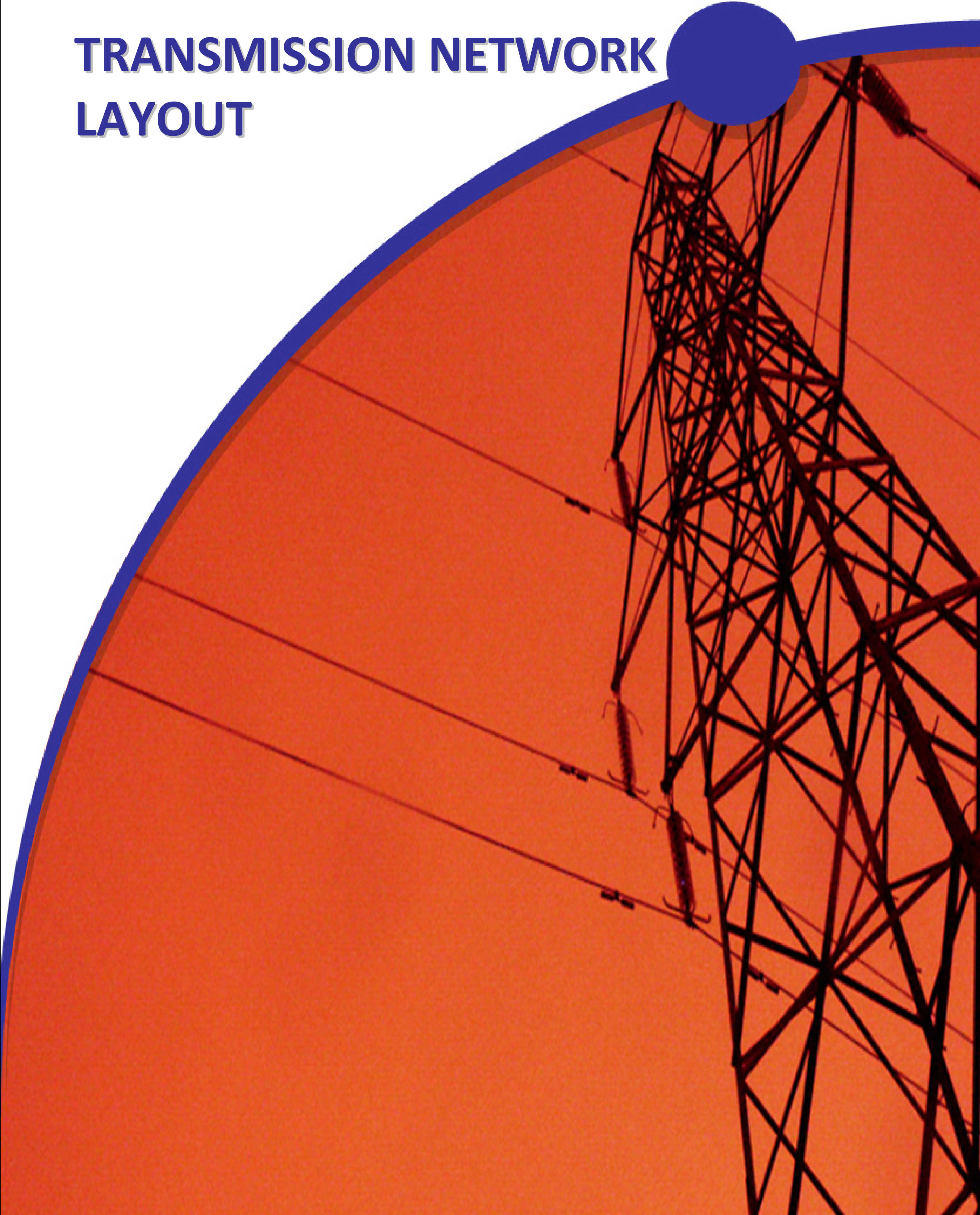
Capacitance is switched in as necessary at all nodes, except at Moyle, where it varies with the transfer on the interconnector, and is switched in, in blocks of 59MVAr, giving a total capacitance between 0 and 236MVAr.

TABLE A.10: REACTANCE DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	LOAD (MVAr)
74572	CAST7Q	CASTLEREAGH	22	-30
81071	HANA7P	HANNAHSTWON	22	-30
81072	HANA7Q	HANNAHSTOWN	22	-30
81571	KELS7P	KELLS	22	-30
81572	KELS7Q	KELLS	22	-30
90071	TAND7P	TANDRAGEE	22	-30
90072	TAND7Q	TANDRAGEE	22	-30

APPENDIX B

TRANSMISSION NETWORK LAYOUT



APPENDIX B TRANSMISSION NETWORK LAYOUT

The following is a list of figures contained in this section:

Larger versions of the maps are available at the back of the document.

FIGURE B.1: BUSBAR LAYOUT WINTER 2010/11

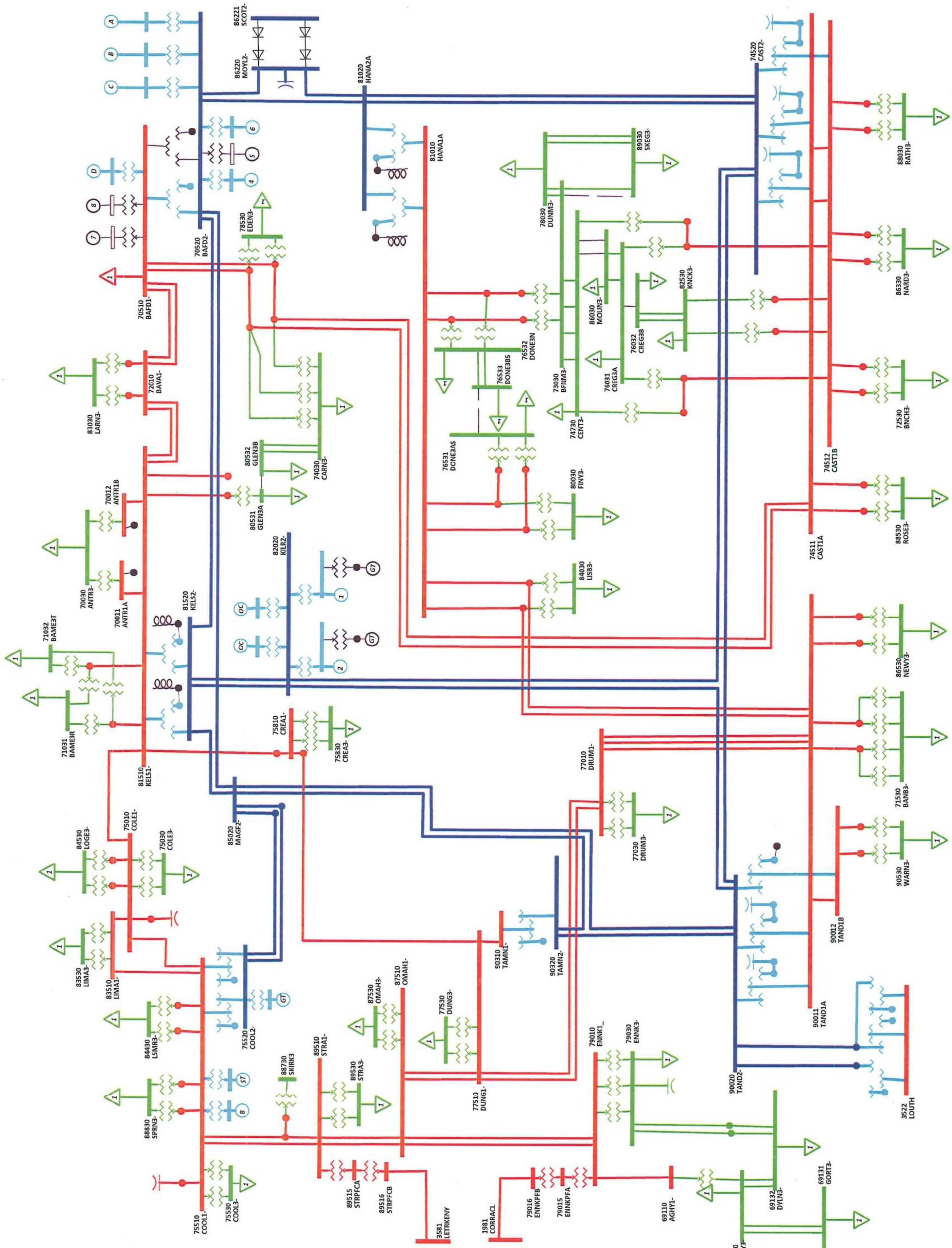
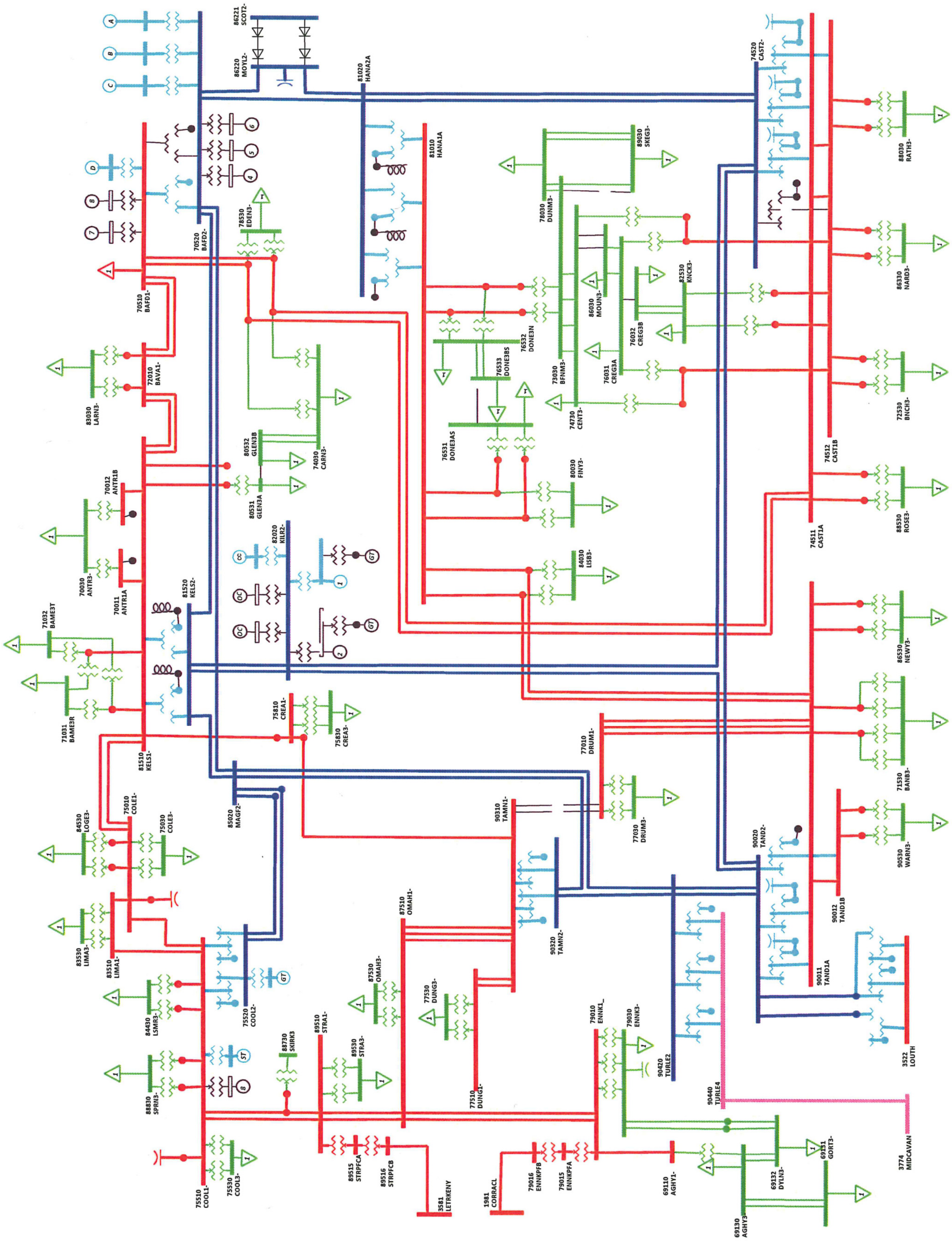
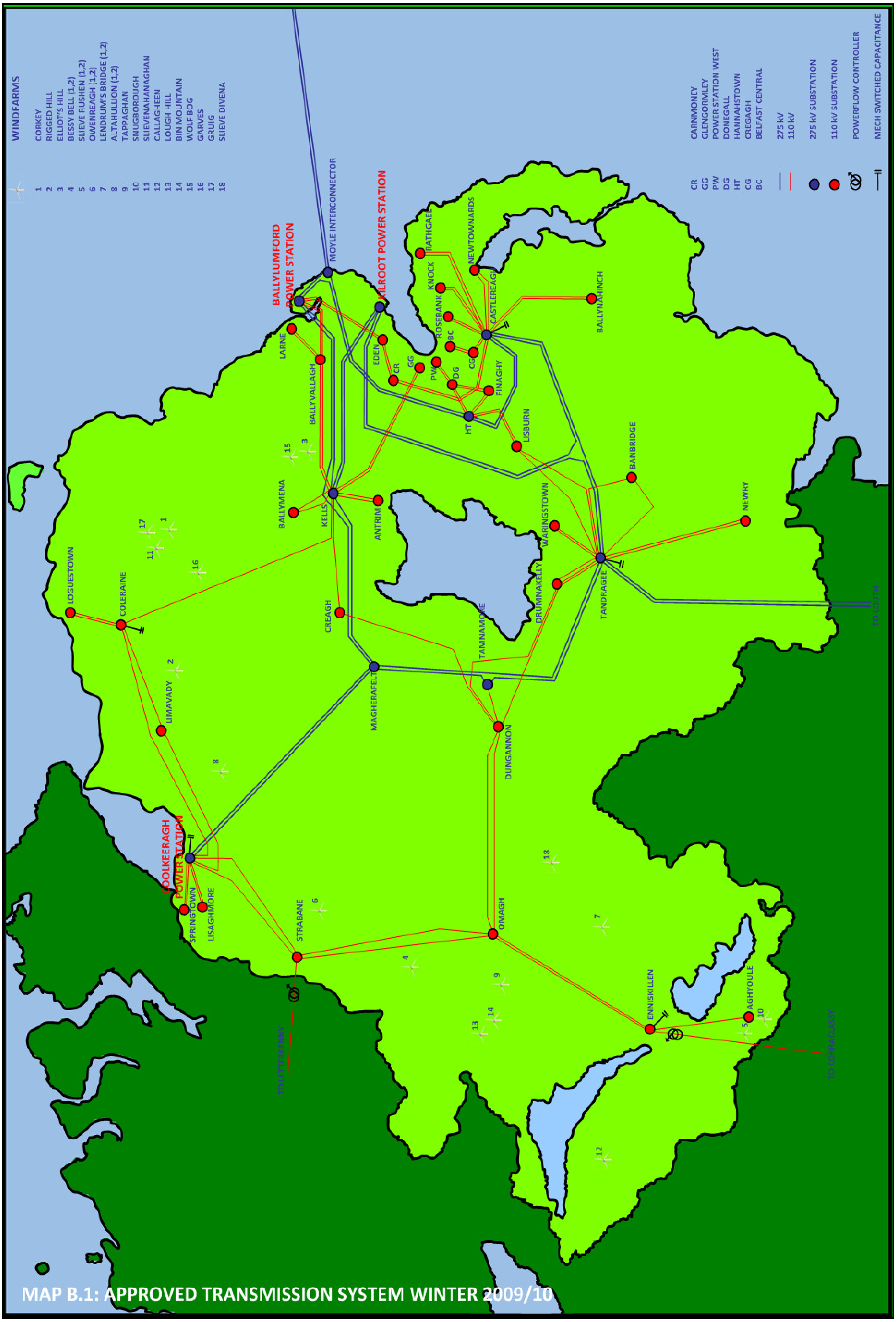
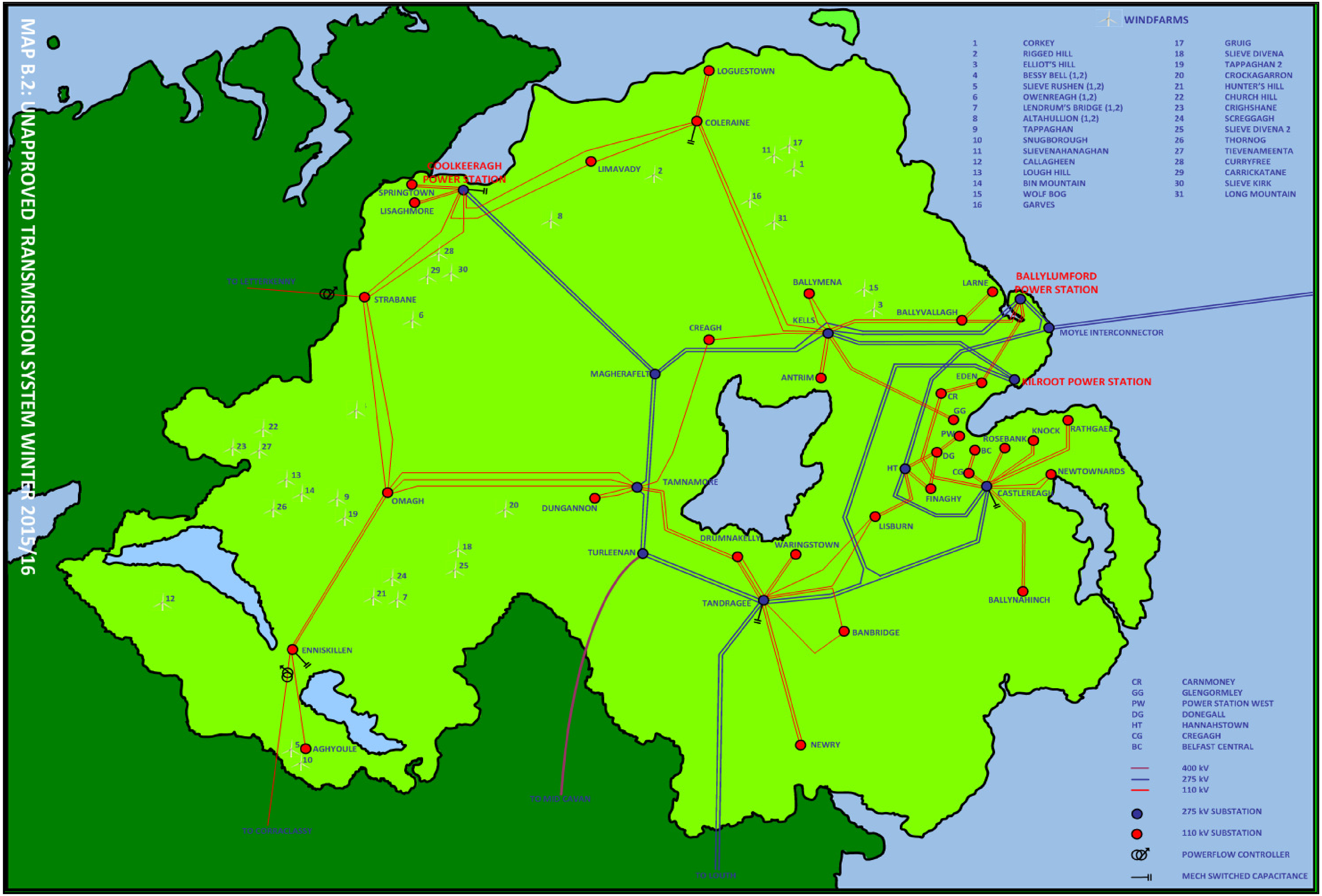


FIGURE B.2: BUSBAR LAYOUT WINTER 2015/16





MAP B.1: APPROVED TRANSMISSION SYSTEM WINTER 2009/10



MAP B.2: UNAPPROVED TRANSMISSION SYSTEM WINTER 2015/16

APPENDIX C

GENERATION DETAILS

APPENDIX C GENERATION DETAILS

The following is a list of tables contained in this section:

TABLE C.1: EXISTING AND PROPOSED GENERATING PLANT CONTRACTED CAPACITIES

CENTRALLY DISPATCHED GENERATING UNIT	FUEL TYPE	GENERATING CAPACITY						
		2009	2010	2011	2012	2013	2014	2015
BALLYLUMFORD ST 4	**GAS**/HFO	170	170	170	170	170	170	170
BALLYLUMFORD ST 5	**GAS**/HFO	170	170	170	170	170		
BALLYLUMFORD ST 6	**GAS**/HFO	170	170	170	170	170		
BALLYLUMFORD CCGT 21	**GAS**/GASOIL	160	160	160	160	160	160	160
BALLYLUMFORD CCGT 22	**GAS**/GASOIL	160	160	160	160	160	160	160
BALLYLUMFORD CCGT 20		170	170	170	170	170	170	170
BALLYLUMFORD CCGT 10	**GAS**/GASOIL	97	97	97	97	97	97	97
BALLYLUMFORD GT 7	GASOIL	58	58	58	58	58	58	58
BALLYLUMFORD GT 8	GASOIL	58	58	58	58	58	58	58
KILROOT ST 1	COAL/**OIL**	238	238	238	238	238	238	238
KILROOT ST 2	COAL/**OIL**	238	238	238	238	238	238	238
KILROOT GT 1	GASOIL	29	29	29	29	29	29	29
KILROOT GT 2	GASOIL	29	29	29	29	29	29	29
KILROOT GT 3	GASOIL	40	40	40	40	40	40	40
KILROOT GT 4	GASOIL	40	40	40	40	40	40	40
KILROOT CCGT	**GAS**/GASOIL					440	440	440
COOLKEERAGH GT8	GASOIL	53	53	53	53	53	53	53
COOLKEERAGH CCGT	**GAS**/GASOIL	402	402	402	402	402	402	402
MOYLE	DC LINK	450	450	450	450	450	450	450
TOTAL		2732	2732	2732	2732	3172	2832	2832

NOTE 1: Where dual fuel capability exists, the fuel type highlighted in **red** is utilised to meet peak demand.

TABLE C.2: EXISTING AND PROPOSED GENERATING PLANT CONTRACT DETAILS

CENTRALLY DISPATCHED GENERATING UNIT	FUEL TYPE	CONTRACT	
		TYPE	DETAILS
BALLYLUMFORD ST 4	GAS/HFO	NIE	CONTRACTED UNTIL 31/03/2012
BALLYLUMFORD ST 5	GAS/HFO	IPP	SEE NOTE 1
BALLYLUMFORD ST 6	GAS/HFO	IPP	SEE NOTE 1
BALLYLUMFORD CCGT 21	GAS/GASOIL	NIE	CONTRACTED UNTIL 31/03/2012
BALLYLUMFORD CCGT 22	GAS/GASOIL	NIE	CONTRACTED UNTIL 31/03/2012
BALLYLUMFORD CCGT 20		NIE	CONTRACTED UNTIL 31/03/2012
BALLYLUMFORD CCGT 10	GAS/GASOIL	NIE	CONTRACTED UNTIL 31/03/2012
BALLYLUMFORD GT 7	GASOIL	NIE	CONTRACTED UNTIL 31/03/2020
BALLYLUMFORD GT 8	GASOIL	NIE	CONTRACTED UNTIL 31/03/2020
KILROOT ST 1	COAL/OIL	NIE	CONTRACTED UNTIL 31/03/2024
KILROOT ST 2	COAL/OIL	NIE	CONTRACTED UNTIL 31/03/2024
KILROOT GT 1	GASOIL	NIE	CONTRACTED UNTIL 31/03/2024
KILROOT GT 2	GASOIL	NIE	CONTRACTED UNTIL 31/03/2024
KILROOT GT 3	GASOIL	IPP	COMMENCE OPERATION 01/03/2009
KILROOT GT 4	GASOIL	IPP	COMMENCE OPERATION 01/03/2009
KILROOT CCGT	GAS/GASOIL	IPP	SEE NOTE 2
COOLKEERAGH GT8	GASOIL	NIE	CONTRACTED UNTIL 31/03/2018
COOLKEERAGH CCGT	GAS/GASOIL	IPP	SEE NOTE 3
MOYLE	DC LINK		SEE NOTE 4

NOTE 1: Due to EU legislation on emissions, it is assumed that generation will be limited beyond the year 2013.

NOTE 2: This will be an Independent Power Producer (IPP), assumed to be available from the year 2013.

NOTE 3: This is an IPP, which commenced commercial operation in April 2005.

NOTE 4: Capacity is auctioned regularly (monthly and annually) to market participants.

TABLE C.3: NON FOSSIL FUELS OBLIGATIONS CAPACITY

SCHEME NAME	TECHNOLOGY	MAXIMUM CAPACITY (kW)	CONTRACT EXPIRY DATE
RIGGED HILL	WIND	5000	31/03/2009
CORKEY	WIND	5000	31/03/2009
SLIEVE RUSHEN	WIND	5000	31/03/2009
ELLIOT'S HILL	WIND	5000	31/03/2009
BESSEY BELL	WIND	5000	31/03/2009
OWENREAGH	WIND	5000	31/03/2009
HARPERSTOWN	HYDRO	250	31/03/2009
BENBURB	HYDRO	75	31/03/2009
CARRICKNESS	HYDRO	155	31/03/2009
PARK MILLS	HYDRO	30	31/03/2009
RANDALSTOWN	HYDRO	500	31/03/2009
BLACKWATER	HYDRO	100	31/03/2009
SION MILLS	HYDRO	780	31/03/2009
OAKLAND'S WTW	HYDRO	49	31/03/2009
SILENT VALLEY	HYDRO	435	31/03/2009
TOTAL NFFO1		**32374**	
LENDRUM'S BRIDGE	WIND	5280	31/08/2013
SLIEVENAHANAGAN	WIND	1000	14/11/2012
BLACKWATER MUSEUM	BIOMASS	204	30/06/2013
BROOK HALL ESTATE	BIOMASS	100	31/10/2012
BENBURB SMALL HYDRO	HYDRO	75	30/04/2012
TOTAL NFFO2		**6659**	

TABLE C.4: EXISTING AND COMMITTED WIND GENERATION

SCHEME NAME	MAXIMUM CAPACITY (MW)	110kV NODE	COMMISSIONING DATE
RIGGED HILL	5	COLERAINE	
CORKEY	5	BALLYMENA	
SLIEVE RUSHEN	5	AGHYOULE	
ELLIOT'S HILL	5	LARNE	
BESSEY BELL	5	OMAGH	
OWENREAGH	5	STRABANE	
LENDRUM'S BRIDGE	5.94	OMAGH	
LENDRUM'S BRIDGE 2	7.26	OMAGH	
ALTAHULLION	26	LIMAVADY	
TAPPAGHAN	19.5	OMAGH	
SNUGBOROUGH	13.5	AGHYOULE	
SLIEVENAHANAGAN	1	BALLYMENA	
CALLAGHEEN	16.9	ENNISKILLEN	
LOUGH HILL	7.8	STRABANE	
BIN MOUNTAIN	9	STRABANE	
WOLF BOG	10	LARNE	
SLIEVE RUSHEN 2	54	AGHYOULE	
ALTAHULLION 2	11.7	LIMAVADY	
BESSEY BELL 2	9	OMAGH	
OWENREAGH 2	5.5	STRABANE	
GARVES	15	COLERAINE	
GRUIG	25	COLERAINE	
SLIEVE DIVENA	30	OMAGH	SPRING 2009
TAPPAGHAN 2	9	OMAGH	AUTUMN 2009
CROCKAGARRON	18	DUNGANNON	AUTUMN 2009
HUNTER'S HILL	20	OMAGH	AUTUMN 2009
CHURCH HILL	18.4	OMAGH	AUTUMN 2010
CRIGHSHANE	32.2	OMAGH	AUTUMN 2010
SCREGGAGH	18.4	OMAGH	AUTUMN 2010
SLIEVE DIVENA 2	20	DUNGANNON	SUMMER 2010
THORNOG	9.2	OMAGH	AUTUMN 2010
TIEVENAMEENTA	45	OMAGH	AUTUMN 2010
CURRYFREE	15	LISAGHMORE	WINTER 2010
CARRICKATANE	45	SLIEVE KIRK	SPRING 2011
SLIEVE KIRK	27	SLIEVE KIRK	SPRING 2011
LONG MOUNTAIN	24	COLERAINE	AUTUMN 2011

TOTAL	**598.3**

APPENDIX D

DEMAND FORECASTS

APPENDIX D DEMAND FORECASTS

This Appendix presents the demand forecasts for the forthcoming seven years used throughout this Transmission Seven Year Statement (TSYS). The demand forecasts for Winter Maximum, Summer Maximum and Summer Minimum are provided. Also included is a table highlighting the spare capacity at each Bulk Supply Point (BSP).

The following is a list of tables contained in this section:

D.1 NOTES RELATING TO THE TABLES

Tables D.1 and D.2 contain a column headed **notes** which refer to the following notes below:

The factor that determines the firm capacity of the substation is...

1 The normal rating of the transformer, as it is greater than 40 years old.
2 The cyclic rating of the transformer.
3 The 110kV line rating.
4 Substation components.
5 Voltage performance under outage conditions.
6 The 110kV line rating in summer, substation components in winter.

Note 7 references Belfast Central. The firm capacity of this BSP is based upon support from Power Station West, via interconnected 33kV cables.

Note 8 references Glengormley, where the firm capacity of the BSP is based upon the rating of the 33kV cable to Carnmoney.

D.2 SUBSTATIONS WHERE FIRM CAPACITY IS EXCEEDED

In the tables, any instance when a BSP is loaded above its firm capacity is highlighted in **red**. These instances are discussed below.

D.2.1 AGHYOULE

At this BSP, there is a single transformer with a capacity of 90MVA. However, the substation has a firm capacity of 26MVA due to 33kV distribution system limitations, and hence this BSP is now shown as overloaded in the demand forecast. However, the current recession conditions have meant that a significant part of the industrial load at Aghyoule is not in operation, and so the BSP is currently operating without an overload. At the freeze date, this was not the case, however, so was not factored into the forecast.

D.2.2 ANTRIM

Capacity issues are planned to be managed with the installation of new transformers. As detailed in **Section 3.5.4**, the existing transformers at Antrim are due to be replaced with two new 90MVA transformers by Autumn 2010.

D.2.3 BALLYMENA RURAL

The overload is presently managed by a load transfer scheme, however, capacity issues are planned to be managed by 2010. As shown in **Section 3.5.4**, the transformers at Ballymena Rural are due to be replaced with two new 90MVA transformers.

D.2.4 LIMAVADY

As with Aghyoule, since the time of the demand forecast, a significant amount of industrial load is not in operation, and as such the BSP load is now below the firm capacity rating.

D.2.5 WARINGSTOWN

The demand forecast is based on a 33/11kV substation Carn Central being transferred to Waringstown in 2010. Capacity issues are to be resolved by 2011. Since the firm capacity of the substation is exceeded, the load transfer will not take place until capacity issues have been managed.

D.2.6 KNOCK

The overload is currently managed by a load transfer scheme. Capacity issues are planned to be managed in early RP5.

TABLE D.1: BULK SUPPLY POINT PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

LOCATION	TX (MVA)	SS (MVA)	FORECAST LOADING (MVA)							NOTES
			09/10	10/11	11/12	12/13	13/14	14/15	15/16	
AGHYOULE	90.0	26.0	**29.87**	**29.87**	**30.02**	**30.32**	**30.77**	**31.24**	**31.70**	**5**
ANTRIM	90.0	45.0	**47.74**	**47.74**	**47.98**	**48.46**	**49.18**	**49.92**	**50.67**	**1**
BALLYMENA RURAL	90.0	45.0	**52.87**	**52.87**	**53.13**	**53.66**	**54.46**	**55.29**	**56.11**	**1**
BALLYMENA TOWN	120.0	72.0	55.62	55.62	55.90	56.46	57.29	58.16	59.03	**4**
BALLYNAHINCH	180.0	71.4	63.99	63.99	64.31	64.95	65.91	66.91	67.91	**4**
BANBRIDGE	120.0	71.4	46.83	46.83	47.07	47.54	48.24	48.97	49.70	**4**
COLERAINE	120.0	78.0	55.45	55.45	55.73	56.29	57.12	57.99	58.86	**2**
COOLKEERAGH	180.0	114.0	27.32	27.32	27.45	27.73	28.14	28.57	28.99	**4**
CREAGH	120.0	78.0	28.32	28.32	28.46	28.75	29.17	29.62	30.06	**2**
DRUMNAKELLY	180.0	111.0	103.22	103.22	103.74	104.77	106.33	107.94	109.55	**4**
DUNGANNON	180.0	117.0	**119.35**	**119.35**	**119.95**	**121.14**	**122.94**	**124.81**	**126.67**	**4**
EDEN	90.0	37.4	34.44	34.44	34.61	34.96	35.48	36.01	36.55	**4**
ENNISKILLEN	150.0	73.0	59.18	59.18	59.48	60.07	60.97	61.89	62.81	**4**
FINAGHY	90.0	58.5	41.08	41.08	41.28	41.70	42.32	42.96	43.60	**2**
LARNE	90.0	55.3	44.73	44.73	44.95	45.40	46.08	46.77	47.47	**4**
LIMAVADY	90.0	40.3	**46.03**	**46.03**	**46.26**	**46.73**	**47.42**	**48.14**	**48.86**	**4**
LISAGHMORE	90.0	58.5	34.85	34.85	35.03	35.38	35.90	36.45	36.99	**2**
LISBURN	180.0	90.0	**91.59**	**91.59**	**92.05**	**92.97**	**94.35**	**95.78**	**97.21**	**1**
LOGUESTOWN	90.0	55.3	41.57	41.57	41.78	42.20	42.82	43.47	44.12	**4**
NEWTOWNARDS	120.0	78.0	47.00	47.00	47.24	47.71	48.42	49.15	49.89	**2**
NEWRY	180.0	103.0	94.18	94.18	94.65	95.60	97.02	98.49	99.96	**3**
OMAGH	120.0	78.0	44.45	44.45	44.67	45.12	45.79	46.48	47.17	**2**
RATHGAEL	180.0	103.0	71.31	71.31	71.67	72.39	73.46	74.57	75.69	**3**
ROSEBANK	180.0	111.0	38.45	38.45	38.65	39.03	39.61	40.21	40.81	**4**
SPRINGTOWN	180.0	91.0	62.48	62.48	62.79	63.42	64.36	65.33	66.31	**6**
STRABANE	90.0	33.8	**37.93**	**37.93**	**38.12**	**38.50**	**39.07**	**39.66**	**40.26**	**4**
WARINGSTOWN	90.0	65.0	**86.23**	**86.23**	**86.67**	**87.53**	**88.83**	**90.18**	**91.52**	**4**
BELFAST CENTRAL	180.0	90.0	73.69	73.69	74.06	74.80	75.91	77.06	78.21	**7**
BELFAST PSW	150.0	75.0	63.85	63.85	64.17	64.81	65.77	66.77	67.77	**1**
CARNMONEY	120.0	60.0	44.99	44.99	45.22	45.67	46.35	47.05	47.75	**1**
GLENGORMLEY	60.0	30.8	20.85	20.85	20.95	21.16	21.48	21.80	22.13	**8**
CREGAGH	150.0	78.9	66.05	66.05	66.38	67.04	68.04	69.07	70.10	**4**
KNOCK	120.0	59.7	**79.02**	**79.02**	**79.42**	**80.21**	**81.40**	**82.63**	**83.87**	**4**
DONEGALL (N)	120.0	73.0	67.89	67.89	68.23	68.91	69.93	70.99	72.05	**4**
DONEGALL (S)	120.0	78.0	59.50	59.50	59.80	60.40	61.29	62.22	63.15	**2**

TABLE D.2: SUBSTATION AVAILABILITY CAPACITY

LOCATION	TX (MVA)	SS (MVA)	FORECAST LOADING (MVA)							NOTES
			09/10	10/11	11/12	12/13	13/14	14/15	15/16	
AGHYOULE	90.0	26.0	**-3.87**	**-3.87**	**-4.02**	**-4.32**	**-4.77**	**-5.24**	**-5.70**	**5**
ANTRIM	90.0	45.0	**-2.74**	**-2.74**	**-2.98**	**-3.46**	**-4.18**	**-4.92**	**-5.67**	**1**
BALLYMENA RURAL	90.0	45.0	**-7.87**	**-7.87**	**-8.13**	**-8.66**	**-9.46**	**-10.29**	**-11.11**	**1**
BALLYMENA TOWN	120.0	72.0	16.38	16.38	16.10	15.54	14.71	13.84	12.97	**4**
BALLYNAHINCH	180.0	71.4	7.41	7.41	7.09	6.45	5.49	4.49	3.49	**4**
BANBRIDGE	120.0	71.4	24.57	24.57	24.33	23.86	23.16	22.43	21.70	**4**
COLERAINE	120.0	78.0	22.55	22.55	22.27	21.71	20.88	20.01	19.14	**2**
COOLKEERAGH	180.0	114.0	86.68	86.68	86.55	86.27	85.86	85.43	85.01	**4**
CREAGH	120.0	78.0	49.68	49.68	49.54	49.25	48.83	48.38	47.94	**2**
DRUMNAKELLY	180.0	111.0	7.78	7.78	7.26	6.23	4.67	3.06	1.45	**4**
DUNGANNON	180.0	117.0	**-2.35**	**-2.35**	**-2.95**	**-4.14**	**-5.94**	**-7.81**	**-9.67**	**4**
EDEN	90.0	37.4	2.96	2.96	2.79	2.44	1.92	1.39	0.85	**4**
ENNISKILLEN	150.0	73.0	13.82	13.82	13.52	12.93	12.03	11.11	10.19	**4**
FINAGHY	90.0	58.5	17.42	17.42	17.22	16.80	16.18	15.54	14.90	**2**
LARNE	90.0	55.3	10.57	10.57	10.35	9.90	9.22	8.53	7.83	**4**
LIMAVADY	90.0	40.3	**-5.73**	**-5.73**	**-5.96**	**-6.43**	**-7.12**	**-7.84**	**-8.56**	**4**
LISAGHMORE	90.0	58.5	23.65	23.65	23.47	23.12	22.60	22.05	21.51	**2**
LISBURN	180.0	90.0	**-1.59**	**-1.59**	**-2.05**	**-2.97**	**-4.35**	**-5.78**	**-7.21**	**1**
LOGUESTOWN	90.0	55.3	13.73	13.73	13.52	13.10	12.48	11.83	11.18	**4**
NEWTOWNARDS	120.0	78.0	31.00	31.00	30.76	30.29	29.58	28.85	28.11	**2**
NEWRY	180.0	103.0	8.82	8.82	8.35	7.40	5.98	4.51	3.04	**3**
OMAGH	120.0	78.0	33.55	33.55	33.33	32.88	32.21	31.52	30.83	**2**
RATHGAEL	180.0	103.0	31.69	31.69	31.33	30.61	29.54	28.43	27.31	**3**
ROSEBANK	180.0	111.0	72.55	72.55	72.35	71.97	71.39	70.79	70.19	**4**
SPRINGTOWN	180.0	91.0	28.52	28.52	28.21	27.58	26.64	25.67	24.69	**6**
STRABANE	90.0	33.8	**-4.13**	**-4.13**	**-4.32**	**-4.70**	**-5.27**	**-5.86**	**-6.46**	**4**
WARINGSTOWN	90.0	65.0	**-21.23**	**-21.23**	**-21.67**	**-22.53**	**-23.83**	**-25.18**	**-26.52**	**4**
BELFAST CENTRAL	180.0	90.0	16.31	16.31	15.94	15.20	14.09	12.94	11.79	**7**
BELFAST PSW	150.0	75.0	11.15	11.15	10.83	10.19	9.23	8.23	7.23	**1**
CARNMONEY	120.0	60.0	15.01	15.01	14.78	14.33	13.65	12.95	12.25	**1**
GLENGORMLEY	60.0	30.8	9.95	9.95	9.85	9.64	9.32	9.00	8.67	**8**
CREGAGH	150.0	78.9	12.85	12.85	12.52	11.86	10.86	9.83	8.80	**4**
KNOCK	120.0	59.7	**-19.32**	**-19.32**	**-19.72**	**-20.51**	**-21.70**	**-22.93**	**-24.17**	**4**
DONEGALL (N)	120.0	73.0	5.11	5.11	4.77	4.09	3.07	2.01	0.95	**4**
DONEGALL (S)	120.0	78.0	18.50	18.50	18.20	17.60	16.71	15.78	14.85	**2**

TABLE D.3: BULK SUPPLY POINT WINTER MAXIMUM DEMAND

LOCATION	POWER FACTOR	FORECAST LOADING (MW)						
		09/10	10/11	11/12	12/13	13/14	14/15	15/16
AGHYOULE	0.952	28.41	28.41	28.55	28.84	29.27	29.71	30.15
ANTRIM	0.918	43.81	43.81	44.03	44.47	45.13	45.82	46.50
BALLYMENA RURAL	0.913	48.28	48.28	48.52	49.01	49.73	50.49	51.24
BALLYMENA TOWN	0.905	50.33	50.33	50.58	51.09	51.84	52.63	53.42
BALLYNAHINCH	0.906	57.95	57.95	58.24	58.82	59.70	60.60	61.51
BANBRIDGE	0.924	43.26	43.26	43.48	43.91	44.56	45.24	45.91
COLERAINE	0.910	50.46	50.46	50.72	51.22	51.98	52.77	53.56
COOLKEERAGH	0.931	25.43	25.43	25.56	25.82	26.20	26.60	26.99
CREAGH	0.929	26.32	26.32	26.45	26.71	27.11	27.52	27.93
DRUMNAKELLY	0.875	90.33	90.33	90.79	91.69	93.05	94.46	95.87
DUNGANNON	0.856	102.15	102.15	102.66	103.68	105.22	106.82	108.41
EDEN	0.924	31.84	31.84	32.00	32.32	32.80	33.29	33.79
ENNISKILLEN	0.927	54.86	54.86	55.14	55.69	56.51	57.37	58.23
FINAGHY	0.920	37.81	37.81	38.00	38.38	38.95	39.54	40.13
LARNE	0.908	40.62	40.62	40.83	41.23	41.85	42.48	43.12
LIMAVADY	0.911	41.94	41.94	42.15	42.57	43.20	43.85	44.51
LISAGHMORE	0.926	32.28	32.28	32.44	32.76	33.25	33.75	34.26
LISBURN	0.881	80.67	80.67	81.08	81.89	83.10	84.36	85.62
LOGUESTOWN	0.918	38.14	38.14	38.34	38.72	39.29	39.89	40.48
NEWTOWNARDS	0.916	43.08	43.08	43.30	43.73	44.38	45.05	45.72
NEWRY	0.883	83.17	83.17	83.59	84.43	85.68	86.98	88.28
OMAGH	0.919	40.84	40.84	41.05	41.46	42.07	42.71	43.35
RATHGAEL	0.896	63.86	63.86	64.18	64.83	65.79	66.78	67.78
ROSEBANK	0.922	35.47	35.47	35.65	36.01	36.54	37.09	37.65
SPRINGTOWN	0.905	56.56	56.56	56.85	57.41	58.27	59.15	60.03
STRABANE	0.922	34.98	34.98	35.16	35.51	36.04	36.58	37.13
WARINGSTOWN	0.888	76.56	76.56	76.95	77.72	78.87	80.06	81.26
BELFAST CENTRAL	0.920	67.80	67.80	68.14	68.82	69.84	70.90	71.96
BELFAST PSW	0.937	58.75	58.75	59.05	59.64	60.52	61.44	62.36
CARNMONEY	0.919	41.33	41.33	41.54	41.95	42.57	43.22	43.86
GLENGORMLEY	0.931	19.83	19.83	19.93	20.13	20.43	20.74	21.05
CREGAGH	0.889	62.82	62.82	63.14	63.77	64.72	65.70	66.68
KNOCK	0.874	69.04	69.04	69.39	70.08	71.12	72.20	73.28
DONEGALL (N)	0.902	61.25	61.25	61.56	62.17	63.09	64.05	65.01
DONEGALL (S)	0.886	52.74	52.74	53.00	53.53	54.33	55.15	55.97

TOTAL	**1793**	**1793**	**1802**	**1820**	**1847**	**1875**	**1903**

TABLE D.4: BULK SUPPLY POINT SUMMER MAXIMUM DEMAND

LOCATION	POWER FACTOR	FORECAST LOADING (MW)						
		2009	2010	2011	2012	2013	2014	2015
AGHYOULE	0.952	28.03	28.03	28.17	28.45	28.87	29.31	29.75
ANTRIM	0.924	37.56	37.56	37.75	38.12	38.69	39.27	39.86
BALLYMENA RURAL	0.918	40.55	40.55	40.75	41.16	41.77	42.40	43.04
BALLYMENA TOWN	0.911	43.68	43.68	43.90	44.34	45.00	45.68	46.36
BALLYNAHINCH	0.917	42.72	42.72	42.94	43.36	44.01	44.67	45.34
BANBRIDGE	0.926	37.08	37.08	37.27	37.64	38.20	38.78	39.36
COLERAINE	0.919	39.38	39.38	39.58	39.97	40.57	41.18	41.80
COOLKEERAGH	0.933	20.75	20.75	20.85	21.06	21.37	21.70	22.02
CREAGH	0.929	22.10	22.10	22.21	22.44	22.77	23.11	23.46
DRUMNAKELLY	0.881	80.52	80.52	80.93	81.73	82.95	84.20	85.46
DUNGANNON	0.863	94.04	94.04	94.51	95.45	96.87	98.34	99.81
EDEN	0.929	23.76	23.76	23.88	24.12	24.48	24.85	25.22
ENNISKILLEN	0.929	46.08	46.08	46.31	46.77	47.47	48.19	48.90
FINAGHY	0.924	31.87	31.87	32.03	32.35	32.83	33.33	33.82
LARNE	0.924	29.56	29.56	29.71	30.00	30.45	30.91	31.37
LIMAVADY	0.921	31.44	31.44	31.59	31.91	32.38	32.87	33.36
LISAGHMORE	0.928	26.45	26.45	26.58	26.85	27.24	27.66	28.07
LISBURN	0.893	64.35	64.35	64.67	65.31	66.28	67.29	68.29
LOGUESTOWN	0.920	33.30	33.30	33.47	33.80	34.30	34.82	35.34
NEWTOWNARDS	0.925	29.85	29.85	30.00	30.30	30.75	31.22	31.68
NEWRY	0.898	64.05	64.05	64.37	65.02	65.98	66.98	67.98
OMAGH	0.922	35.16	35.16	35.34	35.69	36.22	36.77	37.32
RATHGAEL	0.911	46.06	46.06	46.29	46.75	47.45	48.16	48.88
ROSEBANK	0.928	28.21	28.21	28.35	28.64	29.06	29.50	29.94
SPRINGTOWN	0.911	47.51	47.51	47.75	48.23	48.94	49.69	50.43
STRABANE	0.928	27.82	27.82	27.96	28.24	28.66	29.09	29.53
WARINGSTOWN	0.895	67.25	67.25	67.58	68.26	69.27	70.32	71.37
BELFAST CENTRAL	0.930	61.37	61.37	61.67	62.29	63.21	64.17	65.13
BELFAST PSW	0.938	46.78	46.78	47.01	47.48	48.19	48.92	49.65
CARNMONEY	0.922	37.09	37.09	37.27	37.64	38.20	38.78	39.36
GLENGORMLEY	0.932	17.61	17.61	17.70	17.88	18.14	18.42	18.69
CREGAGH	0.898	54.41	54.41	54.69	55.23	56.05	56.90	57.75
KNOCK	0.897	52.71	52.71	52.98	53.51	54.30	55.13	55.95
DONEGALL (N)	0.906	54.79	54.79	55.07	55.62	56.45	57.30	58.16
DONEGALL (S)	0.892	47.90	47.90	48.14	48.62	49.34	50.09	50.84
TOTAL		**1492**	**1492**	**1499**	**1514**	**1537**	**1560**	**1583**

TABLE D.5: BULK SUPPLY POINT SUMMER MINIMUM DEMAND

LOCATION	POWER FACTOR	FORECAST LOADING (MW)						
		2009	2010	2011	2012	2013	2014	2015
AGHYOULE	0.952	26.78	26.78	26.92	27.19	27.59	28.01	28.42
ANTRIM	0.942	14.02	14.02	14.09	14.23	14.44	14.66	14.88
BALLYMENA RURAL	0.941	15.45	15.45	15.53	15.68	15.91	16.16	16.40
BALLYMENA TOWN	0.937	16.11	16.11	16.19	16.35	16.59	16.84	17.09
BALLYNAHINCH	0.938	18.54	18.54	18.64	18.82	19.10	19.39	19.68
BANBRIDGE	0.940	13.84	13.84	13.91	14.05	14.26	14.48	14.69
COLERAINE	0.940	16.15	16.15	16.23	16.39	16.63	16.89	17.14
COOLKEERAGH	0.945	8.14	8.14	8.18	8.26	8.38	8.51	8.64
CREAGH	0.945	8.42	8.42	8.46	8.55	8.67	8.81	8.94
DRUMNAKELLY	0.930	28.91	28.91	29.05	29.34	29.78	30.23	30.68
DUNGANNON	0.925	32.69	32.69	32.85	33.18	33.67	34.18	34.69
EDEN	0.943	10.19	10.19	10.24	10.34	10.49	10.65	10.81
ENNISKILLEN	0.940	17.56	17.56	17.64	17.82	18.08	18.36	18.63
FINAGHY	0.942	12.10	12.10	12.16	12.28	12.46	12.65	12.84
LARNE	0.940	13.00	13.00	13.06	13.20	13.39	13.59	13.80
LIMAVADY	0.939	13.42	13.42	13.49	13.62	13.82	14.03	14.24
LISAGHMORE	0.944	10.33	10.33	10.38	10.48	10.64	10.80	10.96
LISBURN	0.930	25.82	25.82	25.95	26.20	26.59	27.00	27.40
LOGUESTOWN	0.941	12.21	12.21	12.27	12.39	12.57	12.76	12.95
NEWTOWNARDS	0.940	13.79	13.79	13.85	13.99	14.20	14.42	14.63
NEWRY	0.931	26.62	26.62	26.75	27.02	27.42	27.83	28.25
OMAGH	0.941	13.07	13.07	13.14	13.27	13.46	13.67	13.87
RATHGAEL	0.935	20.44	20.44	20.54	20.74	21.05	21.37	21.69
ROSEBANK	0.944	11.35	11.35	11.41	11.52	11.69	11.87	12.05
SPRINGTOWN	0.938	18.10	18.10	18.19	18.37	18.64	18.93	19.21
STRABANE	0.942	11.20	11.20	11.25	11.36	11.53	11.71	11.88
WARINGSTOWN	0.932	24.50	24.50	24.62	24.87	25.24	25.62	26.00
BELFAST CENTRAL	0.944	21.70	21.70	21.81	22.02	22.35	22.69	23.03
BELFAST PSW	0.967	18.80	18.80	18.89	19.08	19.37	19.66	19.95
CARNMONEY	0.955	13.23	13.23	13.29	13.42	13.62	13.83	14.04
GLENGORMLEY	0.946	6.35	6.35	6.38	6.44	6.54	6.64	6.74
CREGAGH	0.951	20.10	20.10	20.20	20.41	20.71	21.02	21.34
KNOCK	0.941	22.09	22.09	22.20	22.43	22.76	23.10	23.45
DONEGALL (N)	0.928	19.60	19.60	19.70	19.90	20.19	20.50	20.80
DONEGALL (S)	0.931	16.88	16.88	16.96	17.13	17.38	17.65	17.91

TOTAL	**591**	**591**	**594**	**600**	**609**	**618**	**628**

APPENDIX E

FAULT LEVELS

APPENDIX E FAULT LEVELS

E.1 BACKGROUND

When IEC909 was issued in 1988 the Electricity Supply Industry had no standard method or uniform methodology for fault level calculation.

The hand calculation methodology detailed in IEC909 was considered conservative, and as a result an industry working group was established in 1990 to define good practice for the calculation of short circuit currents. Engineering Recommendation G74 (ER G74) resulted, and it defines a computer based technique for the calculation of short circuit currents

Previous Transmission Seven Year Statements (TSYS) have not adopted G74 calculation techniques. This is now the first TSYS where short circuit current levels for Northern Ireland (NI) have been calculated in accordance with ER G74. Compliance with G74 includes:

- Fault contributions from all synchronous and asynchronous 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,
- Pre-fault transformer tap settings that should also be obtained from load flow study.

The fault level network model includes the following component parameters:

- Transformer impedance variation with tap position,
- Zero sequence mutual coupling effect,
- Unsaturated generator reactance values,
- Power station auxiliaries fault level contributions.

E.2 TERMINOLOGY

Short circuit current

Short circuit currents are made up of both an AC and a DC component. The AC component has a relatively slow decay rate, and varies depending on the electrical characteristics of the generators acting as fault current sources. The DC component has a much faster decay rate, and is influenced by the X/R ratio of the fault level paths. The AC and DC components combine to produce a typical waveform as shown in figure E.1 below:

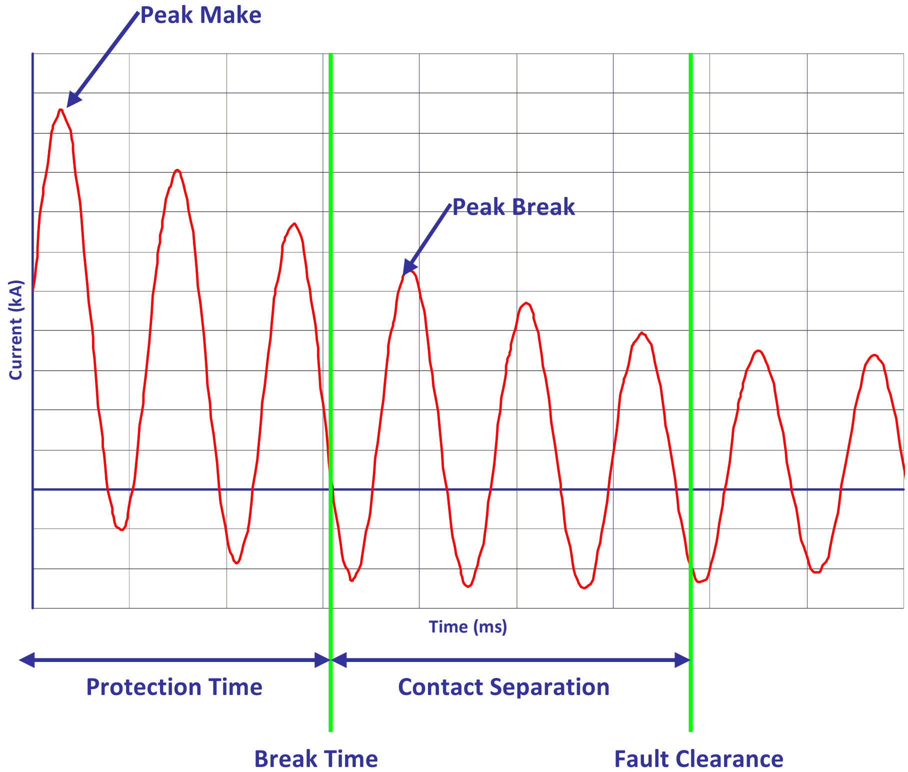


Figure E.1: Short Circuit Current

After fault inception, there is a period of fault detection and protection operation, followed by contact separation and arc suppression within the circuit breaker, and is shown in figure E.1 above.

X/R Ratio

This is the ratio of the reactances to the resistances of the current paths feeding the fault. It influences the rate of decay of the DC component. Higher X/R ratios, found closer to major generation infeeds, for example, lead to a DC component that has a slower rate of decay. The higher X/R ratios can thus lead to higher fault currents when circuit breakers are required to interrupt faults.

The calculation of the X/R ratios is undertaken in accordance with IEC 60909-0 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 DC short circuit currents in the NI transmission system.

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 fault current break time of 50ms for all 275kV and 110kV calculations.

Asymmetrical Break Current (asym B)

This is based on the first peak during contact separation (peak break current). It is the highest short circuit current that a circuit breaker is required to extinguish and is the combination of AC and DC components. The asymmetrical break current is expressed as the equivalent RMS value of this peak break current.

E.3 GENERATION DISPATCHES

Table E.1 below details the various dispatch scenarios in NI used for the fault level analysis. The generation dispatch has a major influence on transmission network fault levels.

CENTRALLY DISPATCHED GENERATING UNIT	2010		2015	
	SUMMER MIN	WINTER MAX	SUMMER MIN	WINTER MAX
BALLYLUMFORD ST 4	-	68	-	160
BALLYLUMFORD ST 5	-	54	-	-
BALLYLUMFORD ST 6	-	74	-	-
BALLYLUMFORD CCGT 21	-	161	-	161
BALLYLUMFORD CCGT 22	-	161	-	161
BALLYLUMFORD CCGT 20	-	181.2	-	181.2
BALLYLUMFORD CCGT 10	60	102	60	102
BALLYLUMFORD GT 7	-	43	-	0
BALLYLUMFORD GT 8	-	0	-	0
KILROOT ST 1	60	202.76	60	202.76
KILROOT ST 2	-	207.74	-	207.74
KILROOT GT 1	-	0	-	0
KILROOT GT 2	-	0	-	0
KILROOT GT 3	-	0	-	0
KILROOT GT 4	-	20	-	0
KILROOT CCGT	-	-	-	400
COOLKEERAGH GT8	-	45	-	0
COOLKEERAGH CCGT	260	413	260	413
MOYLE	36	-80	36	-80

WIND	30%	10%	30%	10%

Table E.1: Generation dispatches used in fault level analysis

All generation dispatch scenarios have been formed using an economic analysis tool. All wind farms have been dispatched at a percentage of their full output as indicated in table E.1.

In winter, generators that are not dispatched are forced on at 0MW to represent the most onerous situation. In summer, the dispatch in NI maintains a “three machine rule” with generation on at key nodes to maintain voltage stability.

E.4 RESULTS

For Winter Maximum studies, all generators have been switched in. From the dispatch scenarios found in table E.1 above, it is clear that not all generators are dispatched on an economic basis. To enable the maximum fault level to be calculated, any generators that are not originally dispatched have been switched in and dispatched at 0 MW.

For all studies, a break time of 50ms has been assumed for the circuit breakers at all nodes, both 275kV and 110kV.

For all studies, Engineering Recommendation G74 has been applied to model the fault contribution from loads. 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.

Previous Transmission Seven Year Statements (TSYS), up to and including ‘Seven Year Transmission Statement 2003/04 – 2009/10’, did not include the G74 recommendation for fault contribution from loads. These older statements showed single-phase fault levels at substations roughly 13% higher than the equivalent three-phase faults. In this TSYS, the two values are a lot closer. Some basic analysis by SONI has indicated that the inclusion of the G74 recommendation for load fault contribution largely explains this trend.

Three phase and single phase fault levels are provided for the following:

- Initial Short Circuit Current (I”)
- Peak Make (iP)
- RMS Break (IB)
- Asymmetrical Break (asym B)

In all tables, the RMS Break, Peak Make and Asymmetrical Break ratings of the nodes are shown. It should be noted that both the Ballylumford and Kells 110kV nodes (highlighted in the tables with *) have separate ratings for three-phase and single-phase faults; these are indicated in the tables. All ratings are in kA.

In all tables, any nodes where the initial short circuit currents exceed 90% of the rating are highlighted in **orange**. Any nodes where the initial short circuit current exceeds the rating are highlighted in **red**.

E.4.1 WINTER MAX 2010/11

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275kV											
BALLYLUMFORD	26.5	66.3	35.65	21.52	55.52	18.48	24.77	24.6	63.71	22.45	29.62
CASTLEREAGH	31.5	79	35.65	16.86	41.65	14.59	16.53	17.24	42.58	15.86	18.00
COOLKEERAGH	31.5	79	35.3	12.72	30.36	11.25	12.34	13.51	33.08	12.56	14.25
HANNAHSTOWN	31.5	79	35.65	16.86	41.87	14.63	16.78	16.96	41.99	15.65	17.97
KELLS	31.5	79	35.65	19.09	48.2	16.51	19.73	19.45	48.54	17.95	20.66
KILROOT	31.5	79	45.3	18.61	47.45	16.18	20.16	20.63	52.88	19.04	23.84
MAGHERAFELT	31.5	79	35.65	18.62	46.56	16.1	18.41	17.01	41.25	15.76	16.76
MOYLE	31.5	79	35.65	20.95	53.96	18.05	23.84	23.84	61.45	21.81	28.01
TANDRAGEE	26.5	66.3	35.65	19.09	47.08	16.48	18.39	19.34	47.57	17.72	19.79
TAMNAMORE	31.5	79	57.3	14.84	36.77	13.14	14.48	13.61	33.22	12.75	14.00

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110kV											
AGHYOULE	25.0	62.5		4.22	9.39	3.27	3.88	4.61	10.27	3.79	4.65
ANTRIM	18.4	46.8		9.91	20.91	9.31	9.42	9.80	20.92	9.44	9.62
BALLYLUMFORD*	21.9	55	25.88	24.27	60.53	21.90	28.95				
	26.2	65.0	29.7					28.16	71.21	26.44	35.35
BALLYMENA	18.4	46.8		9.58	20.52	8.91	9.07	9.73	21.35	9.30	9.58
BANBRIDGE	18.4	46.8		6.80	14.1	6.47	6.51	6.68	14.09	6.68	6.79
BALLYVALLAGH	18.4	46.8	23	16.72	36.3	15.20	15.30	14.96	32.07	14.23	14.29
BALLYNAHINCH	18.4	46.8		6.03	12.54	5.73	5.78	5.90	12.72	5.72	5.86
BELFAST NORTH MAIN	18.4	46.8		13.85	29.61	12.62	12.86	13.71	27.67	12.95	13.46
CARNMONEY	26.2	65	44.9	9.00	18.24	8.53	8.55	8.73	18.43	8.48	8.55
CASTLEREAGH	26.2	65	33.5	21.38	52.41	18.79	22.56	26.49	65.2	24.12	28.75
BELFAST CENTRAL	31.5	79		16.56	38.96	14.92	15.88	18.90	39.63	17.59	18.46
COLERAINE	31.5	79	42.5	8.85	18.59	7.28	7.46	8.97	19.3	7.85	8.03
COOLKEERAGH	31.5	80	33.5	22.98	56.02	19.06	22.68	28.75	71.02	24.94	30.10
CREAGH	31.5	80	33.5	8.09	16.1	7.61	7.61	5.97	12.24	7.27	7.27
CREGAGH	26.2	65		18.94	45.15	16.84	18.50	22.51	50.51	20.71	21.69
DONEGALL NORTH	31.5	79	33.5	16.25	38.34	14.63	15.88	19.74	43.52	18.23	18.98
DONEGALL SOUTH				12.10	26.55	11.15	11.29	12.65	26.83	11.99	12.13
DRUMNAKELLY	31.5	79	42.5	21.36	49.52	18.76	19.85	22.50	52.33	20.67	22.00
DUNGANNON	18.4	46.8	23	17.61	39	15.20	15.84	17.89	38.68	16.24	17.18
EDEN	25.0	62.5	45	10.15	20.79	9.62	9.65	9.74	20.58	9.46	9.55
ENNISKILLEN	25.0	62.5	33.5	9.10	19.93	7.03	7.25	10.69	24.07	8.67	9.09
FINAGHY	31.5	79		16.84	40.14	15.13	16.79	20.92	46.85	19.26	20.28
GLENGORMLEY	18.4	46.8		5.63	11.12	5.38	5.38	5.26	10.87	5.13	5.15
HANNAHSTOWN	31.5	80	33.5	18.55	45.21	16.52	19.72	23.73	58.1	21.67	26.02
KELLS*	21.9	55.9	27.4	20.99	50.26	18.67	22.46				
	26.2	65.0	29.7					25.65	62.17	23.61	28.66
KNOCK	18.4	46.8		17.58	36.95	15.73	15.83	17.02	31.68	15.95	16.22
LARNE	18.4	46.8	42.5	9.94	21.03	9.27	9.31	9.25	20.17	8.90	9.02
LIMAVADY	18.4	46.8	23	8.17	17.22	6.75	6.94	7.57	16.29	6.71	6.94
LISBURN	18.4	46.8	23	11.08	23.41	10.28	10.35	11.27	23.78	10.76	10.91
LISAGHMORE	18.4	46.8		10.33	21.92	9.30	9.40	9.77	21.06	9.20	9.42
LOGUESTOWN	18.4	46.8		6.16	12.57	5.32	5.36	6.36	13.48	5.76	5.84
NEWTOWNARDS	40.0	100		8.47	17.88	7.97	8.02	7.80	16.78	7.54	7.69
NEWRY	18.4	46.8	23	5.85	12.18	5.50	5.58	5.72	12.37	5.50	5.66
OMAGH	40.0	100	42.5	14.67	32.23	11.25	12.09	13.84	30.89	11.59	12.56
RATHGAEL	18.4	46.8		6.51	13.49	6.17	6.21	6.35	13.64	6.15	6.26
ROSEBANK	40.0	100		19.87	47.15	17.60	19.25	24.49	56.83	22.42	23.83
SPRINGTOWN	31.5	79	33.6	10.56	22.5	9.55	9.65	5.23	12.85	5.08	5.44
STRABANE	18.4	46.8	23	15.62	34.16	13.09	13.28	15.69	35.69	13.91	14.51
TANDRAGEE	31.5	79	33.6	23.96	57.78	20.88	24.66	28.01	68.46	25.42	30.54
TAMNAMORE	40.0	100	45	14.84	34.15	13.29	14.97	16.35	38.44	15.14	17.72
WARINGSTOWN	18.4	46.8		8.81	19.09	8.26	8.37	8.14	18.31	7.85	8.07

Table E.2: Winter Max 2010/11 Fault Levels

E.4.2 SUMMER MIN 2010

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275kV											
BALLYLUMFORD	26.5	66.3	35.65	9.14	22.64	8.28	9.37	11.7	29.17	10.97	12.51
CASTLEREAGH	31.5	79	35.65	9.26	22.73	8.34	9.30	11.08	27.25	10.37	11.61
COOLKEERAGH	31.5	79	35.3	9.47	23.4	8.67	9.98	10.96	27.42	10.45	12.29
HANNAHSTOWN	31.5	79	35.65	8.99	22.07	8.11	9.04	10.71	26.33	10.04	11.26
KELLS	31.5	79	35.65	10.11	25.17	9.1	10.48	11.88	29.52	11.17	12.76
KILROOT	31.5	79	45.3	9.88	24.72	8.89	10.44	10.88	27.12	10.28	11.96
MAGHERAFELT	31.5	79	35.65	10.89	27.1	9.81	11.15	11.89	29.02	11.23	12.12
MOYLE	31.5	79	35.65	9.05	22.42	8.21	9.28	11.55	28.75	10.84	12.29
TANDRAGEE	26.5	66.3	35.65	11.3	27.87	10.16	11.41	13.27	32.71	12.44	13.94
TAMNAMORE	31.5	79	57.3	9.63	23.84	8.78	9.78	10.27	25.19	9.77	10.79

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110kV											
AGHYOULE	25.0	62.5		4.13	9.21	4.08	4.55	4.56	10.13	4.52	5.23
ANTRIM	18.4	46.8		8.37	18.05	8.01	8.13	8.26	17.69	8.08	8.18
BALLYLUMFORD*	21.9	55	25.88	13.42	32.17	12.51	14.94				
	26.2	65.0	29.7					15.71	38.29	15.07	18.46
BALLYMENA	18.4	46.8		8.09	17.65	7.74	7.90	8.62	19.12	8.40	8.67
BANBRIDGE	18.4	46.8		6.11	12.87	5.90	5.95	6.24	13.26	6.12	6.23
BALLYVALLAGH	18.4	46.8	23	11.94	26.75	11.25	11.45	11.96	26.29	11.59	11.70
BALLYNAHINCH	18.4	46.8		5.26	11.12	5.06	5.11	5.36	11.63	5.24	5.37
BELFAST NORTH MAIN	18.4	46.8		10.59	23.23	9.91	10.13	11.50	23.72	11.05	11.48
CARNMONEY	26.2	65	44.9	7.36	15.35	7.03	7.06	7.62	16.32	7.43	7.52
CASTLEREAGH	26.2	65	33.5	14.61	36.1	13.36	15.59	19.24	47.67	18.01	20.99
BELFAST CENTRAL	31.5	79		12.12	28.96	11.23	12.03	14.88	32.1	14.12	14.81
COLERAINE	31.5	79	42.5	8.13	17.37	7.85	8.01	8.41	18.28	8.25	8.42
COOLKEERAGH	31.5	80	33.5	19.33	48.03	17.82	21.23	25.05	62.77	23.91	28.72
CREAGH	31.5	80	33.5	7.16	14.57	6.91	6.91	5.64	11.67	5.55	5.56
CREGAGH	26.2	65		13.39	32.37	12.32	13.53	17.02	39.11	16.04	16.89
DONEGALL NORTH	31.5	79	33.5	11.98	28.56	11.12	12.07	15.40	34.69	14.61	15.27
DONEGALL SOUTH				9.58	21.47	9.01	9.17	10.71	23.15	10.31	10.46
DRUMNAKELLY	31.5	79	42.5	15.88	37.45	14.69	15.71	18.16	42.72	17.29	18.49
DUNGANNON	18.4	46.8	23	14.48	32.92	13.66	14.30	15.69	34.42	15.17	16.02
EDEN	25.0	62.5	45	7.91	16.67	7.55	7.61	8.19	17.61	7.99	8.10
ENNISKILLEN	25.0	62.5	33.5	8.29	18.29	8.07	8.25	9.93	22.45	9.76	10.10
FINAGHY	31.5	79		12.34	29.67	11.44	12.62	16.16	36.92	15.29	16.15
GLENGORMLEY	18.4	46.8		5.06	10.17	4.91	4.91	4.89	10.21	4.82	4.84
HANNAHSTOWN	31.5	80	33.5	13.25	32.4	12.23	14.15	17.78	43.62	16.74	19.49
KELLS*	21.9	55.9	27.4	15.19	36.77	14.12	16.46				
	26.2	65.0	29.7					19.52	47.63	18.58	21.90
KNOCK	18.4	46.8		12.77	27.99	11.79	11.94	13.85	26.77	13.21	13.46
LARNE	18.4	46.8	42.5	8.04	17.46	7.72	7.79	8.02	17.74	7.85	8.00
LIMAVADY	18.4	46.8	23	7.61	16.25	7.39	7.54	7.18	15.55	7.08	7.27
LISBURN	18.4	46.8	23	9.05	19.59	8.56	8.64	9.78	20.96	9.46	9.61
LISAGHMORE	18.4	46.8		9.37	20.12	8.99	9.07	9.20	19.94	9.03	9.21
LOGUESTOWN	18.4	46.8		5.78	11.93	5.63	5.67	6.04	12.9	5.95	6.03
NEWTOWNARDS	40.0	100		7.12	15.37	6.78	6.84	6.97	15.17	6.78	6.93
NEWRY	18.4	46.8	23	5.20	10.82	5.02	5.06	5.24	11.29	5.14	5.24
OMAGH	40.0	100	42.5	12.81	28.37	12.36	12.83	12.76	28.52	12.53	13.17
RATHGAEL	18.4	46.8		5.63	11.9	5.41	5.45	5.73	12.42	5.60	5.71
ROSEBANK	40.0	100		13.89	33.51	12.75	13.98	18.17	43.02	17.07	18.27
SPRINGTOWN	31.5	79	33.6	9.66	20.93	9.24	9.35	4.98	12.28	4.93	5.29
STRABANE	18.4	46.8	23	13.75	30.72	13.09	13.30	14.52	33.43	14.18	14.78
TANDRAGEE	31.5	79	33.6	17.17	41.74	15.78	18.30	21.48	52.67	20.27	23.85
TAMNAMORE	40.0	100	45	12.65	29.67	12.02	13.50	14.77	35.19	14.32	16.61
WARINGSTOWN	18.4	46.8		7.66	16.85	7.33	7.45	7.45	16.89	7.28	7.49

Table E.3: Summer Min 2010 Fault Levels

E.4.3 WINTER MAX 2015/16

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
400kV											
TURLEENAN	31.5	79	35.65	12.26	30.17	11.06	12.29	18.44	45.41	16.89	18.71
275kV											
BALLYLUMFORD	26.5	66.3	35.65	20.79	53.05	17.9	22.61	22.74	58.18	20.79	26.08
CASTLEREAGH	31.5	79	35.65	17.66	43.39	15.25	17.07	18.09	44.49	16.57	18.63
COOLKEERAGH	31.5	79	35.3	13.33	31.64	11.74	12.84	14.1	34.33	13.08	14.80
HANNAHSTOWN	31.5	79	35.65	17.41	42.96	15.06	17.01	18.11	44.86	16.59	19.16
KELLS	31.5	79	35.65	20.77	52.55	17.88	21.40	20.83	52.01	19.14	21.99
KILROOT	31.5	79	45.3	21.14	54.28	18.41	23.40	22.73	58.51	21	26.71
MAGHERAFELT	31.5	79	35.65	20.39	50.63	17.48	19.91	20.46	49.79	18.71	19.99
MOYLE	31.5	79	35.65	20.3	51.71	17.52	21.90	22.14	56.43	20.28	24.95
TANDRAGEE	26.5	66.3	35.65	21.21	51.36	18.22	20.07	23.45	56.93	21.25	23.20
TAMNAMORE	31.5	79	57.3	16.15	37.3	14.1	15.18	15.55	36.36	14.4	15.41
TURLEENAN	31.5	79	35.65	20.66	49.37	17.79	19.47	25.97	63.19	23.31	26.19
110kV											
AGHYOULE	25.0	62.5		4.30	9.56	3.35	3.97	4.69	10.44	3.87	4.75
ANTRIM	18.4	46.8		10.47	21.97	9.68	9.78	10.20	21.7	9.72	9.90
BALLYLUMFORD*	21.9	55	25.88	24.89	61.66	22.27	28.94				
	26.2	65.0	29.7					28.63	72.02	26.69	35.13
BALLYMENA	18.4	46.8		10.45	22.6	9.36	9.71	10.36	22.92	9.65	10.13
BANBRIDGE	18.4	46.8		7.05	14.53	6.71	6.75	6.87	14.43	6.67	6.78
BALLYVALLAGH	18.4	46.8	23	17.71	38.43	15.72	15.85	15.48	33.16	14.52	14.59
BALLYNAHINCH	18.4	46.8		6.10	12.66	5.79	5.84	5.95	12.83	5.76	5.90
BELFAST NORTH MAIN	18.4	46.8		16.28	34.07	14.89	15.05	15.30	30.28	14.53	15.00
CARNMONEY	26.2	65	44.9	9.17	18.63	8.68	8.73	8.99	19.05	8.71	8.82
CASTLEREAGH	26.2	65	33.5	22.15	54.23	19.44	23.21	27.39	68.56	24.79	30.57
BELFAST CENTRAL	31.5	79		17.00	39.91	15.32	16.24	19.31	41.18	17.92	18.87
COLERAINE	31.5	79	42.5	10.76	22.54	8.99	9.14	10.56	22.64	9.39	9.54
COOLKEERAGH	31.5	80	33.5	24.75	60.09	20.38	24.22	30.67	75.54	26.57	32.01
CREAGH	31.5	80	33.5	8.55	16.93	8.00	8.00	4.86	10.05	4.75	4.76
CREGAGH	26.2	65		19.53	46.47	17.35	18.96	23.13	52.54	21.19	22.38
DONEGALL NORTH	31.5	79	33.5	19.86	46.83	17.90	19.06	23.75	51.41	22.00	22.63
DONEGALL SOUTH				14.03	30.45	12.99	13.10	14.16	29.62	13.50	13.62
DRUMNAKELLY	31.5	79	42.5	24.07	55.39	21.03	22.08	25.02	57.79	22.91	24.19
DUNGANNON	18.4	46.8	23	19.72	45.13	16.58	17.81	19.14	41.01	17.07	18.72
EDEN	25.0	62.5	45	10.29	21.04	9.73	9.77	9.88	20.86	9.58	9.68
ENNISKILLEN	25.0	62.5	33.5	9.36	20.46	7.31	7.51	10.87	24.46	8.95	9.34
FINAGHY	31.5	79		20.87	49.96	18.76	20.49	25.70	56.75	23.70	24.60
GLENGORMLEY	18.4	46.8		5.82	11.43	5.51	5.51	5.40	11.15	5.23	5.25
HANNAHSTOWN	31.5	80	33.5	23.56	58.08	20.95	24.98	30.13	74.65	27.51	33.17
KELLS*	21.9	55.9	27.4	23.53	56.4	20.19	24.49				
	26.2	65.0	29.7					28.21	68.48	25.16	30.84
KNOCK	18.4	46.8		18.10	37.91	16.17	16.29	17.49	33.77	16.34	16.72
LARNE	18.4	46.8	42.5	10.41	22.08	9.50	9.56	9.51	20.8	9.03	9.20
LIMAVADY	18.4	46.8	23	8.89	18.62	7.41	7.59	8.10	17.39	7.25	7.49
LISBURN	18.4	46.8	23	12.14	25.29	11.32	11.37	12.06	25.18	11.56	11.70
LISAGHMORE	18.4	46.8		10.65	22.48	9.59	9.69	9.98	21.46	9.41	9.63
LOGUESTOWN	18.4	46.8		7.03	14.24	6.18	6.21	7.02	14.81	6.46	6.53
NEWTOWNARDS	40.0	100		8.59	18.1	8.08	8.13	7.87	16.99	7.61	7.76
NEWRY	18.4	46.8	23	6.02	12.47	5.67	5.75	5.83	12.58	5.62	5.78
OMAGH	40.0	100	42.5	16.98	37.32	13.01	13.94	15.76	35.06	13.28	14.31
RATHGAEL	18.4	46.8		6.60	13.65	6.24	6.27	6.43	13.84	6.22	6.33
ROSEBANK	40.0	100		20.54	48.62	18.16	19.76	25.27	60.13	23.01	24.94
SPRINGTOWN	31.5	79	33.6	10.89	23.08	9.85	9.94	5.28	12.95	5.13	5.49
STRABANE	18.4	46.8	23	16.49	35.97	13.70	13.92	16.18	36.76	14.43	15.09
TANDRAGEE	31.5	79	33.6	26.64	63.66	23.16	26.88	31.10	75.55	28.10	33.46
TAMNAMORE	40.0	100	45	25.10	58.37	20.92	23.52	25.57	60.35	22.67	26.40
WARINGSTOWN	18.4	46.8		9.20	19.8	8.64	8.75	8.40	18.83	8.11	8.32

Table E.4: Winter Max 2015/16 Fault Levels

E.4.4 SUMMER MIN 2015

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
400kV											
TURLEENAN	31.5	79	35.65	8.78	21.69	7.23	8.33	13.35	32.98	11.29	12.91
275kV											
BALLYLUMFORD	26.5	66.3	35.65	10.39	25.78	8.34	9.67	12.65	31.49	10.79	12.52
CASTLEREAGH	31.5	79	35.65	10.52	25.77	8.43	9.56	12.39	30.4	10.61	11.98
COOLKEERAGH	31.5	79	35.3	10.39	25.4	8.4	9.77	11.71	29.07	10.2	12.12
HANNAHSTOWN	31.5	79	35.65	10.21	25.03	8.21	9.30	12.19	30.02	10.44	11.98
KELLS	31.5	79	35.65	11.64	29.05	9.17	10.95	13.36	33.23	11.34	13.27
KILROOT	31.5	79	45.3	11.13	27.88	8.91	10.75	11.85	29.47	10.31	12.15
MAGHERAFELT	31.5	79	35.65	12.8	31.84	9.98	11.81	14.7	36.03	12.39	13.67
MOYLE	31.5	79	35.65	10.29	25.5	8.27	9.56	12.48	31.03	10.67	12.31
TANDRAGEE	26.5	66.3	35.65	13.32	32.48	10.44	12.00	16.46	40.15	13.77	15.51
TAMNAMORE	31.5	79	57.3	11.27	26.65	8.95	10.04	12.23	29.01	10.51	11.55
TURLEENAN	31.5	79	35.65	13.23	32.09	10.38	11.91	17.84	43.76	14.74	17.14
110kV											
AGHYOULE	25.0	62.5		4.27	9.48	3.29	3.88	4.67	10.36	3.83	4.67
ANTRIM	18.4	46.8		9.15	19.54	8.04	8.15	9.29	19.99	8.57	8.75
BALLYLUMFORD*	21.9	55	25.88	14.63	34.89	12.44	15.20				
	26.2	65.0	29.7					16.77	40.73	15.02	18.77
BALLYMENA	18.4	46.8		9.15	20.08	7.82	8.18	9.39	20.94	8.48	8.95
BANBRIDGE	18.4	46.8		6.45	13.45	5.98	6.03	6.47	13.66	6.18	6.29
BALLYVALLAGH	18.4	46.8	23	13.36	29.82	11.12	11.38	12.86	28.16	11.50	11.63
BALLYNAHINCH	18.4	46.8		5.45	11.46	5.10	5.15	5.49	11.89	5.27	5.40
BELFAST NORTH MAIN	18.4	46.8		12.85	27.65	11.23	11.42	13.23	26.68	12.17	12.62
CARNMONEY	26.2	65	44.9	7.73	16.06	7.06	7.12	7.99	17.1	7.56	7.68
CASTLEREAGH	26.2	65	33.5	16.08	39.69	13.62	16.18	20.94	51.82	18.41	21.74
BELFAST CENTRAL	31.5	79		13.16	31.35	11.43	12.27	15.92	34.06	14.37	15.10
COLERAINE	31.5	79	42.5	9.85	20.94	7.97	8.13	9.88	21.37	8.59	8.75
COOLKEERAGH	31.5	80	33.5	21.35	52.58	16.60	20.53	27.07	67.35	22.42	27.87
CREAGH	31.5	80	33.5	7.74	15.59	6.94	6.94	4.68	9.73	4.49	4.50
CREGAGH	26.2	65		14.63	35.3	12.54	13.86	18.37	41.94	16.36	17.24
DONEGALL NORTH	31.5	79	33.5	14.94	35.51	12.83	13.83	18.90	41.79	16.86	17.46
DONEGALL SOUTH				11.40	25.24	10.10	10.24	12.27	26.1	11.36	11.49
DRUMNAKELLY	31.5	79	42.5	18.99	44.49	15.60	16.75	21.14	49.38	18.47	19.75
DUNGANNON	18.4	46.8	23	17.09	39.72	13.34	14.65	17.52	37.77	14.81	16.43
EDEN	25.0	62.5	45	8.30	17.35	7.53	7.59	8.48	18.15	8.00	8.11
ENNISKILLEN	25.0	62.5	33.5	8.99	19.83	6.83	7.04	10.55	23.87	8.52	8.93
FINAGHY	31.5	79		15.52	37.33	13.28	14.63	20.12	45.29	17.84	18.66
GLENGORMLEY	18.4	46.8		5.33	10.63	4.91	4.91	5.07	10.52	4.83	4.85
HANNAHSTOWN	31.5	80	33.5	16.98	41.75	14.36	16.89	22.71	56.1	19.90	23.57
KELLS*	21.9	55.9	27.4	17.98	43.51	14.36	17.48				
	26.2	65.0	29.7					22.59	55.17	18.97	23.25
KNOCK	18.4	46.8		13.88	30.16	11.96	12.12	14.78	28.78	13.44	13.77
LARNE	18.4	46.8	42.5	8.77	19.02	7.58	7.68	8.48	18.77	7.76	7.96
LIMAVADY	18.4	46.8	23	8.29	17.5	6.75	6.91	7.64	16.42	6.74	6.94
LISBURN	18.4	46.8	23	10.23	21.77	9.16	9.23	10.72	22.64	10.00	10.13
LISAGHMORE	18.4	46.8		9.98	21.34	8.64	8.75	9.57	20.71	8.81	9.04
LOGUESTOWN	18.4	46.8		6.60	13.52	5.66	5.69	6.67	14.16	6.04	6.11
NEWTOWNARDS	40.0	100		7.46	16.03	6.84	6.90	7.20	15.63	6.85	7.00
NEWRY	18.4	46.8	23	5.52	11.48	5.10	5.17	5.45	11.76	5.20	5.35
OMAGH	40.0	100	42.5	15.87	35.44	11.47	12.46	15.19	34.08	12.26	13.32
RATHGAEL	18.4	46.8		5.85	12.29	5.45	5.49	5.88	12.7	5.63	5.74
ROSEBANK	40.0	100		15.22	36.59	12.98	14.32	19.70	46.39	17.42	18.67
SPRINGTOWN	31.5	79	33.6	10.13	21.76	8.83	8.93	5.06	12.47	4.86	5.23
STRABANE	18.4	46.8	23	15.46	34.32	12.21	12.48	15.66	35.93	13.48	14.21
TANDRAGEE	31.5	79	33.6	20.49	49.53	16.73	19.88	25.35	62.02	21.78	26.32
TAMNAMORE	40.0	100	45	20.86	49.32	16.04	18.56	22.71	54.24	18.89	22.45
WARINGSTOWN	18.4	46.8		8.20	17.86	7.46	7.57	7.77	17.49	7.36	7.56

Table E.5: Summer Min 2015 Fault Levels

APPENDIX F

CAPABILITY

APPENDIX F CAPABILITY

This Appendix contains a detailed description of both the assumptions and the methodology used in the transmission system capability analysis. It also contains tables which cross reference with results tables in **Section 8**. These tables provide information on the contingency and resulting constraint that limit the ability of each transmission node to accept new generation.

F.1 ASSUMPTIONS USED IN STUDIES

F.1.1 SEASONS STUDIED

The transmission system capability analysis studies the year 2015/16- the final year of this TSYS. For this year, four seasons have been studies. They are listed below:

1. Winter maximum 2015/16,
2. Autumn maximum 2015,
3. Summer maximum 2015,
4. Summer minimum 2015.

F.1.2 GENERATION

Table F.1 below lists the generation dispatches used for the four seasons studied.

CENTRALLY DISPATCHED GENERATING UNIT	2015/16			
	WINTER MAX	AUTUMN MAX	SUMMER MAX	SUMMER MIN
BALLYLUMFORD ST 4	-	-	-	-
BALLYLUMFORD CCGT 21	140	140	100	-
BALLYLUMFORD CCGT 22	140	140	100	-
BALLYLUMFORD CCGT 20	160	160	120	-
BALLYLUMFORD CCGT 10	100	100	-	60
BALLYLUMFORD GT 7	-	-	-	-
BALLYLUMFORD GT 8	-	-	-	-
KILROOT ST 1	175	-	-	-
KILROOT ST 2	-	-	-	-
KILROOT GT 1	-	-	-	-
KILROOT GT 2	-	-	-	-
KILROOT GT 3	-	-	-	-
KILROOT GT 4	-	-	-	-
KILROOT CCGT	380	380	380	200
COOLKEERAGH GT8	-	0	0	0
COOLKEERAGH CCGT	413	413	390	260
MOYLE	240	240	240	150
NORTH-SOUTH	320	450	270	550
WIND	100%	100%	100%	100%

Table F.1: Generation Dispatches used in Capability Analysis

CONVENTIONAL GENERATION

For the year 2015/16, it is assumed that the new 400MW CCGT at Kilroot is available. It is also assumed that Units 5 and 6 at Ballylumford are no longer available due to EU emissions targets.

WIND

As shown above in Table F.1, wind is dispatched at full output in all seasons. Table F.2 below details the total amount of wind dispatched in the studies at 110kV nodes. Table C.4 in **Appendix C** provides a full list of windfarms which contribute to these totals.

110kV BUS	MW
AGHYOULE	72.5
BALLYMENA	6
COLERAINE	69
DUNGANNON	38
ENNISKILLEN	16.9
LARNE	15
LIMAVADY	37.7
LISAGHMORE	15
OMAGH	228.9
SLIEVE KIRK	72
STRABANE	27.3
TOTAL	**598.3**

Table F.2: Wind Totals used in Capability Analysis

It has been assumed that this wind generation is operating at a power factor of 0.95 leading.

F.1.3 NEW TRANSMISSION PROJECTS INCLUDED IN THE ANALYSIS

The following transmission projects have been included in the 2015/16 analysis:

1. Tamnamore Phase 2
2. Coleraine to Kells 110kV circuit 2
3. Omagh to Tamnamore 110kV circuit 3
4. New 400kV tie line with Republic of Ireland (RoI)

Information about the projects listed above can be obtained in **Sections 3.4** and **3.5**.

F.1.4 TRANSMISSION SYSTEM OPERATION

Phase 2 at Tamnamore involves the installation of a second 275/110kV Interbus Transformer (IBTX). It has been assumed that the completion of Tamnamore Phase 2 will result in the two 110kV circuits between Tamnamore and Drumnakelly being normally run open. For maintenance of one IBTX at Tamnamore, the circuits will be closed for system security purposes. These assumptions have been included in the transmission system capability analysis.

F.1.5 VOLTAGE SUPPORT

For all studies, a SVC of circa ±100MVAr has been included in the North West region. This maintains voltage stability in the area under outage conditions, given the large amount of wind generation in operation.

F.2 METHODOLOGY

F.2.1 SUMMARY

The capability analysis studies determine the incremental transfer capability when a generator is located at a node. Using A.C. steady state contingency analysis (see **Appendix F.2.4**), the capability of a node to accept new generation is recorded, along with the corresponding contingency and resultant network constraint.

The year studied in this TSYS is 2015/16, and the connection of new generation has been facilitated by one of three scenarios:

SUPPLYING THE NORTHERN IRELAND (NI) EXISTING LOAD

In this scenario, new generation is connected to a node. As this new generation output increases in size, a corresponding amount is scaled off the existing conventional generation in NI. The renewable generation, however, remains at full output. In effect, the new generation is supplying the existing NI load.

SUPPLYING LOAD IN THE REPUBLIC OF IRELAND (RoI)

In this scenario, the new generation connected to a node is transferred across the tie lines to RoI.

REDUCING IMPORTS FROM GREAT BRITAIN (GB)

In this scenario, as the new generation is connected to a node, the amount of energy being transferred across the Moyle interconnector is correspondingly adjusted. In effect, imports are reduced, and can result in power being exported to GB. It should be noted that these studies do not take into consideration any existing or future constraints of export capacity on the Scottish System.

For each of these scenarios, the four seasons listed in **Section F.1.1** have been studied. For all scenarios and seasons, new generation is connected to a particular node, contingency analysis is performed, and the maximum amount of generation that can be connected is recorded. This results in a set of twelve values of generation capacities for each node. The minimum of these values is then selected as the maximum generation capacity that can be accommodated at that node.

It is important to note that when a generation node is tested, the existing generation connected at that node is maximised before capability analysis is performed. This generation is also not scaled back as the new generation is increased in size.

F.2.2 NEW GENERATION CONNECTION LOCATIONS

Analysis of generation connections has been carried out at all nodes on the 275kV and 110kV networks. Generation is also connected at 33kV nodes at 110/33kV Bulk Supply Points (BSP) and analysed. This is necessary because of the increasing amounts of renewable generation connecting at 33kV or at lower voltage levels. This is causing circuit thermal limits on the transmission system to be exceeded and constraints are necessary at certain times. Therefore it is important to study the effects of further connection at distribution level.

F.2.3 CONTINGENCY ANALYSIS PERFORMED

Table F.3 below described the contingency analysis performed in each set of studies.

SEASON	CONTINGENCY ANALYSIS
Winter	n-1 and n-dc
Autumn	n-m-t
Summer	n-m-t

Table F.3: Range of Contingency Analysis Performed

F.2.4 VOLTAGE SUPPORT

If the amount of generation that can be added to a node is limited by voltage issues, i.e. after contingency analysis, the voltage is outside limits imposed by the Planning and Security Standards, then capacitance is added at three sites to help support the voltage. The total amount of capacitance added is then noted in the results.

F.2.5 OPERATING AND PROTECTION SCHEMES

During certain outages, protection schemes at Ballylumford and Coolkeeragh have also been included in the analysis. These are detailed below.

BALLYLUMFORD

The loss of the 275kV double circuit between Castlereagh and Ballylumford can result in significant overloads on the 110kV circuits between Ballylumford and Castlereagh, and Ballylumford and Kells. Therefore, in the event of the loss of the 275kV double circuit, the four 110kV circuits are opened, between Kells and Ballyvallagh, and Castlereagh and Carnmoney, as shown in figure F.1 below (circuits opened are shown in grey). These 110kV circuits are sensitive to contingencies on the 275kV network. Without this tripping scheme, there would be little or no incremental capacity at many 275kV nodes.

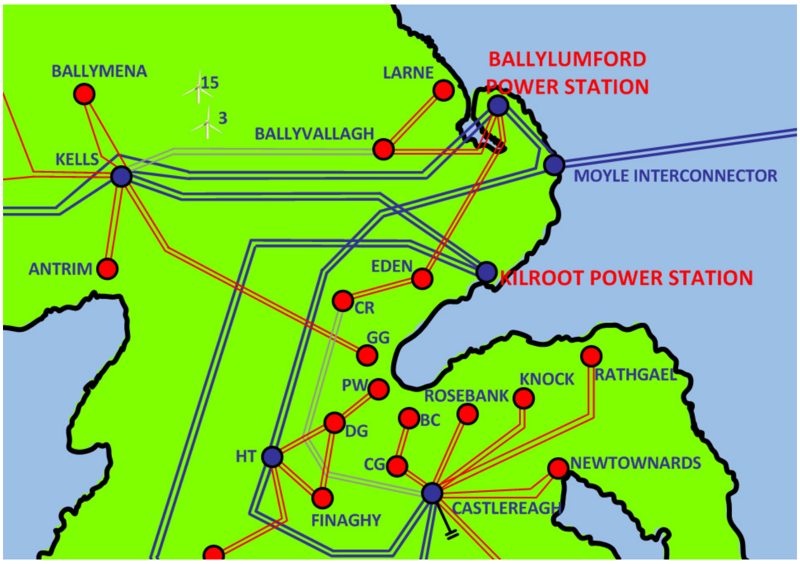


Figure F.1: Circuits Opened in Ballylumford Protection Scheme

COOLKEERAGH

The loss of the 275kV double circuit between Coolkeeragh and Magherafelt can lead to large overloads on the 110kV circuits in the area. As discussed in **Section 3.6.3**, following the loss of the 275kV double circuit, the CCGT at Coolkeeragh is automatically curtailed to 160MW. In addition to this, several windfarms in the area can also be switched out via Special Protection Schemes, and this was also taken into account when implementing this protection scheme. This equates to the reduction in wind generation of 35MW at both Coleraine and Omagh nodes.

It should be noted that this protection scheme was not implemented when testing the capability of nodes at Coolkeeragh and nodes radially fed from Coolkeeragh.

F.3 CONSTRAINTS LIMITING CAPACITY

The analysis for this TSYS indicated a number of potential contingencies that could limit generation opportunities in the year 2015/16. These are presented in tables below. In each table, both the contingency and the resulting constraint are shown, for scenarios identified in the left hand column. These scenarios cross-reference with notes in the results tables in **Section 8**.

F.3.1 CONSTARINTS AT 275kV

Table F.4 below cross references both the contingency and the resulting constraint for the 275kV nodes studied in the capability analysis in **Section 8.1.1**.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 275kV		
ID	OUTAGE	CONSTRAINT
A1	275kV circuits from Hannahstown to Ballylumford/Moyle.	Ballylumford to Kells 275kV circuit 1 overloaded.
A2	275kV double circuit from Ballylumford to Kells/Magherafelt.	Overload on 110kV Ballylumford to Eden circuits 1 and 2.
A3	275kV double circuit from Castlereagh to Tandragee/Kilroot.	Overload on 110kV Hannahstown to Lisburn circuit 1.
A4	275kV double circuit from Coolkeeragh to Magherafelt.	Overload on 110kV Coleraine to Limavady circuit 1.
A5	275kV circuits from Tamnamore to Magherafelt/Turleenan.	Overload on 110kV Drumnakelly to Tandragee circuits 1 and 2.

Table F.4: Contingencies and Constraints Limiting 275kV Capability

F.3.2 CONSTARINTS AT 110kV

Table F.5 below cross references both the contingency and the resulting constraint for the 110kV nodes studied in the capability analysis in **Section 8.1.2**.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 110kV		
ID	**OUTAGE**	**CONSTRAINT**
B1	110kV circuit 1 from Aghyoule to Enniskillen.	Overloads on 33kV circuits around Aghyoule.
B2	110kV double circuit from Ballyvallagh to Ballylumford.	Overload on 110kV Ballylumford to Eden circuits 1 and 2.
B3	275kV double circuit from Hannahstown to Ballylumford/Moyle.	Overload on 110kV Ballylumford to Ballyvallagh circuits 1 and 2.
B4	110kV circuit 1 from Belfast Central to Cregagh.	Overload on 110kV Belfast Central to Cregagh circuit 2.
B5	110kV circuit 1 from Belfast North Main to Donegall.	Overload on 110kV Belfast North Main to Donegall circuit 2.
B6	110kV circuit 1 from Carnmoney to Castlereagh.	Overload on 110kV Carnmoney to Castlereagh circuit 2.
B7	275kV double circuit from Castlereagh to Tandragee/Kilroot.	Overload on 110kV Hannahstown to Lisburn circuit 1.
B8	IBTX 1 and 2 at Coolkeeragh.	Overload on 110kV Coleraine to Kells circuit 1.
B9	275kV double circuit from Coolkeeragh to Magherafelt.	Overload on 110kV Coleraine to Limavady circuit 1.
B10	275kV double circuit from Magherafelt to Tamnamore/Turleenan.	Overload on 110kV Creagh to Kells circuit 1.
B11	IBTX 1 and 2 at Tamnamore.	Overload on 110kV Drumnakelly to Tamnamore circuits 1 and 2.
B12	275kV circuits from Tamnamore to Magherafelt/Turleenan.	Overload on 110kV Drumnakelly to Tandragee circuits 1 and 2
B13	110kV circuit 1 from Carnmoney to Eden.	Overload on 110kV Carnmoney to Eden circuit 2.
B14	110kV circuit 1 from Enniskillen to Omagh.	Overload on 110kV Enniskillen to Omagh circuit 2.
B15	110kV circuit 1 from Hannahstown to Finaghy.	Overload on 110kV Finaghy to Hannahstown circuit 2.
B16	IBTX 1 and 2 at Kells.	Overload on 110kV Ballylumford to Ballyvallagh circuits 1 and 2.
B17	110kV, circuits 1 and 2, Lisburn to Tandragee.	Overload on 110kV Hannahstown to Lisburn circuit 1.
B18	110kV, circuit 1, from Coolkeeragh to Strabane.	Overload on 110kV Coolkeeragh to Slieve Kirk circuit 1.
N	No capacity available at the node.	
R	110kV station is fed radially; loss of one 110k V circuit.	Overload on second 110kV circuit feeding the station.

Table F.5: Contingencies and Constraints Limiting 110kV Capability

F.3.3 CONSTARINTS AT 33kV

Table F.6 below cross references both the contingency and the resulting constraint for the 33kV nodes studied in the capability analysis in **Section 8.1.2**.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 33kV		
ID	**OUTAGE**	**CONSTRAINT**
C1	110kV circuit 1 from Aghyoule to Enniskillen.	Overloads on 33kV circuits around Aghyoule.
C2	275kV double circuit from Coolkeeragh to Magherafelt.	Overload on 110kV Coleraine to Limavady circuit 1.
C3	275kV double circuit from Magherafelt to Tamnamore/Turleenan.	Overload on 110kV Creagh to Kells circuit 1.
C4	IBTX 1 and 2 at Tamnamore.	Overload on 110kV Drumnakelly to Tamnamore circuits 1 and 2.
C5	110kV circuit 1 from Enniskillen to Omagh.	Overload on 110kV Enniskillen to Omagh circuit 2.
N	No capacity available at the node.	
T	33kV station supplied through 2 TXs; Loss of Transformer 1.	Overload on second Transformer.

Table F.6: Contingencies and Constraints Limiting 33kV Capability

APPENDIX G

GLOSSARY

APPENDIX G GLOSSARY

AAAC	All Aluminium Alloy Conductor
AC	Alternating Current
ACS	Average Cold Spell
BETTA	British Electricity Trading and Transmission Agreements
BSP	Bulk Supply Point
CCGT	Combined Cycle Gas Turbine
DCENR	Department of Communications, Energy and Natural Resources
DETI	Department of Enterprise Trade and Investment
Demand Customer	A large customer connected to the transmission system
D/C	Double Circuit
DC	Direct Current
DNC	Declared Net Capacity
ESB	Electricity Supply Board
EU	European Union
FACTS	Flexible AC Transmission System
HVDC	High Voltage Direct Current
IME	Internal Market for Electricity
IPP	Independent Power Producer
kV	Kilo Volts
MVA	Mega Volt-Amperes
NFFO	Non-Fossil Fuel Obligation
NGET	National Grid Electricity Transmission
NI	Northern Ireland
NIAUR	Northern Ireland Authority for Utility Regulation
NIE	Northern Ireland Electricity
NTC	Net Transfer Capacity
OCGT	Open Cycle Gas Turbine
PPB	Power Procurement Business
PU	Per Unit
RoI	Republic of Ireland
RP	Review Period
SONI	System Operator for Northern Ireland
SPS	Special Protection Scheme
SSSA	System Support Services Agreement
STATCOM	Static Compensator
SVC	Static Var Compensator
TUoS	Transmission Use of System

TABLE G.1: LICENCE (SYSTEM AND SECURITY) STANDARDS- REFERENCES

DOCUMENT	DESCRIPTION
ER P2/5	Security of Supply, dated October 1978, and NIE amendment sheet Issue 2, dated 7 August 1992.
PLM-SP-1	Planning Standards of Security for the Connection of Generating Stations to the System Issue 1, dated 1975, and NIE amendment sheet Issue 2, dated 7 August 1992.
PLM-ST-4	CEGB Criteria for System Transient Stability Studies Issue 1, dated September 1975, and NIE amendment sheet Issue 2, dated 7 August 1992.
PLM-ST-9	Voltage Criteria for the Design of 400kV and 275kV Supergrid System Issue 1, dated 1 December 1985, and NIE amendment sheet Issue 2, dated 7 August 1992.
ER-P28	Planning Limits for Voltage Fluctuations
ER-P16	EHV or HV Supplies to Induction Furnaces
ER-P29	Planning Limits for Voltage Unbalance.
ER-G5/3	Limits for Harmonics (To be replaced by ER-G5/4 following UK practice and in conjunction with a joint review with EirGrid).
EPM-1	Operational Standards of Security of Supply, dated November 2004.

Table G.1: Licence (System and Security) Standards- References

NOTES

APPENDIX H

POWER FLOWS

APPENDIX H POWER FLOWS

H.1 POWER FLOW DIAGRAMS

The following scenarios are represented by power flows in this appendix:

- H.1 Summer Max 2010
- H.2 Summer Min 2010
- H.3 Winter Max 2010/11
- H.4 Summer Max 2012
- H.5 Summer Min 2012
- H.6 Winter Max 2012/13
- H.7 Summer Max 2015
- H.8 Summer Min 2015
- H.9 Winter Max 2015/16
- H.10 Summer Max 2015 with maximum wind
- H.11 Summer Min 2015 with maximum wind
- H.12 Winter Max 2015/16 with maximum wind

H.2 SYMBOLS USED IN POWER FLOW DIAGRAMS

Table H.1 below details the symbols and voltage levels used in the power flow diagrams. Buses are represented with both their name and number. The voltage, in both per unit value and kV, is also shown at each bus.

At both ends of each circuit, the flow in MW and MVAr is shown.

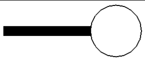
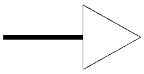
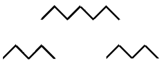
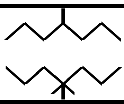
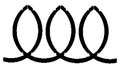
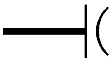
SYMBOL	DESCRIPTION
	400kV
	275kV
	110kV
	33kV
	< 33kV
	GENERATOR
	LOAD
	INTERBUS TRANSFORMER
	2 WINDING TRANSFORMER
	REACTANCE
	CAPACITANCE
	MW FLOW
	MVAR FLOW

Figure H.1: Symbols used in the Power Flow Diagrams

- Circuits normally run open are indicated with a dashed line, coloured dark grey.
- Equipment or generators not in service are coloured dark grey.

FIGURE H.1: SUMMER MAXIMUM POWER FLOW 2010

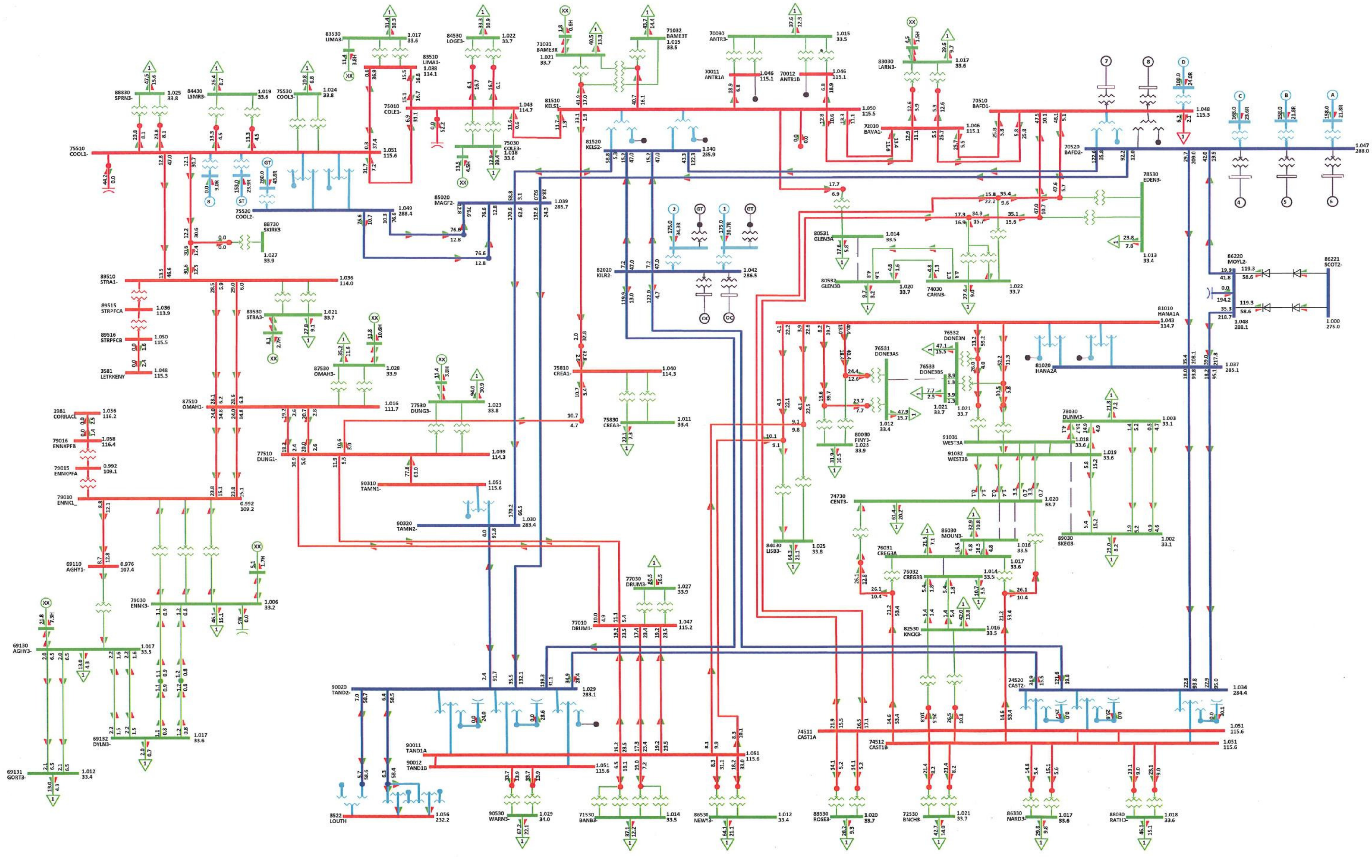


FIGURE H.2: SUMMER MINIMUM POWER FLOW 2010

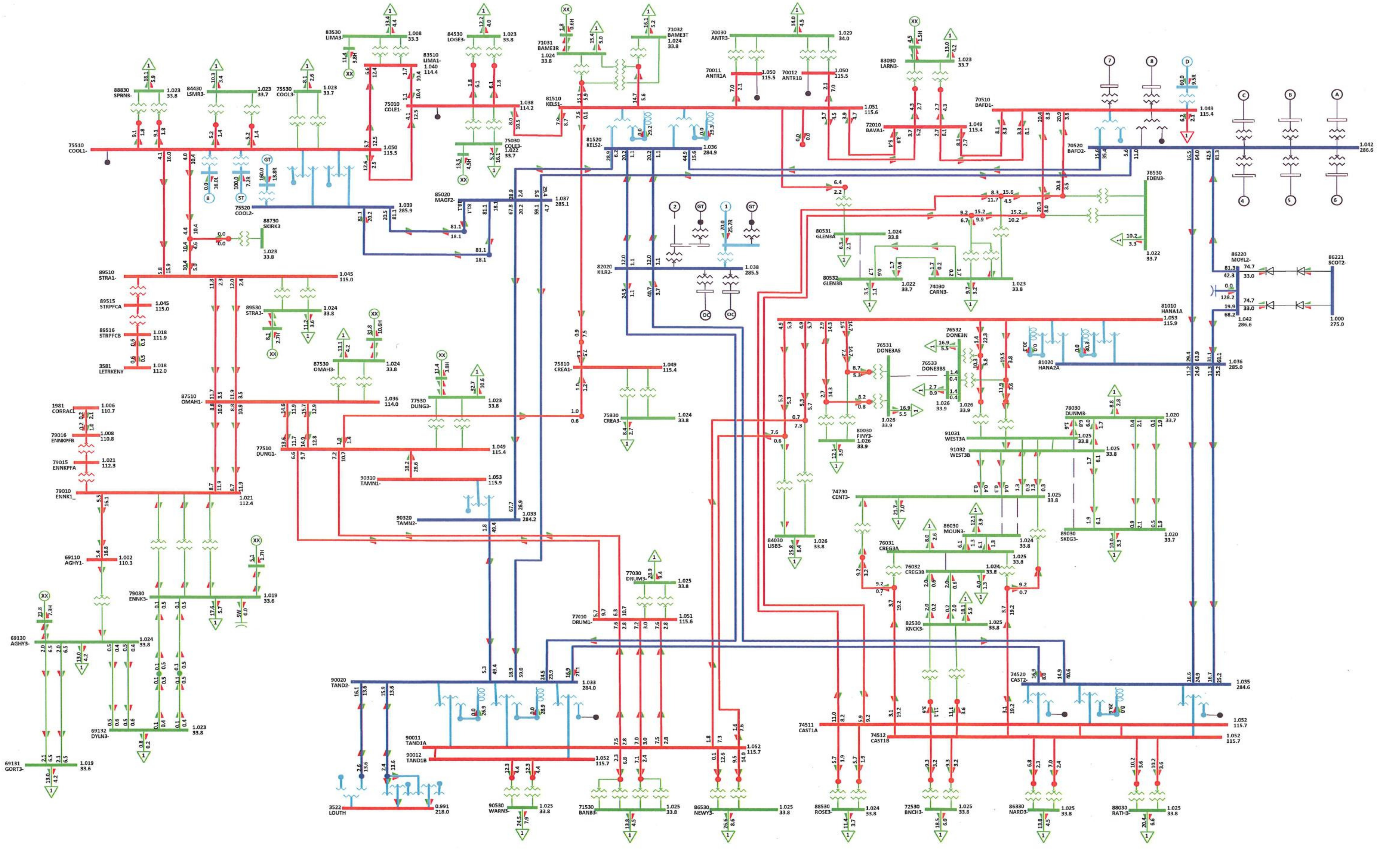


FIGURE H.3: WINTER MAXIMUM POWER FLOW 2010/11

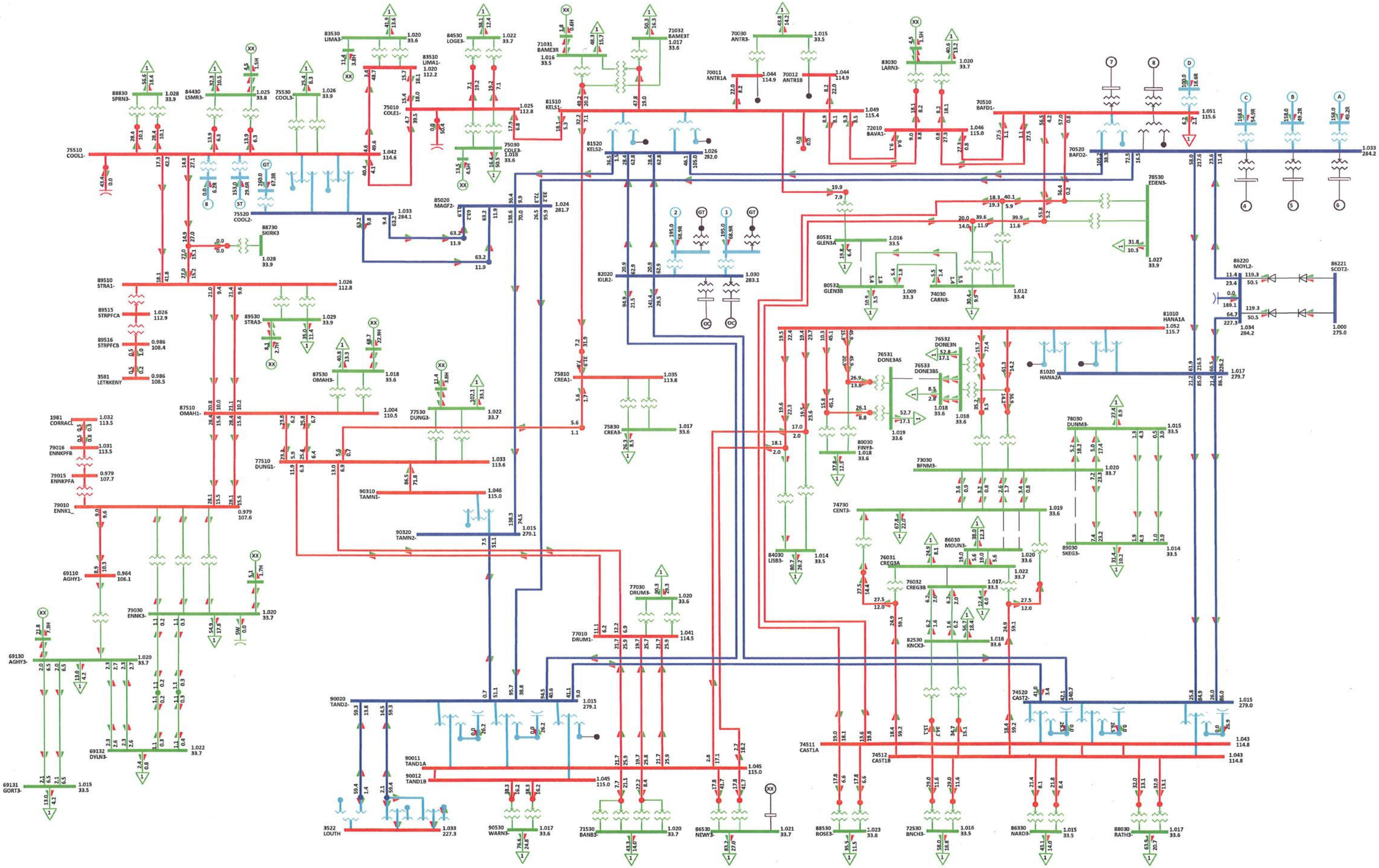


FIGURE H.4: SUMMER MAXIMUM POWER FLOW 2012

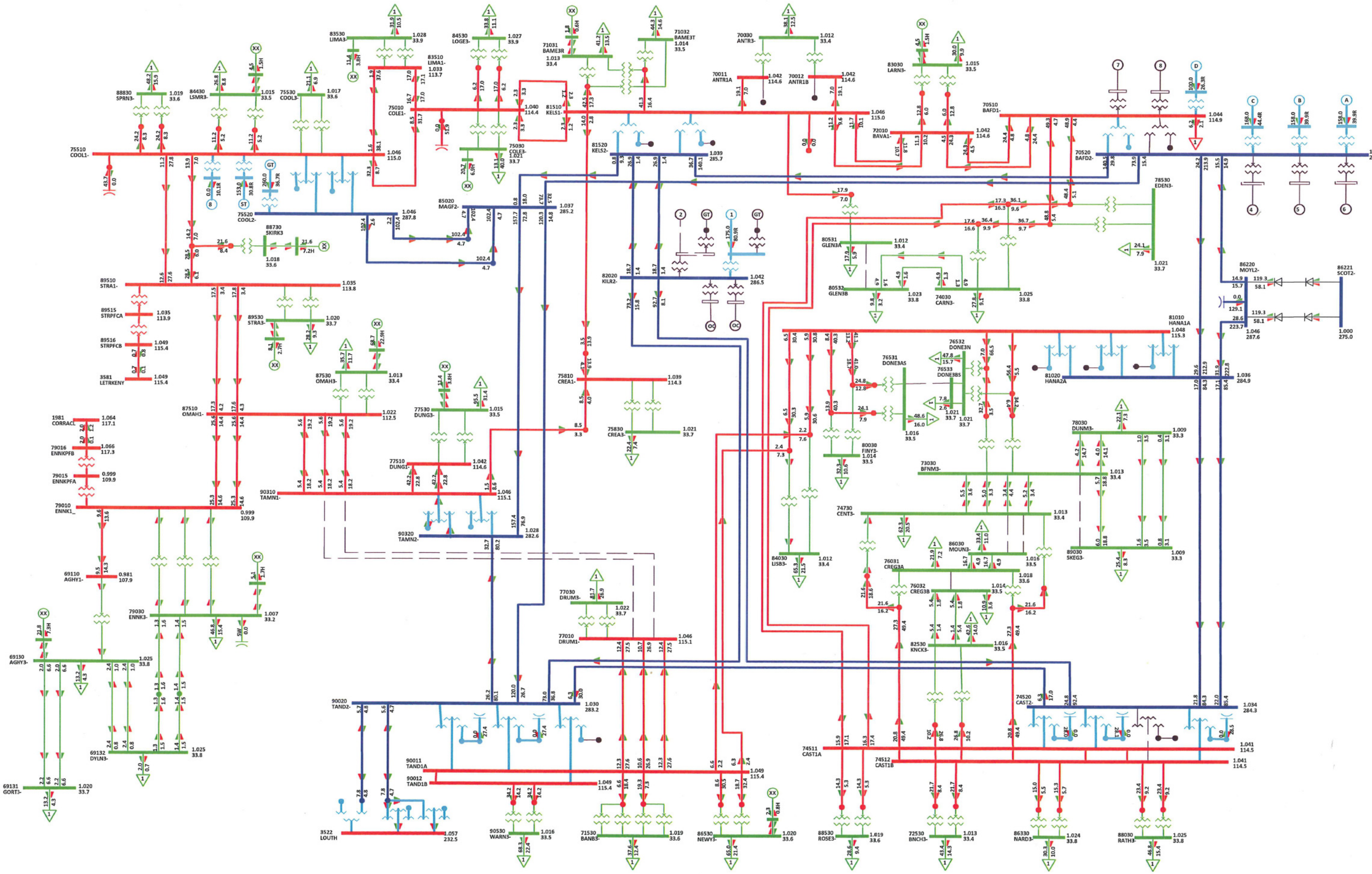


FIGURE H.5: SUMMER MINIMUM POWER FLOW 2012

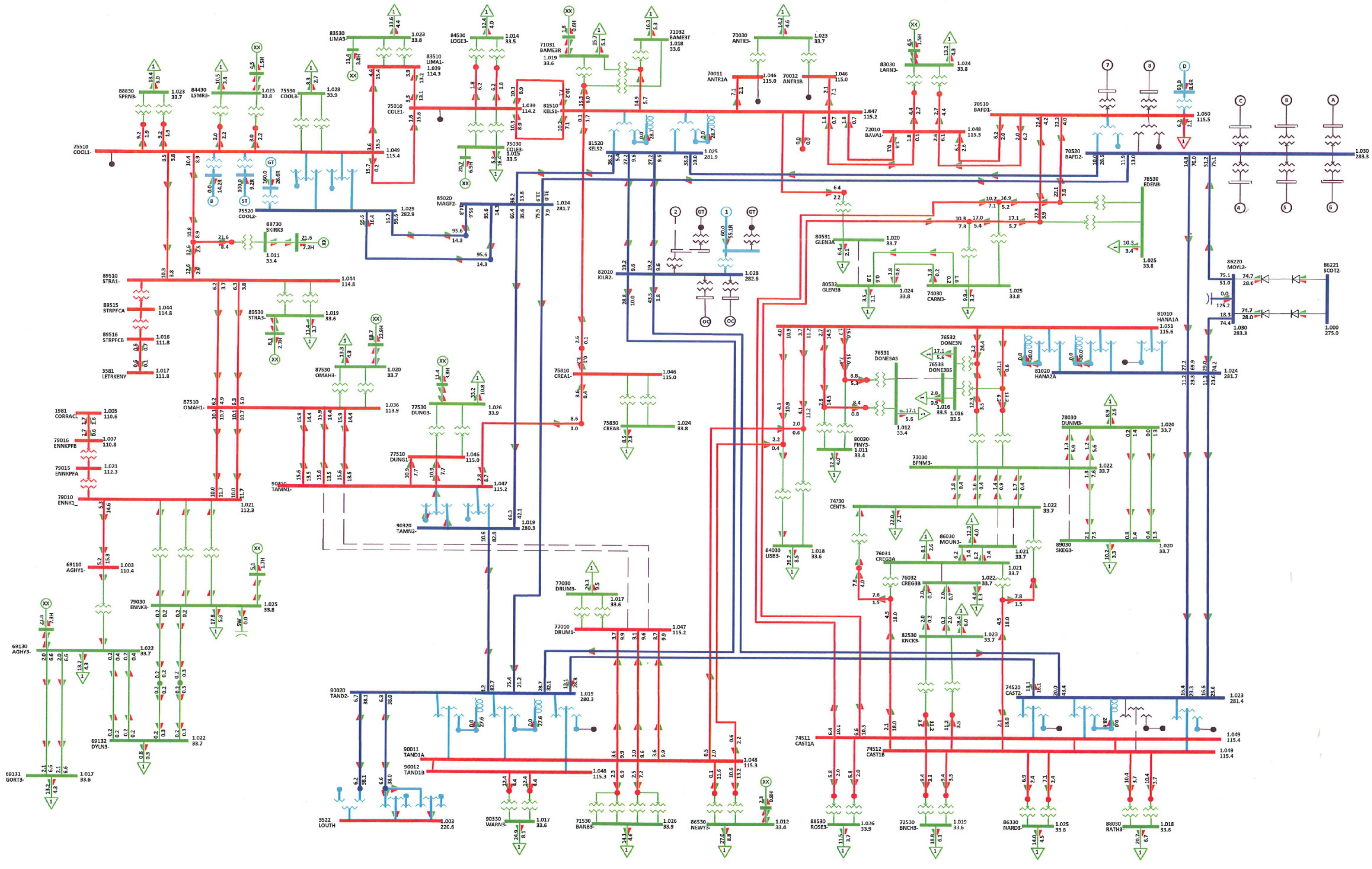


FIGURE H.6: WINTER MAXIMUM POWER FLOW 2012/13

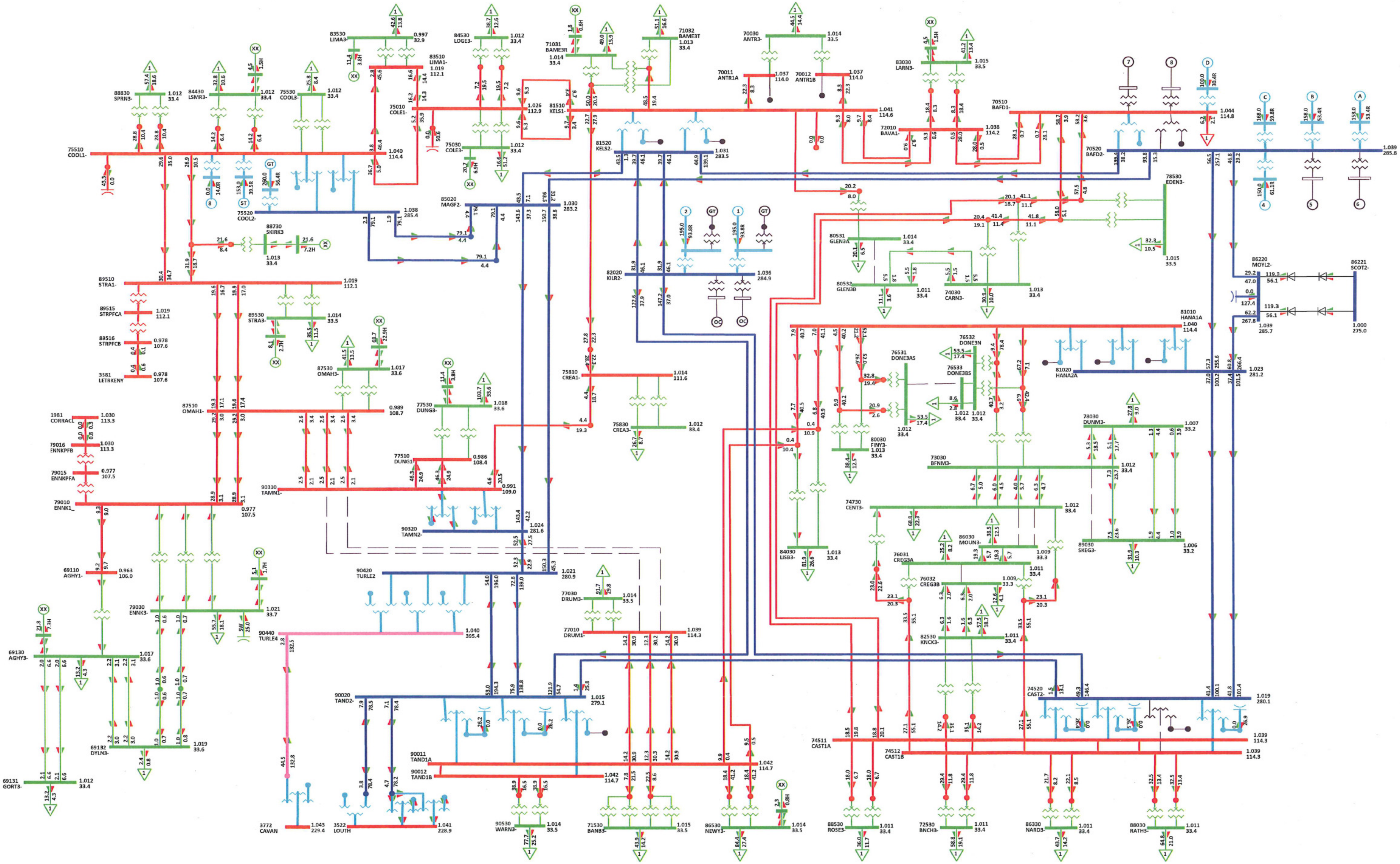


FIGURE H.7: SUMMER MAXIMUM POWER FLOW 2015

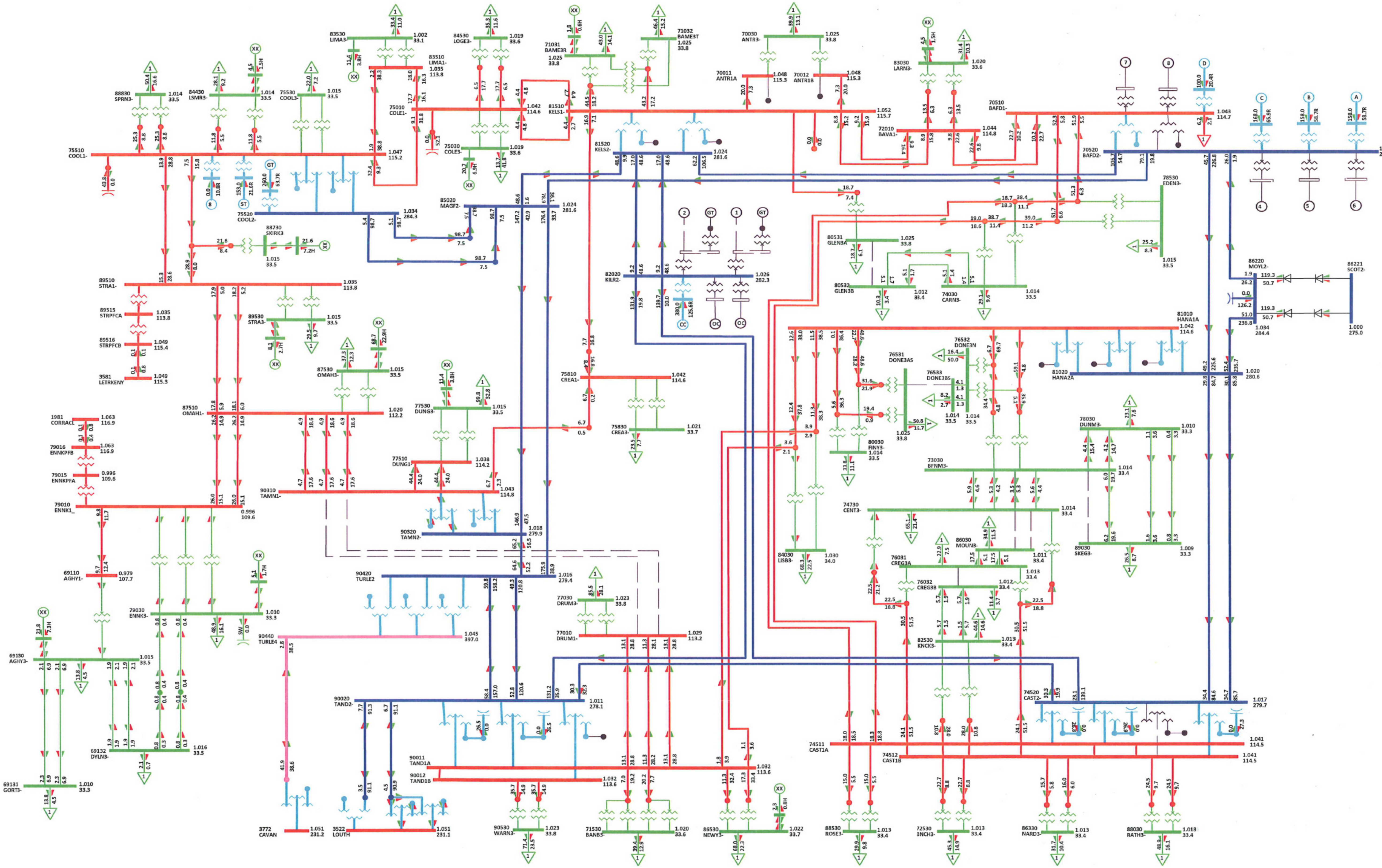


FIGURE H.8: SUMMER MINIMUM POWER FLOW 2015

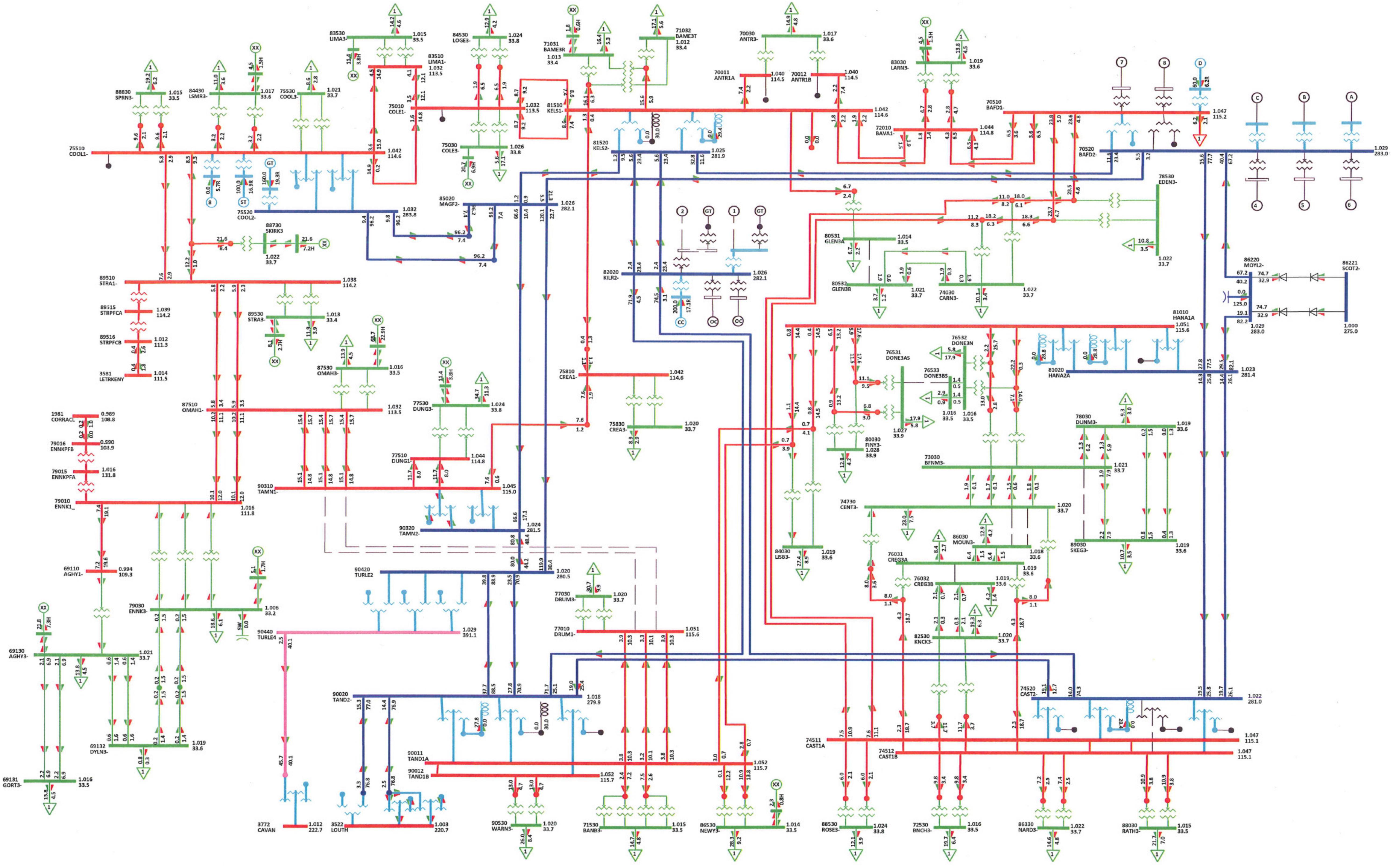


FIGURE H.9: WINTER MAXIMUM POWER FLOW 2015/16

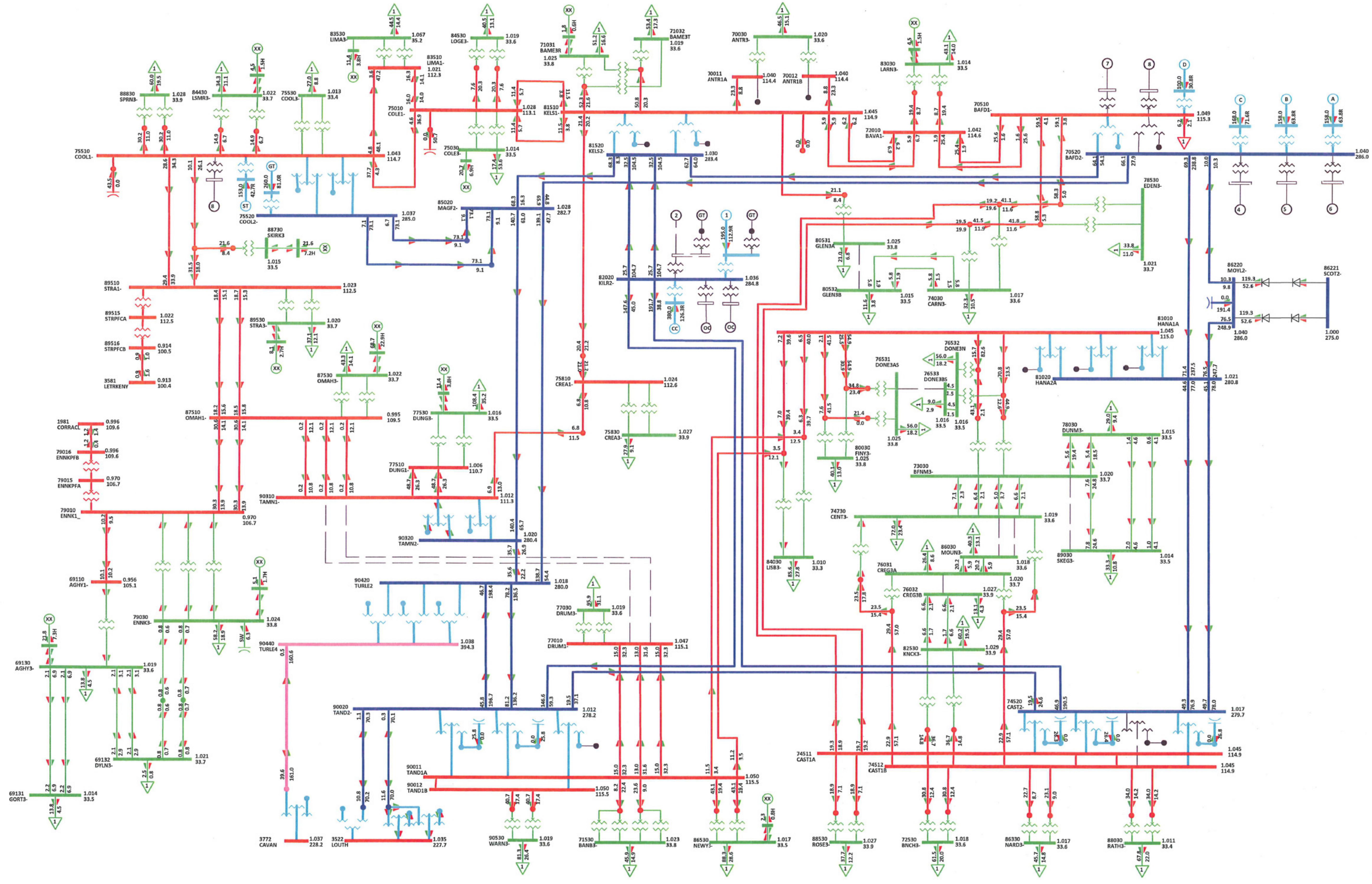


FIGURE H.10: SUMMER MAXIMUM POWER FLOW 2015 WITH MAXIMUM WIND

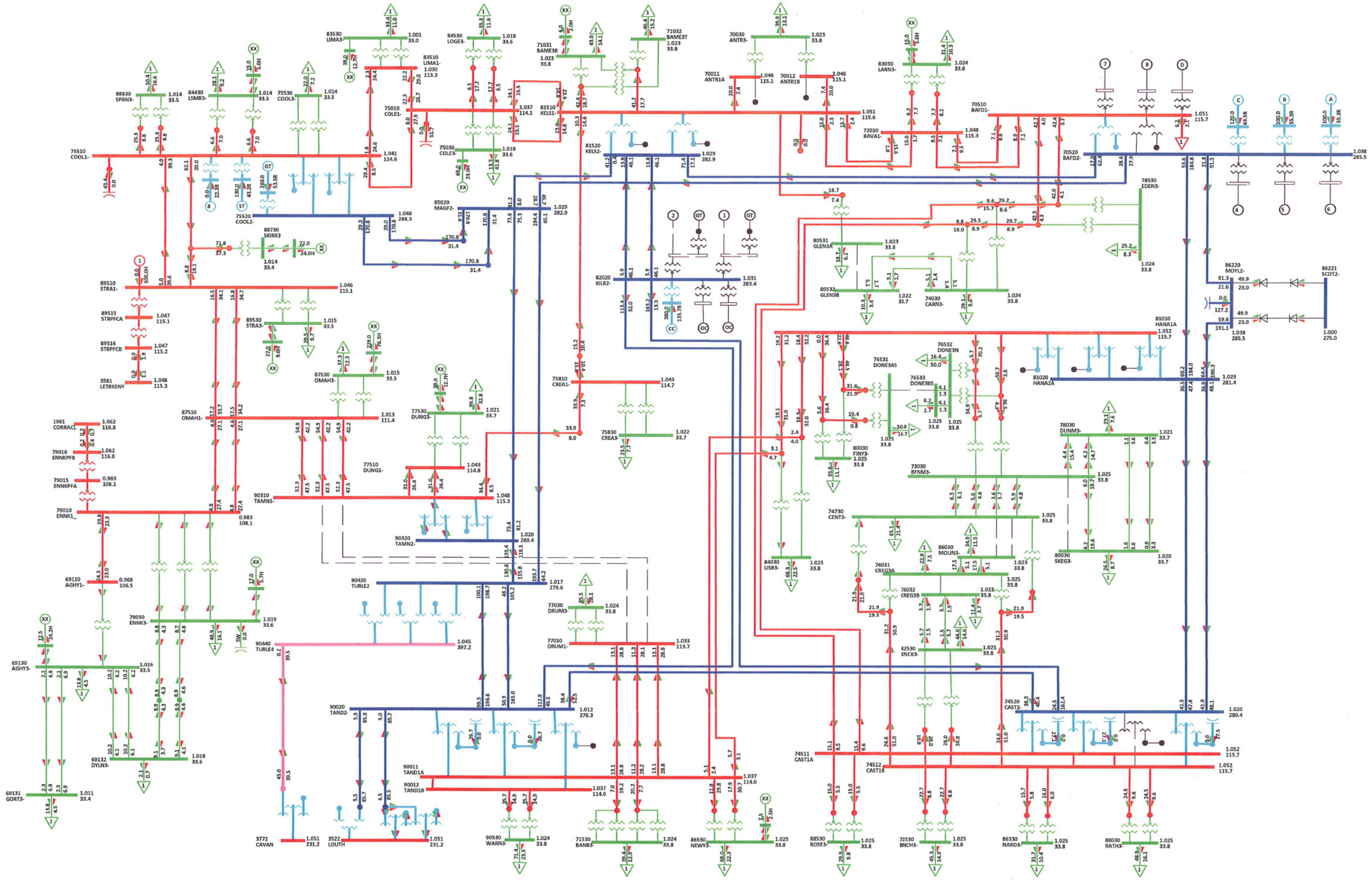


FIGURE H.11: SUMMER MINIMUM POWER FLOW 2015 WITH MAXIMUM WIND

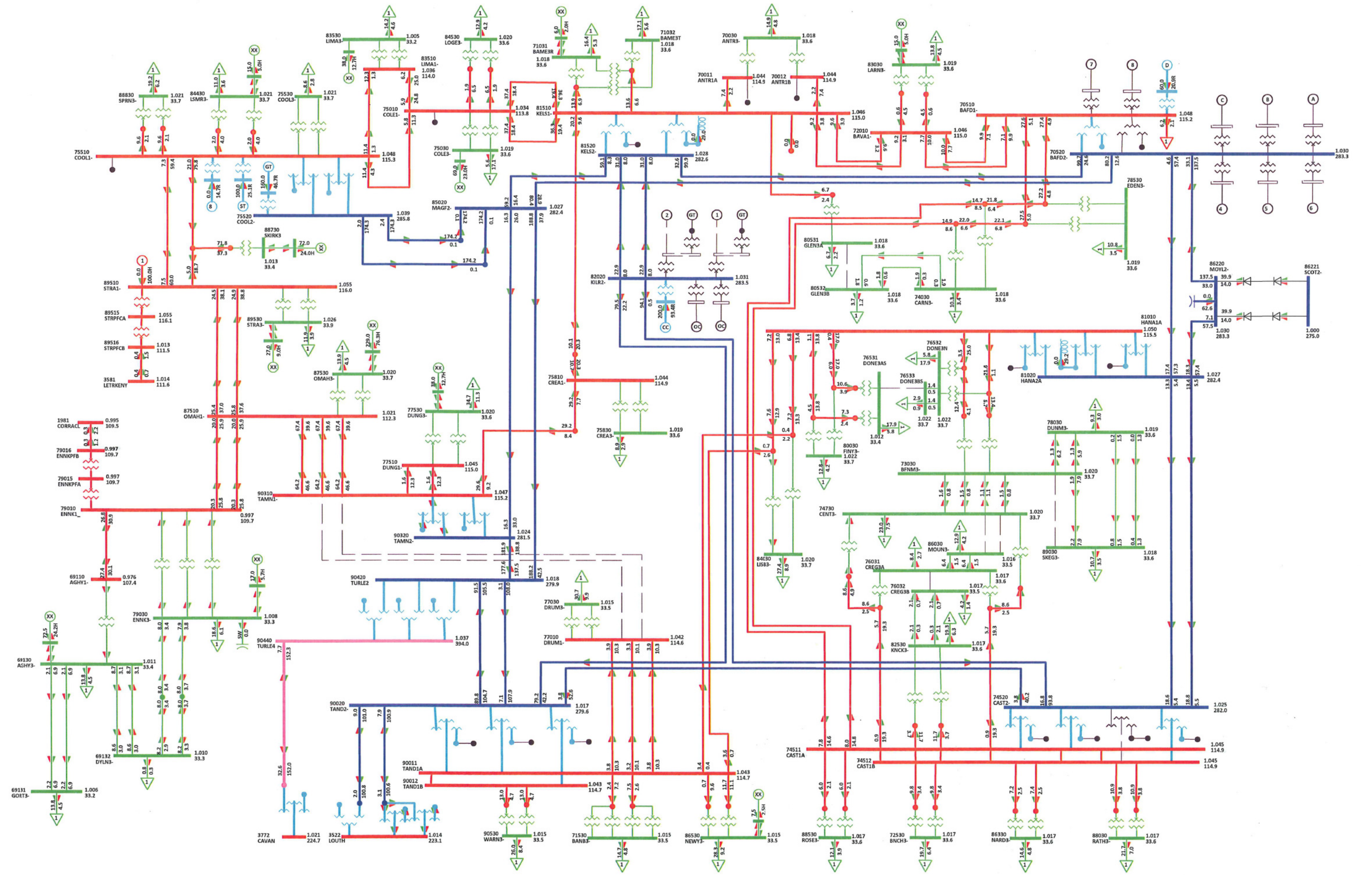
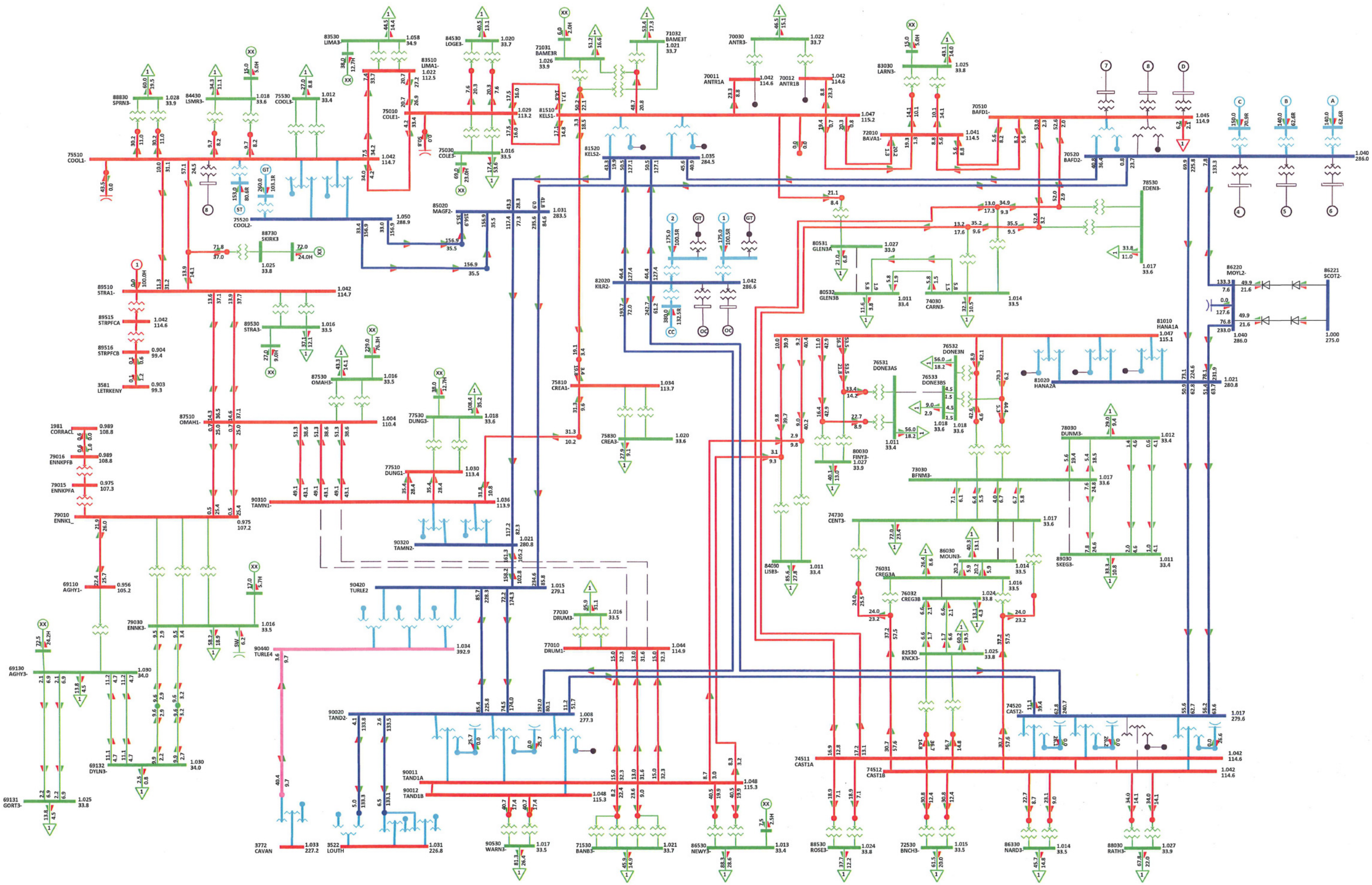
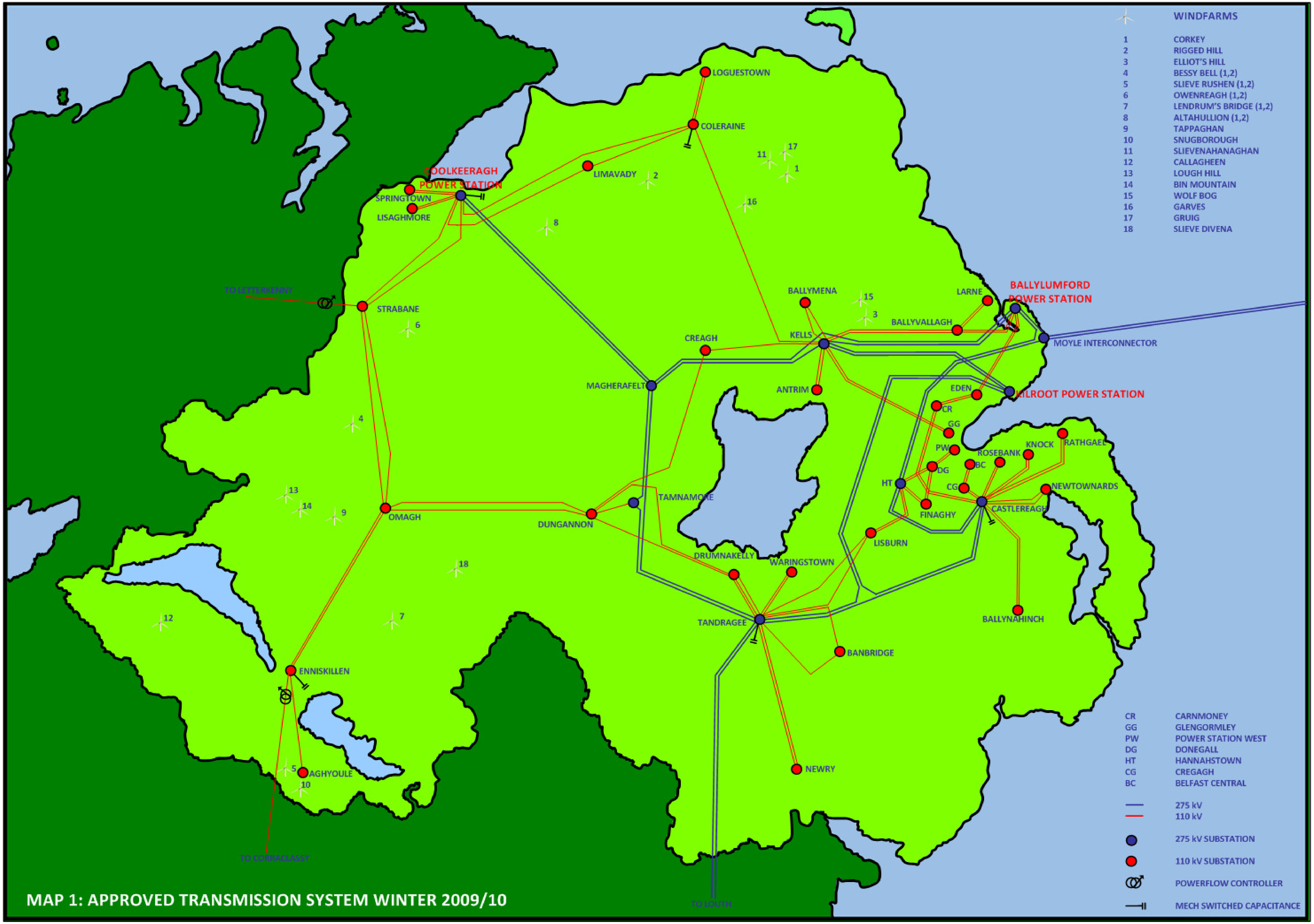
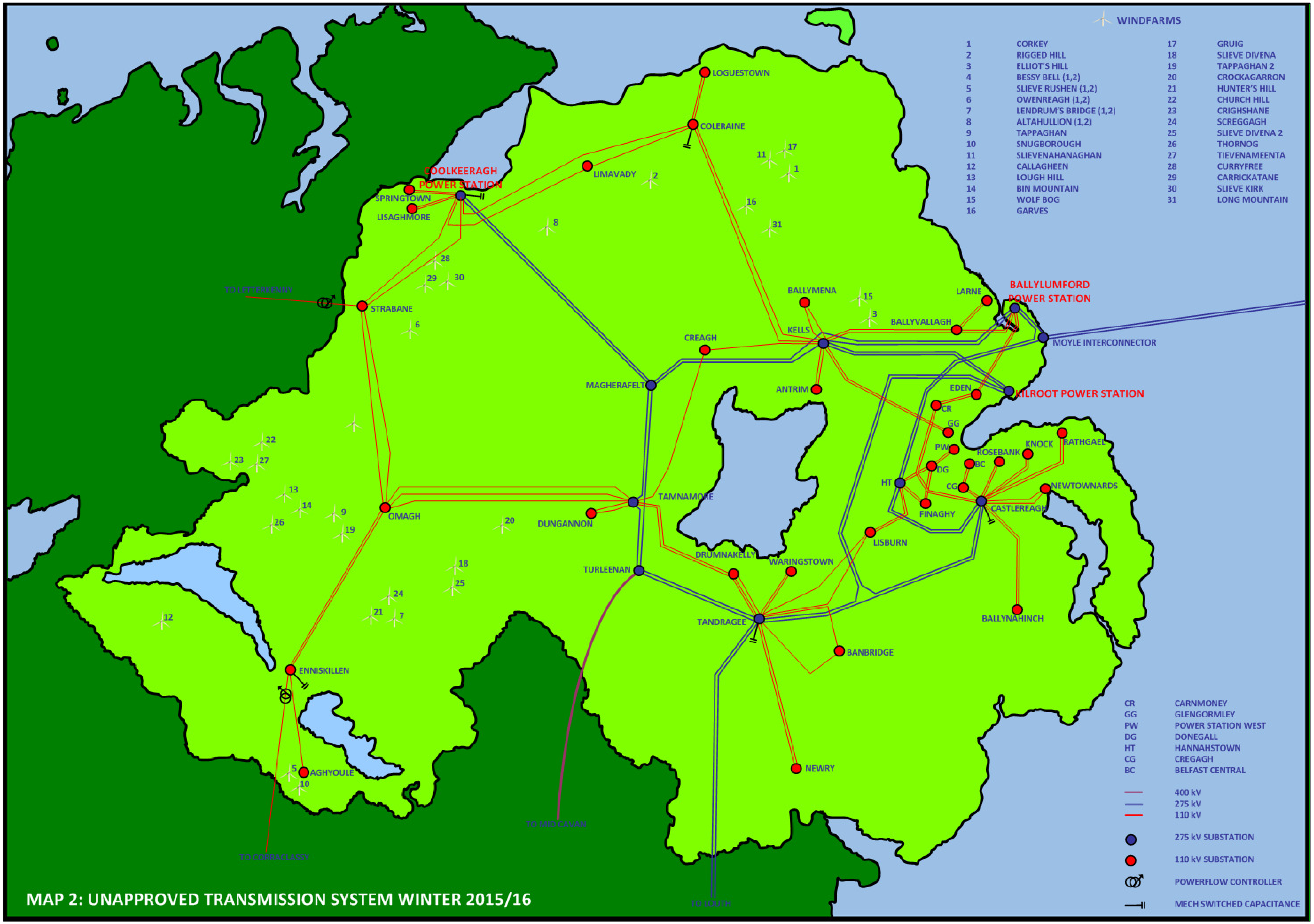


FIGURE H.12: WINTER MAXIMUM POWER FLOW 2015/16 WITH MAXIMUM WIND





MAP 1: APPROVED TRANSMISSION SYSTEM WINTER 2009/10



MAP 2: UNAPPROVED TRANSMISSION SYSTEM WINTER 2015/16