System Operator for Northern Ireland

TRANSMISSION SYSTEM CAPACITY STATEMENT 2011/12 – 2017/18




www.soni.ltd.uk

Front cover image from left to right: Crockagarran Wind Farm (courtesy of T. Harron); Tamnamore 275/110 kV Substation; Castlereagh - Kilroot/Tandragee 275 kV circuit and Kilroot Power Station (courtesy of AES Kilroot Limited).

FOREWORD

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

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

This document is posted on the SONI website (www.soni.ltd.uk) in a form approved by the Utility Regulator (UREGNI).

TRANSMISSION SYSTEM CAPACITY STATEMENT

FOR THE YEARS 2011/12 TO 2017/18

For queries relating to this document or to request a copy contact john.ohiggins@soni.ltd.uk

SEPTEMBER 2011

12 Manse Road, Belfast.
BT6 9RT

TABLE OF CONTENTS PAGE

TABLE OF CONTENTS PAGE

TABLE OF CONTENTS PAGE

TABLE OF CONTENTS PAGE

TABLE OF CONTENTS **PAGE**

LIST OF TABLES PAGE

LIST OF TABLES PAGE

LIST OF MAPS

LIST OF FIGURES

POWER FLOWS

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This Transmission System Capacity Statement (TSCS) has been prepared by SONI (System Operator for 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 2011/12 to 2017/18.

INTRODUCTION

This Transmission System Capacity Statement (TSCS) describes the statutory operational requirements, the existing transmission network, its configuration and its planned development over the seven year period to 2017/18. 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 TSCS 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.

THE TRANSMISSION SYSTEM

The Northern Ireland (NI) Transmission System comprises some 2000 circuit kilometres of 275 kV and 110 kV 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 Republic of Ireland (RoI) transmission system via a double circuit 275 kV connection at Tandragee and two 110 kV connections at Enniskillen and Strabane. It is planned to have a new 400 kV connection in place by winter 2016/17. The NI transmission system is also connected to the Great Britain (GB) transmission system by the Moyle Interconnector, a 500 MW DC link between Ballycronan More and Auchencrosh in Scotland.

This TSCS 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 TSCS was **31 March 2011.** 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 2011, some **2760 MW** of generation capacity was installed in NI, of which **370 MW** 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	0
RENEWABLE	670

Table S.1: Planned Generation Connections by 2017/18

No thermal generation plant is planned to connect to the NI Transmission System over the seven year period covered by the statement. At the data freeze AES Kilroot holds a formal connection offer for additional generation capacity; however they have been unable to confirm a commissioning date for this additional generation.

The Heavy Fuel Oil Directive is anticipated to result in the loss of some **540 MW** of capacity at Ballylumford Power Station by the end of 2015. Over the seven year period covered by this TSCS, **168.5 MW** of committed renewable generation with a further **502 MW** of unapproved renewable generation is expected to connect to in NI. By the year 2017/18; the total NI installed capacity will be circa **2850 MW**.

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. In order for NI to meet this target approximately 1600 MW of installed renewable generation capacity would be required to achieve the 40% target. This represents a considerable challenge for SONI to manage, and is discussed in more detail in **Section 4** of this TSCS.

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 TSCS includes the latest forecasts which have been calculated after the recent economic slump. The methodology of this forecast is discussed in **Section 5. Table S.2** below shows the seven year peak demand forecast used throughout this TSCS.

YEAR	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
DEMAND (MW)	1833	1857	1883	1911	1939	1967	1995

Table S.2: Seven Year Peak Demand Forecast

This TSCS highlights the seven year demand forecast at all BSPs for the time of peak demand in all seasons (winter, and summer maximum). This TSCS also includes seven year forecasts for the time of minimum demand (summer minimum). These forecasts can be seen in **Appendix D**.

POWER FLOWS

This TSCS provides power flows for summer minimum conditions, to go along with summer maximum and winter maximum conditions. Power flows for 2017/18 with maximum renewable generation output have also been included. These 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:

- The modelling of the 33 kV network between BSPs and planned/existing Wind Farm Power Stations (WFPSs) to improve the accuracy of the power flow analysis
- The modelling of BSP loads with seasonal power factors and the calculation of house loads for the different generator output levels to create accurate demand scenarios
- The modelling of cluster substations to connect new WFPSs

FAULT LEVELS

Fault levels have been calculated in accordance with Engineering Recommendation G74, which itself is based upon International Standard IEC60909. This TSCS provides fault levels at times of maximum and minimum demand for 2011/12 and 2017/18. This highlights changes in fault levels brought about by increased renewable generation renewable and the introduction of the 400 kV Turleenan – Mid-Cavan tie line with RoI. Fault levels for Winter Max, 2011/12, are shown below in **Figure S.1**.

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. In later years, increased renewable generation and the new 400 kV Turleenan – Mid-Cavan tie-line with RoI raise fault levels further. The high fault levels at some substations 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**.

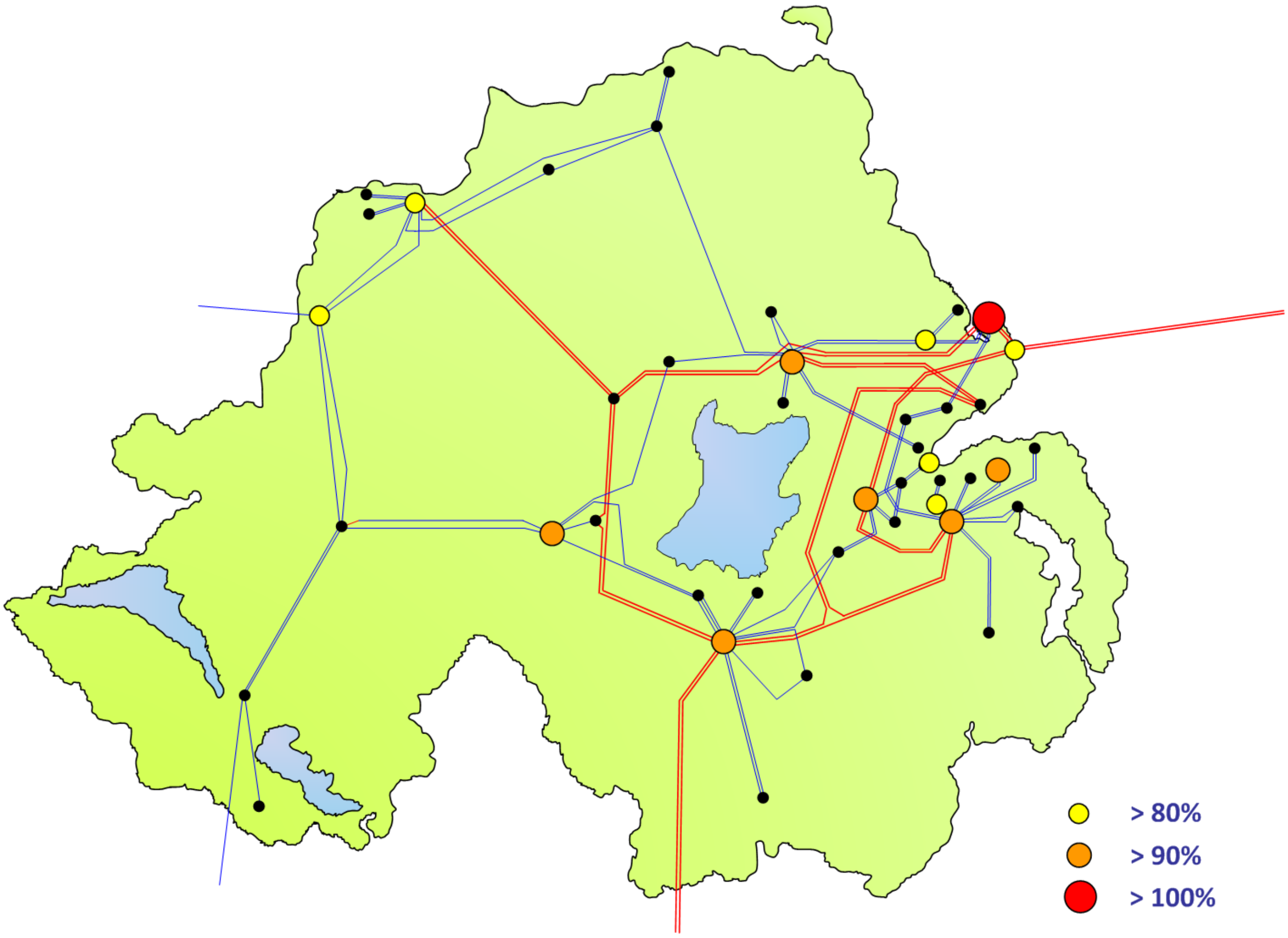


Figure S.1: Fault Levels for Winter Max 2011/12

TRANSMISSION CAPABILITY

This TSCS examines the capability of the NI transmission system to accommodate a new source of generation in the year 2017/18, 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 275 kV (map on the top) and 110 kV (map on the bottom) to accept new generation in 2017/18. 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 400 MW of capacity are represented with a yellow dot.

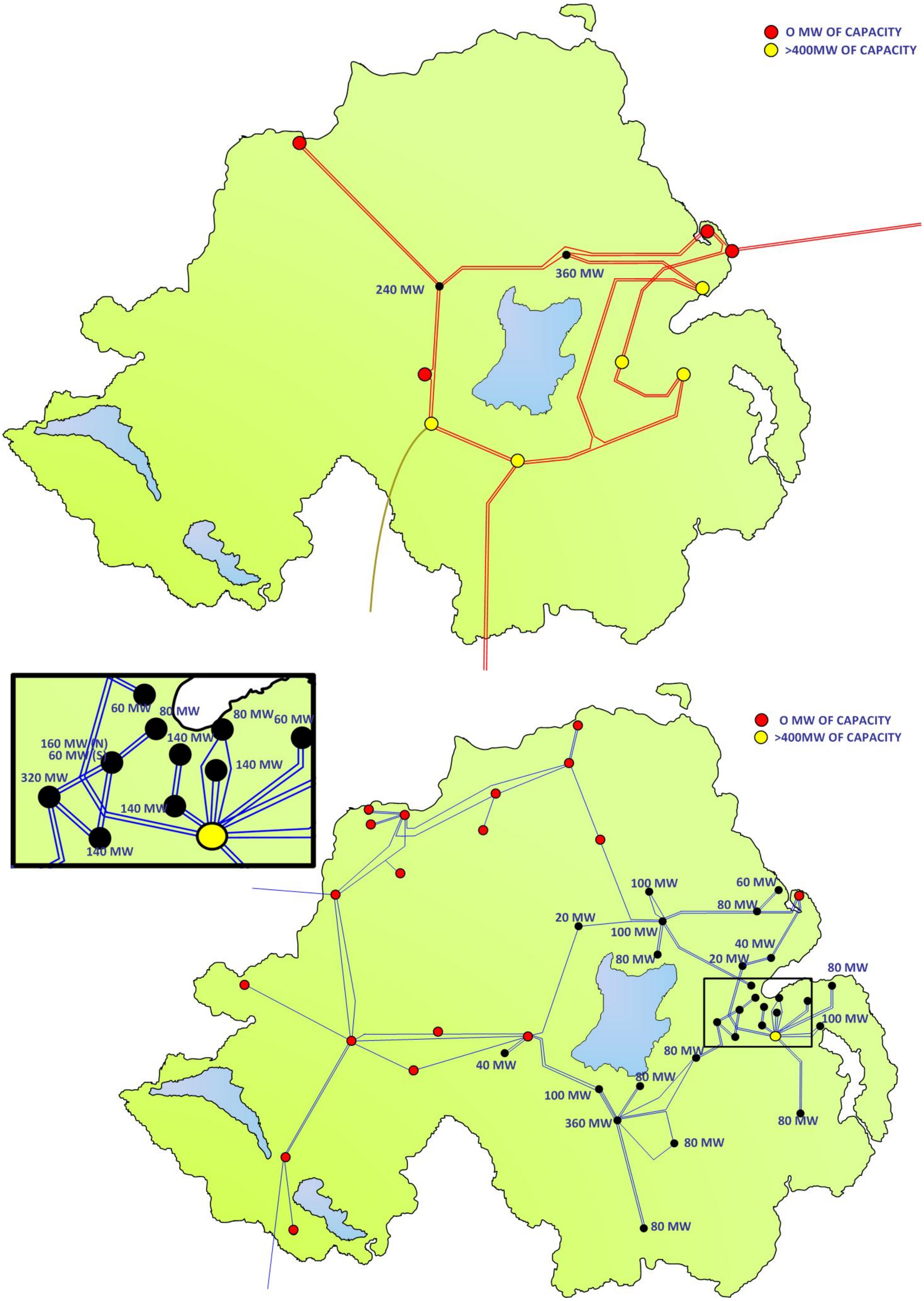


Figure S.2: Generation Opportunities at 275 kV and 110 kV for 2017/18

OPPORTUNITIES FOR NEW LARGE GENERATION AT 275 kV

The analysis shows that several 275 kV nodes could accept a new generator of size 400 MW without requiring significant transmission network reinforcement. Other nodes such as Kells and Magherafelt would also be capable of connecting a generator of significant size. However, the analysis also highlighted several areas where there is no capacity; these are the Islandmagee area (Ballylumford and Moyle), Tamnamore and Coolkeeragh.

OPPORTUNITIES FOR SMALLER GENERATION AT 110 kV

The results indicate that in 2017/18, there is no spare capacity in the North-West region of the country, despite a number of unapproved reinforcement schemes at 110 kV 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. The Network Reactive Compensation Schemes planned by NIE were required to support the voltage in the North-Western area.

As with the 275 kV studies, the best opportunities for new generation at 110 kV 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

CONCUSSIONS

The NI transmission system was originally built to a high standard in the 1960s and 1970s. Until the recent economic downturn, it had 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 this Transmission System Capacity Statement.

1 INTRODUCTION

1 INTRODUCTION

This 2011 Transmission System Capacity Statement (TSCS) 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" in a form approved by the Authority.

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 sets out the information exchange requirements and timescales to assist each party to meet its licence obligations. This TSCS forms part of the transmission planning process described in Section C of the TIA. One of the aims of the TIA is to facilitate the operation of the NI transmission system in an efficient, economically co-ordinated, safe, secure and reliable manner, as part of the All-Island 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 TSCS.

The NI transmission network is operated at 275 kV and 110 kV. 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 TSCS describes the statutory operational requirements, the existing network, its configuration and its planned development over the seven year period to 2017/18. 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 TSCS 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 renewable 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 network equipment.

Sections 6 provides the capacity of the transmission network by use of power flow diagrams for the years 2011/12, 2014/15 and 2017/18.

Section 7 analyses the network fault levels. They are calculated for Winter Maximum and Summer Minimum conditions for the years 2011/12 and 2017/18.

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**[1]
- **Licence Standards**[2]- Transmission and Distribution System Security and Planning Standards
- The SONI **Transmission Connection Charging Methodology Statement**[3]
- The **Statement of Charges**[4] for Use of the NIE Transmission and Distribution System

[1] http://www.soni.ltd.uk/gridcode.asp
[2] http://www.soni.ltd.uk/searchresults.asp
[3] http://www.soni.ltd.uk/upload/SEM-08-029%20SONI%20Charging%20%20Statement[1].pdf
[4] http://www.niegetconnected.co.uk/publications.php

- The **All-Island Generation Capacity Statement 2011-2020**[5]
- The **SONI Transmission System Performance Report**[6]

This TSCS does not assess the adequacy of generation capacity in NI. This assessment is undertaken separately and reported in the All-Island Generation Capacity Statement 2011 -2020 detailed above.

1.2 PURPOSE OF STATEMENT

The purpose of this TSCS 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 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 275 kV connection between Tandragee and Louth, and two 110 kV 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.

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

[5] http://www.soni.ltd.uk/newsstory.asp?news_id=99
[6] http://www.soni.ltd.uk/newsstory.asp?news_id=101

The SEM is currently constrained by the fact that there is not a 2nd circuit between the NI and RoI Transmission Systems. The flow of power between the two systems must be limited, and each jurisdiction must carry enough reserve to ensure that the systems are secure for the loss of the Tandragee to Louth 275 kV double circuit.

A second 400 kV tie line between Turleenan and Mid-Cavan was originally expected to be established in 2012; it has been delayed and is now expected to be complete in Winter 2016/17.

1.4 CHANGES SINCE THE LAST STATEMENT

Since the last TSCS, a number of policy documents that impact NI Transmission System development have been published; including:

- 'The Strategic Energy Framework (SEF) 2010' details NI's key energy goals in terms of ensuring security of supply, enhancing sustainability and developing our energy infrastructure. The SEF states that 40% of electricity consumption in NI should come from renewable sources by the year 2020.

- 'The Offshore Wind and Marine Renewable Energy in NI Strategic Environmental Assessment (SEA) 2009[7]' identifies the fact that although offshore renewables could make a significant contribution to the 40% target; onshore wind is the most readily available and currently least costly renewable technology. It concludes that within the 2020 timescales, onshore wind will continue to make the greatest contribution towards NI renewable electricity targets.

SONI are currently involved in the production of an Onshore Renewable Electricity Action Plan (OREAP) for NI. This OREAP is currently being developed; an Onshore SEA is due to be consulted on in Summer 2011.

If government targets are to be realised, increased renewable penetration can be expected on the NI Transmission System in next seven years. The TSCS study files contain Wind Farm Power Stations (WFPSs) which are expected to connect within the seven year period covered by this TSCS. Some of the WFPSs included the TSCS study files have not yet received approval from NIE and the Utility Regulator (UREGNI). SONI believe these generators should be included in analysis to ensure that representative outcomes are produced which highlight potential future problems on the NI Transmission System.

The Utility Regulator (UREGNI) has approved in principle NIE's policy of clustering WFPS connections. The TSCS study files contain a number of cluster substations.

---

[7] http://www.offshoreenergyni.co.uk/EnvironmentalReport.html

Additional major projects included in NIE's Transmission Investment Plan (TIP) include; Network Reactive Compensation Schemes included in the study files from Winter 2012/13; the upgrade of the Coolkeeragh-Magherafelt 275 kV double circuit from Winter 2015/16 and the upgrade of the Hannahstown-Lisburn 110 kV circuits from Winter 2016/17. At the time of writing NIE's TIP is awaiting approval from the Utility Regulator (UREGNI).

The planned North-South 400 kV connection between Turleenan and Mid-Cavan in RoI is now due to be established Winter 2016/17. The previous TSCS was based on the assumption that this circuit would be in service from 2012 onwards. As discussed in **Section 1.3** the delay of this project has major implications for the All-Island Transmission System.

The Kilroot CCGT is no longer included in the TSCS study files in line with the assumptions of the 2011-2020 All-Island Generation Capacity Statement, this issue is discussed in detail in **Section 4.1.3.**

2 MAIN TECHNICAL REQUIREMENTS OF THE SUPPLY SYSTEM

2 MAIN TECHNICAL REQUIREMENTS OF THE SUPPLY SYSTEM

It is important for parties 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 transmission system is planned and operated in accordance with the document entitled 'Transmission and Distribution System Security and Planning Standards', which has been approved by the Utility Regulator (UREGNI). The relevant standards applicable to the NI Transmission System are described in **Table G.1** of this document.

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 TSCS, a tower failure at 275 kV is considered to be a single event, i.e. the outage of two 275 kV circuits on the same tower. This is to ensure that the system does not suffer catastrophic failure.

The Security and Planning Standards were first written in the 1970s. In the intervening 40 years the Electricity Supply Industry in NI has undergone major changes with the introduction of the SEM; the large penetration of renewable generation and the movement away from a vertically integrated industry. There is an urgent requirement to review Planning, Operational and Connection Standards to ensure they meet the requirements of the new environment on the Island of Ireland.

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 (NI) 1991 set out the statutory obligations in relation to both frequency and voltage.

2.2.1 FREQUENCY

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

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 49.5 Hz for a few seconds. In such circumstances some system load may be shed automatically to assist in recovery of the frequency.

The NI and RoI Transmission Systems are connected via a 275 kV double circuit between Louth and Tandragee, and two 'power flow controlled' 110 kV 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 to complement reserve that had been provided by conventional generation. In 2010 the maximum reserve that can be provided by the Moyle Interconnector is 75 MW; 50 MW of reserve is provided when the frequency falls below 49.6 Hz and a further 25 MW of reserve is provided when the frequency falls below 49.5 Hz. Note that for imports of power from GB greater than 425 MW the reserve available from Moyle will be reduced. The Moyle interconnector also automatically reduces the import of power by 50 MW when the NI system frequency exceeds 50.3 Hz.

2.2.2 VOLTAGE

The voltage variation permitted by the Electricity Supply Regulations (NI) 1991 on the NI transmission system is ±10%. 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 110 kV voltages 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/system transformer, the electrical characteristics of the system, the level of system load and its power factor.

Voltage control is affected by providing automatic voltage control on generators, 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.

2.4 SYSTEM RELIABILITY, STABILITY AND QUALITY

The operation of the NI Transmission 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 generators 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
- Loss of customer supply

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

2.4.1 INCREASED RENEWABLE GENERATION LEVELS

The connection of generation from renewable sources such as; biomass, tidal, hydro and particularly wind changes the NI generation portfolio. An ever increasing proportion of the generation has characteristics which differ from those of conventional fossil fuel generators. SONI face many challenges to manage the NI transmission system in a safe, secure and reliable manner; these challenges include different operating conditions caused by:

- The connection of generation to the distribution network
- The introduction of new generator technologies
- Increased distances between sources of generation and load centres
- Increased risk of overloads on heavily loaded transmission corridors.

Technical areas requiring investigation include:

a) The energy source can be uncertain, this uncertainty impacts on the ramping of the system load and has implications for the required plant flexibility in NI.
b) The provision of ancillary services, including frequency response, by these renewable technologies will require attention in the future.
c) The reactive power/voltage control requirements of the NI Transmission System under transient and steady state conditions needs to be understood especially as conventional plant is increasingly becoming displaced by WFPSs which contribute less to the reactive power balance on the NI Transmission System.
d) The ability of these renewable technologies to ride through faults is considerably different from conventional plant. The behaviour of these technologies during and after a fault must be understood so that their response can be predicted and managed by SONI.
e) The affect of the reduction of the NI Transmission System inertia on the characteristics of the system needs to be understood so that the dynamic and transient stability is maintained.
f) The thermal limits of the equipment on the NI Transmission System may be exceeded under 'high wind-low demand' scenarios under maintenance/fault conditions. SONI must ensure the NI Transmission System is operated to the appropriate standards and that adequate measures are in place; such as generation constraint mechanisms, to safeguard the system.

SONI & EirGrid have investigated the above concerns in the All-Island Facilitation of Renewables Studies[8]. Further investigations are required to ensure a secure, sustainable power system. The areas requiring development are frequency response, voltage control, ramping services, operational policies. SONI is actively working with developers and manufacturers to ensure WFPSs are compliant with Grid Code and are fully controllable. Cooperation is required between all parties involved in renewable generation connections to ensure that levels of connection are effectively managed so that government targets can be met.

[8] http://www.eirgrid.com/renewables/facilitationofrenewables/

SONI is engaged in wind energy forecasting (WEPROG[9]) to manage the uncertainty of wind generation. More accurate wind forecasts facilitate the adequate commitment of thermal plant on the NI Transmission System.

SONI will be proposing modifications to the Grid Code in relation to points **a)** and **d)** above. It is likely that in order to facilitate high penetration of wind power; obligations will be required for WFPSs to contribute to system inertia (see **e)** above). **Section 4.2** discusses the increase of renewable generation into the future.

2.4.2 INTERCONNECTION WITH GREAT BRITAIN

The 500 MW 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 50 Hz ac synchronous waveform in import mode. The rapid response means that the HVDC link can have a net stabilising effect on the all-island system in the event of generation loss.

With large imports of power from GB across the HVDC link, conventional generation is displaced by this non-synchronous source of generation, this:

- Reduces the system inertia; which is also reduced by the increased wind penetration
- Increases the dynamic reactive support required by the NI Transmission System; the HVDC link does not have dynamic reactive power export capability

The HVDC link can now export up to 300 MW to GB; when the HVDC link is flowing full export, under certain contingencies, additional reactive support above those levels already planned will be required to ensure NI Transmission System reliability, stability and quality.

[9] http://www.weprog.com

3 THE NORTHERN IRELAND TRANSMISSION SYSTEM

3 THE NORTHERN IRELAND TRANSMISSION SYSTEM

This section describes the topology of the existing Northern Ireland (NI) transmission system and the future planned network developments that may occur over the coming years. Transmission developments, large generation and demand connection projects all tend to have long lead in times. Consideration of future planned network developments will give an indication of how the configuration of the system will change. NIE have supplied SONI the following information:

- A Transmission Investment Plan (TIP)
- The Transmission Network Annual Data (TNAD)
- PSS/E network files representing the seven year period covered by this TSCS
- NI Sequence Data to facilitate Fault Level Analysis for 2011/12 and 2017/18

This information as of the freeze date forms the basis of this Transmission System Capacity Statement (TSCS).

3.1 THE EXISTING SYSTEM

The NI transmission system comprises some 2,000 circuit kilometres of 275 kV and 110 kV overhead lines and cables. The backbone of the transmission network in NI was originally built to a high standard in the 1970's. This network has been very effective and has accommodated many years of load growth that was seen in NI u until the recent economic downturn. A geographic layout of the existing transmission system is shown in **Map B.1**.

3.2 CONNECTIONS WITH REPUBLIC OF IRELAND

3.2.1 275 kV CONNECTIONS

The NI and Republic of Ireland (RoI) transmission systems are connected via a double circuit 275 kV line between Tandragee and Louth, terminated in two paralleled 300 MVA 275/220 kV transformers on one circuit, and a 600 MVA 275/220 kV 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- 660 MVA 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 in NI
- Thermal overloads in some associated transmission corridors

For certain North-South power transfers; the loss of the Tandragee-Louth 275 kV circuits requires the tripping of the 110 kV Strabane-Letterkenny and Enniskillen-Corraclassy circuits as well as the fast run-back of the power flowing into NI on the Moyle HVDC Interconnector to secure the frequency stability of the NI System.

3.2.2 110 kV CONNECTIONS

In addition to the main 275 kV double circuit; there are two 110 kV connections that were commissioned in March 1995, as described below:

- Strabane-Letterkenny: single 110 kV circuit
- Enniskillen-Corraclassy: single 110 kV circuit

Until 2001 both circuits operated in a standby mode but were converted into permanent connections by the deployment of power flow controllers, rated at 125 MW. The power flow controllers are normally adjusted close to 0 MW transfer, but can be set to a desired flow to support either system during abnormal system operation. The systems are not considered stable in the absence of the 275 kV Tandragee-Louth double circuit, and therefore the 110 kV connections are automatically removed from service in the absence of both 275 kV circuits. In the event of a severe outage, e.g. Coolkeeragh-Magherafelt 275 kV 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 400 kV 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 possible power flows. The total transfer capacity will be in the region of 1500 MVA and is expected to be commissioned by Winter 2016/17.

3.2.4 CONSTRAINTS

Currently, in the event of the loss of the existing 275 kV double circuit connecting NI to RoI, the two 110 kV 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 275/220 kV 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 275 kV Circuits

Once the new 400 kV tie line comes into operation, a second high capacity path will be provided in the event of a fault on the existing circuits. The current constraints 275 kV double circuit will be revised.

The map below in **Figure 3.1** shows the location of the connections with RoI & GB.

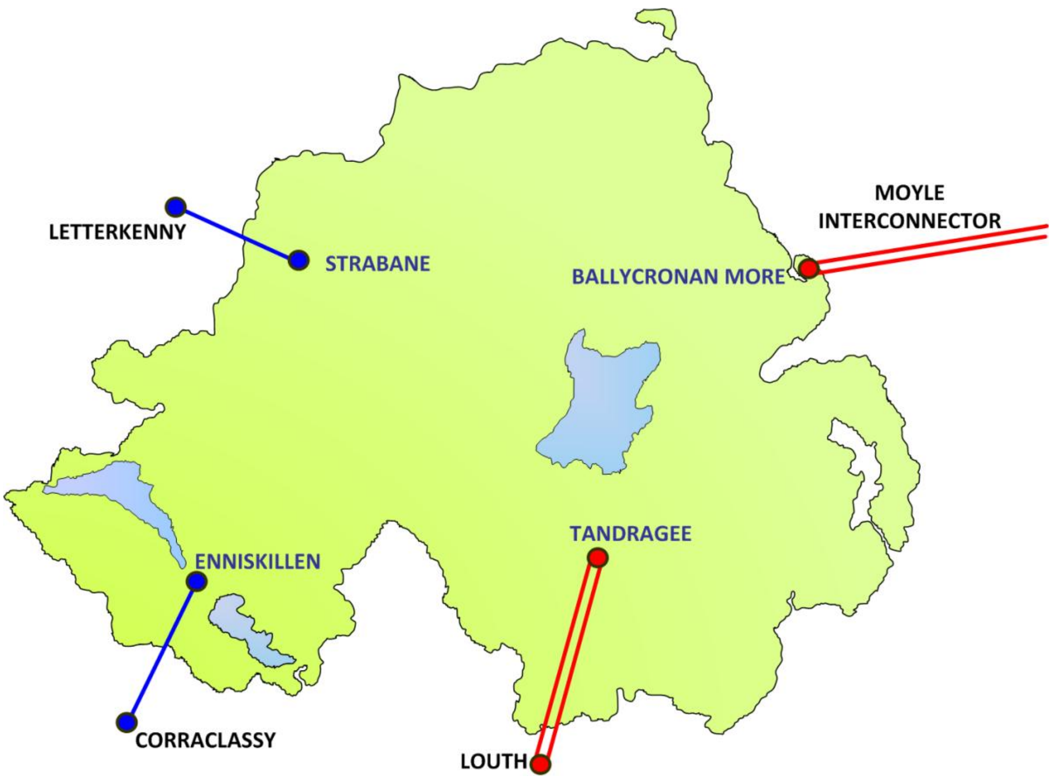


Figure 3.1: Existing Cross Border Circuits and Interconnection

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 500 MW; however, this is curtailed due to certain network limitations on both sides of the link. An emergency flow of up to 75 MW is available should the frequency in NI drop below 49.6 Hz.

The convertor station at Ballycronan More is looped into one of the 275 kV Ballylumford to Hannahstown circuits. The Moyle Interconnector is a Line Commutated Converter (LCC) HVDC link. The Moyle link is self compensating for reactive power losses. There are 4 x 59 MVAr capacitor banks at the Ballycronan More converter station with 3 of these capacitor banks acting as filters.

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.

Since the last TSCS the amount of power that is permitted to be exported from NI to GB across the Moyle Interconnector has been increased to 300 MW all year. **Table 3.2** below details the available capacity of the Moyle interconnector.

DIRECTION	SUMMER	WINTER
GB - NI	410 MW	450 MW
NI - GB	300 MW	300 MW

Table 3.2: Existing Constraints on the Moyle Interconnector

3.4 PLANNED TRANSMISSION SYSTEM PROJECTS

NIE have provided SONI with details of the transmission system projects that are planned to take place, subject to regulatory approval as part of the overall price review settlement, over the next seven years. These planned projects can be classified as either:

- Load Related Network Projects
- Asset Replacement Projects
- The North South Project
- Renewable Integration Projects
- Wind Farm Cluster Projects

The planned transmission system projects must receive capital approval from the NIE Executive before work can commence. The following sections provide details of the planned works as well the date the project is included in the TSCS study files.

In order to create TSCS study files that are as representative as possible of the future Transmission System unapproved projects have been included using provisional completion dates provided by NIE at the time of the data freeze.

3.4.1 LOAD RELATED NETWORK DEVELOPMENTS

a) TAMNAMORE MAIN 275/110 kV SUBSTATION – PHASE 1[10]

Tamnamore, a new 275/110 kV injection point, connecting at 110 kV into Dungannon Main has been established. Tamnamore Phase 1 has NIE Executive approval. A new 275/110 kV single transformer substation has been established at Tamnamore. The existing 275 kV Magherafelt to Tandragee circuit has been diverted into the substation. A new 240 MVA 275/110 kV transformer has been connected and the associated 110 kV switchgear has been installed. A new 110 kV circuit is to be constructed, to Dungannon 110/33 kV substation. The 110 kV circuit from Tamnamore to Dungannon will be constructed with

[10] NIE have undertaken to review the proposal of only turning in one 275 kV circuit based on lifetime economic costs.

UPAS at 65 °C rated at 144 MVA. The network reinforcement first appears in the TSCS study files in summer 2011.

b) HANNAHSTOWN 3rd 275/110 kV IBTX

A third 240 MVA IBTX is to be installed at Hannahstown. The demand at Hannahstown will require all supplies to be maintained for the maintenance of one 275/110 kV IBTX coinciding with a forced outage of the other IBTX. Approval is in place for the 3rd IBTX at Hannahstown and the project first appears in the TSCS study files in winter 2011/12.

c) CASTLEREAGH 4th 275/110 kV IBTX

A fourth 240 MVA IBTX at Castlereagh is to be installed. The level of demand on Castlereagh requires all supplies to be maintained for the maintenance of one 240/110 kV transformer coinciding with a forced outage of one of the IBTX's. Approval has been obtained for a fourth transformer at Castlereagh; the project first appears in the TSCS study files during winter 2012/13. This fourth IBTX planned to be switched in to manage maintenance outages.

d) BELFAST NORTH MAIN 110/33 kV BSP

A new 110/33 kV substation at Whitla Street is to be established. This substation will replace the existing 110/33 kV substation at Power Station West. This project is required due to the deterioration in condition of the substation assets at PSW. The existing Whitla Street site will be redeveloped for a new 33 kV switchboard and pair of 90 MVA 110/33 kV transformers. The existing Donegall to PSW 110 kV feeders will be turned in and connected to the proposed new 110/33 kV transformers, the residual sections of 110kV circuits to PSW will be decommissioned. This project has NIE approval and first appears in the TSCS study files in winter 2013/14.

e) BALLYLUMFORD - EDEN - CARNMONEY 110 kV CIRCUIT*

The conductor on the Ballylumford-Eden-Carnmoney 110 kV circuit is to be replaced. Upgrade is required because the loss of the Hannahstown to Ballylumford / Moyle 275 kV double circuit tower line results in significant overload of the circuit, also single circuit outages can also cause the remaining circuit to be overloaded under normal dispatch levels. It is planned to reconductor the existing double circuit tower line with a Gap conductor, which will allow the up-rating of each circuit to a minimum of 190 MVA. The project will be included in NIE's RP5 submission for approval. The Ballylumford to Eden portion of the circuit is upgraded in the TSCS files in winter 2012/13. The Eden to Carnmoney section of the circuit is upgraded in the TSCS files one year later in winter 2013/14.

f) AIRPORT ROAD MAIN

A new 110/33 kV substation at Airport Road is to be established to service the Titanic Quarter and Harbour Estate. A new substation is required because significant demand growth has been forecast in the Belfast Harbour area due to the Titanic Quarter redevelopment, Bombardier and

***After the data freeze date NIE have notified SONI that 110 kV Invar and Gap conductor will be rated at 177/181/183 MVA instead of 190/200/210 MVA**

Belfast Harbour Commissioner proposals. It is planned to construct a new 110/33 kV substation including 2 x 90 MVA transformers and 33 kV switchboard at Airport Road. 110 kV cables will be laid from the Dee Street terminal tower direct to the transformer end boxes. It is proposed that the existing Rosebank to Dee Street tower line will be connected to the 110 kV network at Rosebank in a tee off arrangement. This will take place after the Castlereagh to Rosebank 110 kV cables are replaced. This project will be included in NIE's RP5 submission for approval. Airport Road first appears in the TSCS study files during winter 2013/14.

g) CASTLEREAGH / TANDRAGEE REACTIVE COMPENSATION

Reactive support at Castlereagh and Tandragee is to be installed. This reactive compensation is required because the loss of the 275 kV double circuit tower line from Hannahstown to Moyle / Ballylumford has the potential to cause a severe reduction in voltage at Hannahstown and Castlereagh (depending on the demand and dispatch scenario). It is proposed that the reactive compensation schemes will be a combination of fixed and dynamic reactive support. In the TSCS files each substation has two fixed 25 MVAr capacitors working in conjunction with a Static Var Compensator (SVC) with a range of ± 50 MVAr. These schemes have not yet been approved and first appear in the TSCS study files in winter 2012/13.

h) NORTH WEST REACTIVE COMPENSATION

Reactive support at Coolkeeragh is to be installed. This reactive support is required because in the event of the Coolkeeragh CCGT not running and a double circuit outage of the 275 kV circuits between Coolkeeragh and Magherafelt, the 110 kV Transmission System and the synchronous compensator GT8 are not capable of supporting the voltage in the North West at peak load times. Also under certain wind generation conditions there is the potential for transmission circuit overloads in the North West. It is proposed that the reactive compensation scheme will be a combination of fixed and dynamic reactive support. In the TSCS files there are two fixed 25 MVAr capacitors working in conjunction with a Static Var Compensator (SVC) with a range of ± 50 MVAr. This scheme has not yet been approved. The North West reactive compensation scheme first appears in the TSCS study files in 2012/13 winter.

i) HANNAHSTOWN TO LISBURN 110 kV CIRCUITS

The conductor on the Hannahstown to Lisburn A and B single circuits is to be replaced. Several credible contingencies cause the above circuits to be overloaded during high transfers from North to South. With the completion of the 400 kV North-South interconnector the Net Transfer Capability is expected to be increased initially to 1000 MVA. The rating of the Hannahstown to Lisburn circuits however will restrict that. The above project is included in NIE's RP5 submission for approval. It is planned to change the conductors to match the cable sections, i.e. a rating 144 MVA. The project first appears in the TSCS study files during Winter 2016/17.

j) BALLYLUMFORD SWITCHGEAR

The switchgear at Ballylumford is to be replaced with new indoor GIS switchboard. This will allow both interbus transformers at Ballylumford to be switched in as opposed to only one presently, due to fault level concerns. It is planned to construct a new switch house. A new GIS double busbar 40 kA 110 kV switchboard will be installed and the 110 kV circuits diverted accordingly. The NIE Executive has yet to approve this project. The project first appears in the TSCS study files during winter 2013/14. It is assumed that after this work takes place both Interbus transformers at Ballylumford can be in service.

3.4.2 ASSET REPLACEMENT PROJECTS

a) CASTLEREAGH 275/110 kV IBTX 1

The Interbus transformer IBTX1 at Castlereagh is to be replaced. The replacement transformer will have a 60 MVA tertiary winding. The asset replacement first appears in the study files during winter 2013/14.

b) COOLKEERAGH 275/110 IBTX1

The Interbus transformer IBTX 1 at Coolkeeragh is to be replaced with a transformer that will have a 60 MVA tertiary winding. The asset replacement first appears in the TSCS study files during winter 2016/17.

c) BALLYMENA MAIN MESH

Two 45 MVA transformers at Ballymena Mesh are to be replaced by two 90 MVA transformers which are due to be installed and commissioned by winter 2011/12.

d) DONEGALL MAIN (NORTH)

One 60 MVA transformer at Donegal North is to be replaced by one 90 MVA transformer which is due to be installed and commissioned by winter 2011/12. Donegall North will then have two 90 MVA transformers in situ.

e) CARNMONEY MAIN

One 60 MVA and two 30 MVA transformers at Carnmoney Main will be replaced by two 90 MVA transformers. This asset replacement first appears in the TSCS files during Winter 2012/13.

f) DONEGALL MAIN (SOUTH)

It is proposed to replace two 60 MVA transformers at Donegall South with two 90 MVA transformers. The asset replacement first appears in the TSCS study files during winter 2015/16.

g) KNOCK MAIN

Two 60 MVA transformers at Knock Main are to be replaced by two 90 MVA transformers which are planned to be installed and commissioned by winter 2012/13.

h) CREGAGH MAIN

It is proposed to replace two 75 MVA transformers at Cregagh Main with two 90 MVA transformers. The asset replacement first appears in the TSCS study files during winter 2014/15.

i) BALLYMENA MAIN (SWITCHBOARD)

It is proposed to replace two 60 MVA transformers at Ballymena Switchboard with two 90 MVA transformers. The asset replacement first appears in the TSCS study files during Winter 2014/15.

j) ENNISKILLEN MAIN

It is proposed to replace two 45 MVA transformers and one 60 MVA transformer at Enniskillen Main with two 90 MVA transformers. The asset replacement first appears in the TSCS study files in winter 2013/14.

k) CASTLEREAGH TO ROSEBANK 110 kV CIRCUITS

It is proposed to replace the two existing cable circuits which will allow the up-rating of each circuit to a minimum of 144 MVA. This asset replacement first appears in the TSCS study files during winter 2013/14.

l) COOLKEERAGH MAGHERAFELT 275 kV CIRCUITS

It is proposed to change the conductor on the existing double-circuit tower line. The proposed new conductor has yet to be selected but may be Rubus 500 mm^2 AAAC. The works when complete will allow the up-rating of each circuit to a minimum of 761 MVA. The existing cable becomes the restricting element in each circuit. This asset replacement first appears in the TSCS study files during winter 2015/16.

3.4.3 NORTH-SOUTH PROJECT

A new 400/275 kV substation at Turleenan and a new 400 kV interconnector between Turleenan and Kingscourt, Co. Cavan (provisionally referred to as Mid-Cavan) is to be established. The project has in principle Regulatory and NIE Executive approval. It is planned to construct a 400/275 kV substation at Turleenan. The substation will initially be equipped with two 500 MVA transformers with a spare base and switchgear bays for a third. The Tamnamore to Tandragee and Magherafelt to Tandragee circuits will be looped into the 275 kV double bus. It is also proposed to construct an 80 km 400 kV single circuit tower line from Turleenan to Kingscourt.

The new circuit will have a rating of approx 1500 MVA. With two transformers in service initially however the interconnector will be rated at 1000 MVA. All switchgear will have a fault rating of 40 kA. This project first appears in the TSCS study files during winter 2016/17. Once this connection is established, the constraints on the existing Tandragee-Louth 275 kV double circuit (see Section 3.2.4) will be removed.

3.4.4 RENEWABLE INTEGRATION PROJECTS

a) DUNGANNON TO OMAGH 110 kV CIRCUITS – PHASE 2[11]

The remaining lengths of the Dungannon Omagh 110 kV Circuits that were not replaced during Phase 1 works will be reconductored with INVAR conductor. The cable on circuit B will also be replaced. Phase 2 works will enable each circuit to have a minimum rating of 190 MVA. This work is due to be completed by winter 2011/12.

b) OMAGH MAIN 110/33 kV TRANSFORMERS

Two 60 MVA transformers at Omagh Main will be replaced by two 90 MVA transformers. For a transformer outage at Omagh it is possible that in the presence of wind, the remaining 60 MVA unit could be significantly overloaded. The two 90 MVA transformers are due to be installed and commissioned by winter 2011/12.

c) KELLS COLERAINE 110 kV CIRCUIT PHASE 1

It is proposed to up-rate one side of the existing 110 kV tower line between Terrygowan and Kells with the INVAR conductor. In terms of the PSS/E network files the resistance, reactance and susceptance of the circuit between Kells and Coleraine is altered when this network reinforcement first appears in the TSCS study files in winter 2012/13.

d) TAMNAMORE MAIN 275/110 kV SUBSTATION – PHASE 2

Phase 2 is the completion of the Tamnamore 275/110 kV project. It is proposed to extend the existing 275 kV and 110 kV double busbars at Tamnamore, install a second 275/110 kV transformer and loop in the Dungannon-Drumnakelly and Dungannon-Creagh 110 kV circuits. Dungannon Main will be supplied by two radial circuits from Tamnamore Main. The network reinforcement first appears in the TSCS study files during winter 2013/14.

e) OMAGH TO TAMNAMORE NEW 110 kV CIRCUIT

It is proposed to construct a 3rd Tamnamore to Omagh 110 kV single circuit during 2013, following on from Tamnamore Phase 2 works where the two Omagh to Dungannon 110 kV circuits were reconfigured to become two Omagh to Tamnamore circuits. This 3rd circuit will be approximately 45 km in length on Portal construction and conductored with Zebra strung for 75 ^{o}C. The circuit will also be looped in to connect with the proposed Fallaghearn

[11] After the data freeze date NIE have notified SONI that the rating of these circuits will be limited to 150 MVA by the mesh at Dungannon. After the completion of Tamnamore Phase 2 these circuits will be rated at 177/181/183 MVA

WFPS cluster substation. The network reinforcement first appears in the TSCS study files during winter 2013/14.

f) **KELLS COLERAINE 110 kV CIRCUIT PHASE 2***

It is proposed to up rate approximately 26 km of the 110 kV line between Terrygowan and the loop-in point for the Mid-Antrim WFPS cluster substation (**Section 3.9.4**). As with Kells-Coleraine Phase 1 it has been assumed that the upgrade will be to Invar conductor, strung for 200 ^{o}C. The phase 2 works, when complete, will allow the up rating of the circuit betweens Kells and Mid-Antrim to a minimum of 190 MVA. This network reinforcement first appears in the TSCS study files from winter 2014/15 onwards.

g) **OMAGH ENNISKILLEN 110 kV CIRCUITS**

It is proposed to up-rate both sides of the double circuit tower line to cope with the wind generation being connected in Co. Fermanagh. The works when complete will allow the up-rating of each circuit to a minimum of 109 MVA. This network reinforcement first appears in the TSCS study files in winter 2015/16.

h) **COOLKEERAGH-LIMAVADY-COLERAINE 110 kV CIRCUITS***

It is proposed to up-rate the 110 kV circuits between Coolkeeragh, Limavady and Coleraine to accommodate the wind farm clusters expected to connect to the Limavady Main node. It has been assumed that the upgrade will be to INVAR conductor, strung for 200 ^{o}C. When works are complete the circuits will be up rated to a minimum of 190 MVA. This network reinforcement first appears in the study files in winter 2015/16.

i) **KELLS COLERAINE 110 kV CIRCUIT PHASE 3***

It is proposed to up-rate the remaining 20 km section of the 110 kV line between the loop-in point for the Mid-Antrim WFPS cluster substation (**Section 3.9.4**) and Coleraine. It has been assumed that the upgrade will be to INVAR conductor, strung for 200 ^{o}C. When works are complete the circuit will be up rated to a minimum of 190 MVA. This network reinforcement first appears in the TSCS study files in winter 2015/16.

3.4.5 WIND FARM CLUSTER PROJECTS

a) **KILLYMALLAGHT 110/33 kV CLUSTER**

A new 110/33 kV substation is currently under construction, the substation will comprise of one 60 MVA transformer. The site is adjacent to the Coolkeeragh to Strabane 'C' 110 kV circuit, approximately 10 km south of Coolkeeragh and 16 km north of Strabane Main. The existing Coolkeeragh to Strabane 'C' circuit is to be looped into Killymallaght. Installation and commissioning are expected to be complete by autumn 2011. Slieve Kirk WFPS will feed into the Killymallaght cluster via a 110 kV circuit.

***After the data freeze date NIE have notified SONI that 110 kV Invar and Gap conductor will be rated at 177/181/183 MVA instead of 190/200/210 MVA

b) MAGHERAKEEL 110/33 kV CLUSTER*

A new 110/33 kV substation with two 90 MVA transformers is to be constructed. The cluster substation is to be located approximately 38 km west of Omagh Main. A single 110 kV overhead line circuit will be constructed (AP1 construction) to connect the new cluster node into the existing 110 kV mesh at Omagh Main. The conductor is likely to be UPAS, strung for 75 ^{o}C; this circuit will be limited to a rating of 144 MVA due to cable connection into the Omagh Main. Magherakeel first appears in the TSCS study files in summer 2012.

c) FALLAGHEARN 110/33 kV CLUSTER

It is proposed to construct a 110/33 kV substation with one 60 MVA transformer at a site adjacent to the proposed new 110 kV Omagh to Tamnamore 3rd circuit approximately 19 km east of Omagh Main and 38 km west of Tamnamore Main. The new circuit would be looped into this new cluster hub. Fallaghearn cluster first appears in the TSCS study files in winter 2013/14.

d) POMEROY 110/33 kV CLUSTER

The proposed establishment of a 110/33 kV substation with one 60 MVA transformer at a site adjacent to the existing 110 kV Omagh to Dungannon B circuit (following Tamnamore Phase 2 works this circuit will be re-named 'Omagh to Tamnamore' (**Section 3.6.4**)), approximately 21 km east of Omagh Main and 18 km west of Tamnamore Main. The existing circuit will be looped into this new cluster substation. Pomeroy cluster first appears in the TSCS study files in winter 2013/14.

e) MID-ANTRIM 110/33 kV CLUSTER

The construction of a 110/33 kV substation with one 60 MVA transformer at a site close to the existing Coleraine to Kells 110 kV circuit, approximately 20 km southeast of Coleraine Main. The existing circuit will be looped into this new cluster substation via the construction of two portal 110 kV circuits of 6 km in length each. The conductor is assumed to be Invar, strung for 200 ^{o}C. This cluster first appears in the TSCS study files in winter 2014/15.

f) ALTAHULLION 110/33 kV CLUSTER

A new 110/33 kV substation is to be constructed with one 60 MVA transformer. The Altahullion Cluster is to be located approximately 13 km southwest of Limavady Main. A single 110 kV overhead line circuit will be constructed (AP1 construction) to connect the new cluster hub into the existing 110 kV mesh at Limavady Main. The conductor is likely to be UPAS, strung for 75 ^{o}C the circuit is limited to a rating of 144 MVA because of cable connection into Limavady Main. This cluster first appears in the TSCS study files in Winter 2014/15.

*****After the data freeze date NIE have notified SONI that 110 kV Invar and Gap conductor will be rated at 177/181/183 MVA instead of 190/200/210 MVA

3.5 SPECIAL PROTECTION SCHEMES

Special protection schemes (SPSs) monitor the network and take automatic action to protect system assets when faults occur. For example, SPSs may detect low network voltages, circuit overloads, or circuit tripping, and protect system assets by automatically reconfiguring the network, disconnecting demand/generation or changing the output of generation.

The design of individual SPSs determines how they effect network operation in specific parts of the network listed below. The TSO would not view SPSs as satisfactory long term solutions, as they could have a negative impact on system security in the future.

SONI is currently comparing the level of generation that is disconnected via SPS to the reserve available on conventional thermal plant. There is a limit to the amount of generation that can be securely connected by utilising SPS disconnection.

It is important when investment decisions are taken that complete economic costs are considered; this analysis should include costs of potential constraints along with the implications on the cost of energy in the SEM on the Island of Ireland. SONI is concerned about the interaction of the SPSs on the NI Transmission system; it is increasingly difficult to determine the impact of an unexpected event because of the added operational complexity that SPSs cause on the NI Transmission System.

3.5.1 110 kV CIRCUIT PROTECTION SCHEME: TANDRAGEE-DRUMNAKELLY

Under certain 110 kV 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.

3.5.2 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 275 kV double circuit
- Both 275/110 kV IBTXs at Coolkeeragh

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

3.5.3 MOYLE LOW FREQUENCY RESCUE FLOW

If the frequency of the NI system falls below 49.6 Hz, the Moyle interconnector provides a rescue flow of 50 MW. If the frequency continues to fall, at 49.5 Hz a further 25 MW is provided. As the frequency recovers, the rescue flow is stopped once the frequency rises above 49.8 Hz. A reduction in the import from Scotland is also triggered if the NI system frequency exceeds 50.3 Hz.

3.5.4 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 300 MW. This scheme also trips the 110 kV Strabane-Letterkenny and Enniskillen-Corraclassy circuits.

3.5.5 BALLYLUMFORD GENERATION TRIPPING SCHEME

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

3.5.6 NORTH WEST GENERATION CURTAILMENT SCHEME[12]

If generation in the North West is operating at high output at times of low NI demand, and an outage of the 275 kV double circuit between Coolkeeragh and Magherafelt occurs, the local 110 kV 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 160 MW along with the disconnection of Gruig and Curryfree WFPSs (40 MW). In addition, a special protection scheme monitoring for overloads on the 110 kV circuits between Omagh and Dungannon will automatically reduce the output of Slieve Divena, Hunters Hill, Screggagh and Tappaghan Extension WFPSs.

[12] SONI is particularity concerned with the reliability and use of this SPS. The operation of this SPS has caused C30 CCGT to trip. It is important that adequate reactive support (see **section 3.7.1**) is available in the North West to ensure the NI Transmission System is secure for the mal-operation of this SPS.

3.6 TRANSMISSION SYSTEM DATA

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

3.6.1 BUSBAR DATA

The data for the year 2011/12 is given in **Table A.1**. The data comprises the node definition, voltage, active and reactive load.

3.6.2 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 year 2011/12 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 TSCS. There may be instances where protection system characteristics produce a further limitation.

3.6.3 TRANSFORMER DATA

BSP, cross-border connections and generator transformer data for the year 2011/12 are 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 TSCS.

3.6.4 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 TSCS are indicated in **Tables A.8** and **A.9.**

3.6.5 3-WINDING GENERATOR TRANSFORMER DATA

The Kilroot OCGTs KGT3 and KGT4 are connected to the transmission system via a 3 winding transformer. Data relating to this generator transformer is displayed in **Table A.7.** This comprises the transformer upper and lower tapping ratios, the number of tap steps, winding resistance/reactance and rating information.

3.6.6 SHUNT DATA

Table A.10 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.12** describes the location, voltage level and magnitude of installed fixed reactive support. Capacitance that is to be added to the system over the seven year period covered by this TSCS is detailed in **Table A.11**.

3.6.7 SVC DATA

Table A.12 indicates the location, voltage level and the upper and lower limits of the Static Var Compensation that is to be added to the system over the seven year period covered by this TSCS. The operation of this equipment will be variable and dependent on network operating conditions

4 GENERATION

4 GENERATION

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

The expected increase renewable generation capacity (predominantly wind) will have a large impact on the operation and planning of the NI transmission system over the next seven years. It is important to understand the composition of the NI generation portfolio as well as how system operating characteristics are likely to change in the period covered by this TSCS.

For a detailed generation adequacy analysis, SONI in conjunction with EirGrid have published the All-Island Generation Capacity Statement 2011-2020[13].

4.1 CONVENTIONAL GENERATION CAPACITY

In NI conventional thermal generation plant can be spit into two contractual categories:

- Plant contracted to NIE PPB (Contracted Plant)
- Independent Power Producers (Non-Contracted Plant)

Table C.2 provides a complete list of contracted and non-contracted generators connected to the NI transmission system.

4.1.1 CONTRACTED CONVENTIONAL GENERATION CAPACITY

Plant contracted to NIE via their Power Procurement Business (PPB) under pre-vesting contracts, or contracts negotiated thereafter, totals 1007 MW, 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 Utility Regulator (UREGNI) may cancel contracts at earlier cancellation dates. On the 10th of June 2010 UREGNI took the decision to end the GUAs for the coal/oil fired Kilroot generating units K1 and K2 after a consultation process[14].

The Power Purchasing Agreements (PPA) or Generating Unit Agreements (GUAs) cover availability, operating characteristics, payments, metering etc. These Agreements cover matters such as

[13] http://www.soni.ltd.uk/newsstory.asp?news_id=99

[14] http://www.uregni.gov.uk/uploads/publications/100610_GUA_Cancellation_Decision_Paper_Final.pdf

outage planning, emissions and fuel stocks. PPB pays a Transmission Use of System (TUoS) to SONI.

4.1.2 NON-CONTRACTED CONVENTIONAL GENERATION CAPACITY

UREGNI has a duty to promote competition in the generation and supply of electricity; this is in line with the EU IME Directive (concerning common rules for the internal market in electricity 2003/54/EC), which was introduced in June 2003. Coolkeeragh C30, Kilroot K1, K2, KGT3 and KGT4, the Moyle Interconnector, as well as B5 and B6 at Ballylumford are all Independent Power Producers (IPPs) in NI. IPPs pay a Transmission Use of System (TUoS) to SONI.

4.1.3 PLANNED CONNECTIONS OF CONVENTIONAL GENERATION PLANT

AES Kilroot still holds a formal connection offer for additional generation capacity. At the time of the data freeze Kilroot have been unable to confirm a commissioning date for this additional generation. In a change to the previous statement, no thermal generation plant is planned to connect to the NI Transmission System over the seven years covered by this TSCS.

4.1.4 ASSUMED RETIREMENT OF CONVENTIONAL GENERATION PLANT

In line with the All-Island Generation Capacity Statement 2011-2020; it has been assumed by SONI that Ballylumford units B4, B5 and B6 will be decommissioned by December 2015. This decommissioning is driven by the EU Heavy Fuel Oil Directive.

4.2 RENEWABLE GENERATION

4.2.1 RENEWABLE GENERATION DEVELOPMENT INITIATIVES

NON FOSSIL FUEL OBLIGATION

There are a number of renewable generation schemes that are contracted with NIE under the Non Fossil Fuel Obligation 2 (NFFO2.) The commissioned schemes are shown in **Table C.3**. Contracts will expire from between April 2012 and August 2013. For the purposes of this TSCS, it is assumed that all the plant will continue to remain available as renewable IPP plant.

NORTHERN IRELAND RENEWABLES OBLIGATION (NIRO)[15]

Under the Renewables Obligation Order (Northern Ireland) 2011, there is a legal requirement on all NI licensed electricity suppliers, to provide Ofgem (on behalf of the Utility Regulator (UREGNI)) with evidence that a specified quantity of the electricity supplied to final consumers, can be accounted for by generation from renewable sources.

[15] http://www.detini.gov.uk/deti-energy-index/deti-energy-sustainable/northern_ireland_renewables_obligation_.htm

Renewable electricity generation technologies receive Renewables Obligation Certificates (ROCs) for the electrical energy they generate. Suppliers can then buy these ROCs to fulfil part of their Renewable Obligation. The obligation is set at a level higher than the amount of renewable generation available; giving ROCs a value. The income renewable generators receive from ROCs incentivises the development of renewable generation technologies in NI.

4.2.2 EXISTING/APPROVED RENEWABLE GENERATION

The WFPS schemes that are already connected to the NI network, and schemes approved for development or that are in construction at the time of the data freeze, are listed in **Table C.4**. In Autumn 2011 the first transmission connected WFPS in NI is due to be connected at 110 kV. Slieve Kirk will have a capacity of 27.6 MW will be connected at the Killymallaght cluster.

As was discussed in **Section 3.8** NIE are developing WFPS clusters which consist of a 110/33 kV substation in the vicinity of a number of WFPS locations. These WFPSs would connect into the cluster at the 33 kV level.

Figure 4.1 shows the locations of WFPSs that are connected or under construction at the time of writing or have had their connection offer accepted. The map indicates the various 110/33 kV Bulk Supply Points (BSPs) and WFPS clusters substations they feed into, up to the winter of 2017/18.

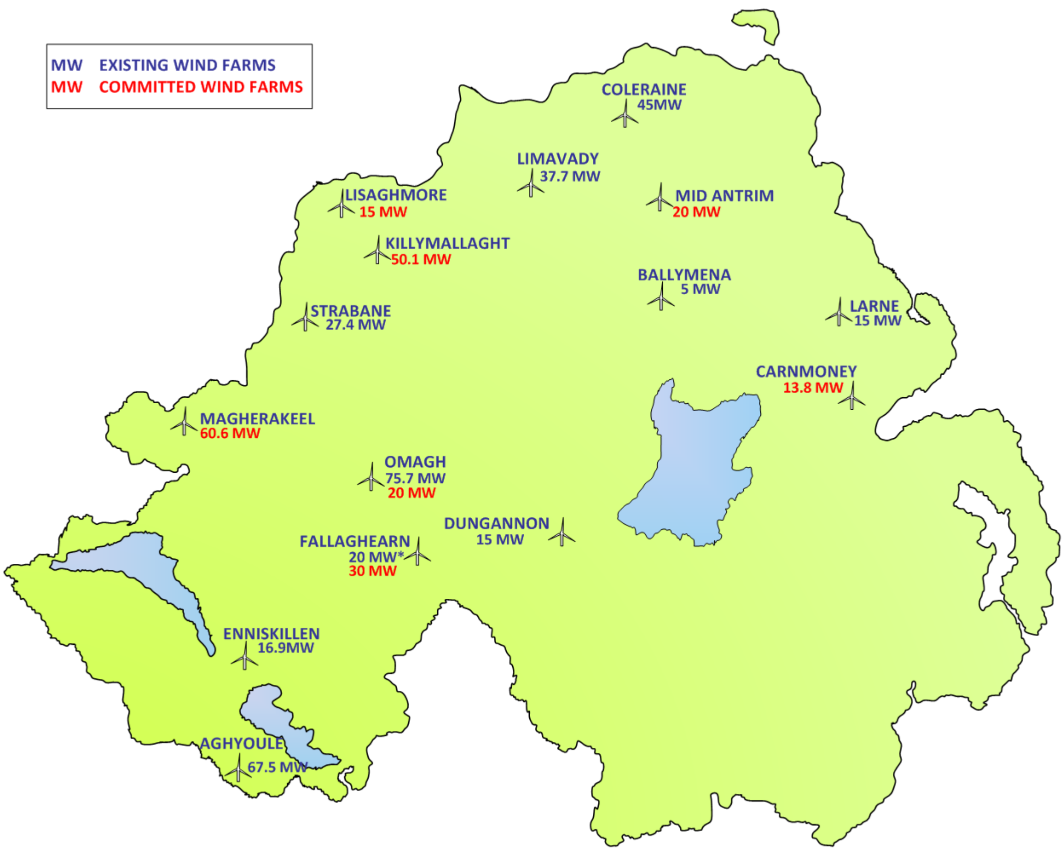


Figure 4.1: Existing and Committed Wind Farms

4.2.3 UNAPPROVED RENEWABLE GENERATION

The Draft Strategic Energy Framework (SEF) 2010 for NI states that 40% of electricity consumption 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 40% government target translates into approximately 1600 MW of renewable generation capacity in NI. This figure is a reduction on the figure quoted in the 2009 TSCS as the NI demand in 2020 is now forecast to be lower. This demand reduction can be attributed to the economic downturn.

If the SEF 2020 target for electricity is to be met; it is clear that the NI wind generation capacity in the year 2017/18 will need to be greater than the 542.3 MW of renewable generation that is connected or approved for connection at the time of the data freeze.

In order to ensure that this statement is representative of the future NI transmission system; renewable projects that were not approved by NIE at the time of the data freeze, but are expected to connect to the NI Transmission System over the next seven years have been modelled in the TSCS study files. The unapproved wind generation that has been included in the TSCS study files are detailed in **Table 4.1** and **Appendix C.5**.

TRANSMISSION NODE	UNAPPROVED CAPACITY (MW)						
	2011	2012	2013	2014	2015	2016	2017
ALTAHULLION					27.6	27.6	27.6
ANTRIM					7	7	7
ENNISKILLEN				3	3	3	23.7
FALLAGHEARN				22.5	22.5	31.5	31.5
KILLYMALLAGHT			20	20	35	35	35
LARNE				10	10	10	10
LIMAVADY						63	123
MAGHERAKEEL		37.5	37.5	37.5	76.5	76.5	88.5
MID-ANTRIM				18	18	18	18
NEWRY			12.5	12.5	12.5	12.5	12.5
OMAGH						71.7	71.7
POMEROY				47	47	53	53
Totals	**0**	**37.5**	**70.0**	**150.5**	**259.1**	**408.8**	**501.5**

Table 4.1: Capacity and location of unapproved wind generation (by year end)

It should be noted that NIE have indicated that Slieve Divena WFPS will transfer from Omagh to Fallaghearn Cluster in 2014. **Figure 4.2** uses information from the list of wind applications in the planning service to demonstrate where renewable generation may be located in 2020.

Figure 4.2: Potential Renewable Generation in 2020

It is clear from **Figure 4.2** that the majority of the renewable connections are in the Northern and Western regions of the province. This coincides with some of the weakest areas of the existing transmission network. It can be concluded that for NI to meet renewable targets, improvements will have to be made to the transmission network in these areas.

The Renewable Integration Development Project RIDP[16] is currently identifying the optimum reinforcement of the electricity transmission grid in the north and the north west of the island to cater for expected power output from renewable energy sources.

4.3 NORTHERN IRELAND GENERATION MIX

The chart in **Figure 4.3** 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.

[16] www.ridp2020.com

Figure 4.3 shows a surplus of generation in relation to the demand. However, factors such as economic dispatch, wind variability, reserve requirements and actual HVDC interconnector flows are not taken into account.

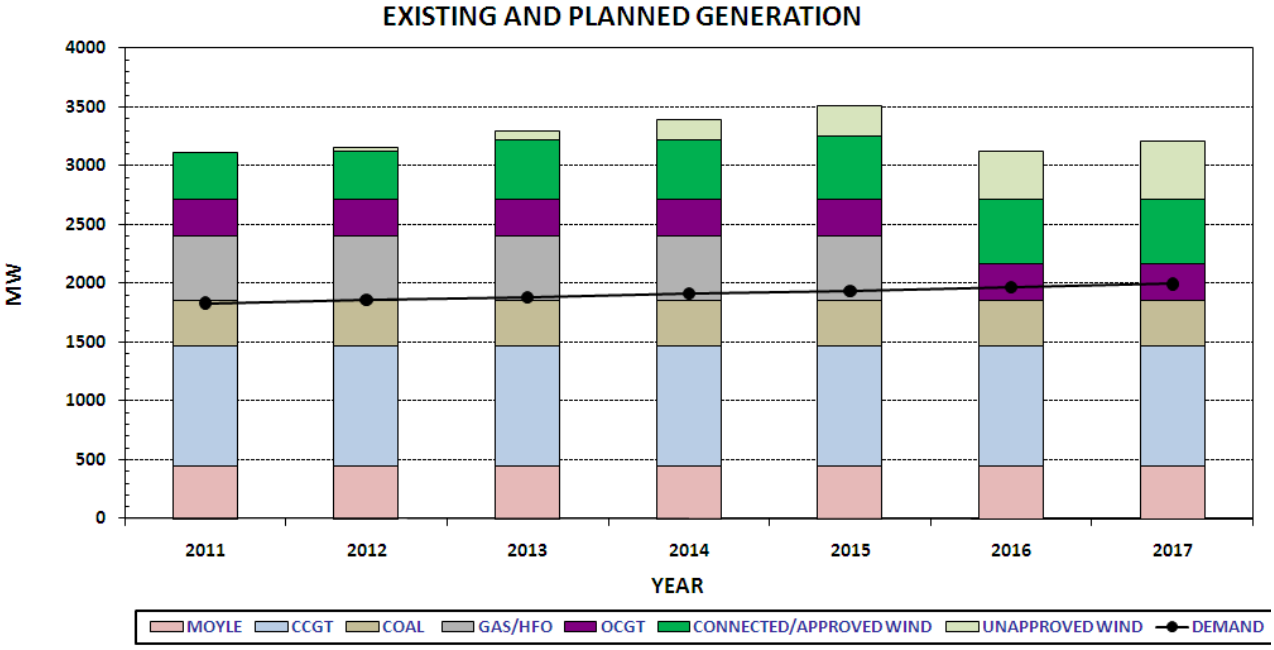


Figure 4.3: Existing and Planned Generation 2011-2017

The assumed retirement of Ballylumford B4, B5 and B6 in December 2015 means that NI Generation capacity is reduced by 540 MW for the last two years of study. This reduction in GAS/HFO generation capacity means that if the Moyle HVDC link and wind generation are removed from the stack for example, NI would have a generation deficit and would be depending on energy from RoI to meet the peak demand. The chart also shows the large increases in wind generation expected over the next seven years.

4.4 SMALL SCALE EMBEDDED GENERATION

4.4.1 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 2009/10 winter, generation of this type is estimated to total 44 MW. This is a reduction compared to previous years, where figures of 100 MW were calculated. This further reduction can be attributed to the economic downturn occurring in NI and rising generation costs. A 22 MW Aggregated Generating Unit (AGU) is operated by Energia in the SEM. The AGU is made up of diesel generator sets located around NI.

4.4.2 COMBINED HEAT AND POWER

There are currently 3 fully dispatchable 3 MW CHP units operated by Contour Global in NI. These units currently participate in the Single Electricity Market. There is a further 8 MW of CHP plant connected to the NI System; this 8 MW is expected to rise to 19 MW by 2017. SONI has considered this increase when forecasting demand growth for the period covered by this TSCS.

4.4.3 BIOMASS & BIOGAS

In NI there is currently 1 MW of solid bio fuels and 13 MW of landfill gas generation. It is assumed that by 2020 biomass generation capacity is expected to increase to 2 MW and biogas generation capacity is predicted to 27 MW.

4.4.4 SMALL-SCALE RENEWABLE ENERGY SYSTEMS

The UK Renewable Energy Strategy (RES[17]) describes how in April 2007 the Code for Sustainable Homes came into operation as the national standard for sustainable new build homes. A rating from 1 to 6 for new homes designed and assessed against the Code is helping developers to build more sustainable homes which include, where appropriate, small-scale renewable energy systems.

Typically homes built to Code level 3 and above, the current standard for publicly-funded housing, have high levels of energy efficiency to reduce the energy requirement combined with solar thermal or photo voltaic panels, air or ground source heat pumps as well as biomass boilers. Implementation of these renewable energy schemes will affect the NI demand profile. The impact on the NI Demand profile will be monitored into the future as these schemes become more prevalent.

4.4.5 OFF-SHORE WIND AND MARINE GENERATION

Offshore Renewable Energy Strategic Environmental Assessment (SEA) 2009[18]; has concluded that between 900 MW and 1200 MW of electricity could be generated by 2020 from offshore wind and marine renewables (tidal arrays) in NI waters. The SEA stated that these levels of off-shore renewable generation can be accommodated without significant adverse effects on the environment. The SEA has identified two main resource zones for off-shore renewable generation;

[17] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx
[18] http://www.offshorenergyni.co.uk/EnvironmentalReport.html

- ‘Zone 1’ is off the north-coast
- ‘Zone 2’ is off the east-coast

The Crown Estates are seeking expressions of interest in September 2011 for the right to develop renewable generation in NI waters. At the time of writing SONI are in contact with these developers regarding the connection of off-shore renewable generation. It is not expected that this off-shore wind or marine generation will be connected by the period covered by this TSCS.

4.4.5 SMALL SCALE HYDRO

There are currently 3 MW of small-scale hydro generation installed on the waterways of NI. This is a mature technology however due to the lack of suitable new locations; the small-scale hydro capacity is not expected to increase in the foreseeable future.

4.5 ELECTRIC VEHICLES (EV)

The UK Renewable Energy Strategy (RES[19]) has detailed targets for energy consumption. The RES is aiming to achieve has set a target for 10% of transport energy consumption from renewable sources by 2020.

Travel by road is responsible for 70.3% of all energy consumed in the transport sector therefore offering the largest benefit from decarbonisation. One of the emerging technologies in this sector is the Electric Vehicle (EV). To meet the 10% target by 2020 there is likely to be an increase in NI System Demand in the coming years as a result of EV charging. SONI have preliminary studies ongoing into the operational implications of potential demands on the network caused by EV.

4.6 GENERATION OPERATION

The scheduling and dispatch of generation is 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 in the event of a forced generator outage, SONI/EirGrid known what unit(s) should economically be called on to meet demand.

[19] http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx

4.7 HARMONISED ANCILLARY SERVICES[20]

Ancillary Services are products, other than energy, that are required to ensure the secure operation of the transmission system. These services form part of the System Support Services (SSS) in NI. The provision of Ancillary Services on the Island of Ireland has been harmonised so that generators in NI and RoI are treated with parity.

These AS agreements cover details of payments and charges associated with reserve and reactive power provision.

4.7.1 RESERVE

Transmission systems must be able to deal with unexpected losses of generation capacity or unexpected increases in demand. This is accomplished by maintaining a prudent level of operating margin. The operating margin is the amount of reserve available (provided by additional generation or demand reduction measures) above that required to meet the expected power system demand. The prudent level of operating margin required for the island is set jointly by the SONI and EirGrid.

Critical factors which input into setting that prudent level include the largest in-feed on the island, variability in load and generation in the operational timeframe, generation reliability and the reliability of provision by service providers of reserve. Service providers are contracted to provide reserve through the AS agreements.

Currently in the SEM, the total combined system spinning reserve requirement is based on 75% of the largest island in-feed. Also NI generating units currently must carry at least 50 MW of spinning reserve between them. The 275/220 kV Tandragee-Louth tie line enables spinning reserve to be shared between the NI and RoI Transmission Systems. The allocation of sharing spinning reserve is kept under review to maintain an optimal economic and secure operation of the combined systems. In addition to this spinning reserve the Moyle Interconnector can carry up to 73.5 MW of static reserve depending on the flow of power between GB and NI.

When the 275/220 kV Tandragee-Louth tie-line is in operation; at least three thermal generating units in NI are dispatched; when the tie line is out of service and NI isolated from the RoI Transmission System, a minimum of four thermal generating units are dispatched on the NI Transmission System. If required SONI can restore the generation-load balance by shedding load via a low frequency selective tripping scheme.

[20] Harmonised Ancillary Services Policy Decision Paper
http://www.allislandproject.org/en/transmission_decision_documents.aspx?page=2

4.7.2 REACTIVE POWER

SONI and EirGrid must maintain voltage stability on the Island of Ireland; this is achieved by ensuring that there are the appropriate levels of reactive power reserves (leading and lagging) available throughout the NI transmission system. Generators can provide dynamic reactive power support to the NI Transmission System.

It should be noted that the Transmission System voltage can also be controlled by:

- Altering transformer tap positions,
- Switching in/out shunt reactors or capacitors and
- In future, the Network Reactive Compensation Schemes described in **Section 3**

5 DEMAND

5 DEMAND

This section of the Transmission System Capacity Statement (TSCS) describes the base demand data, upon which, the analysis 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. SONI are aware that temperature and economic activity are factors that can affect demand.

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.

The past two years have been difficult for the NI Economy because of the recession and the associated reduction in Public expenditure. It is anticipated that, with the prospect of dwindling public expenditure in 2011 and the following year’s economic growth will be restricted and this may lead to a decline in business activity. This resultant reduction in business activity will have an impact on the SMD forecast.[21]

This 2011-2017 TSCS is based on the SMD forecast data up to and including the 2009/10 winter period. The 2009/10 NI system peak demand was **1866 MW**. This peak demand occurred on Tuesday 12th January 2010 between 17.00 and 17.30hrs. **Table 5.1** shows when the system peak demand is adjusted to ACS conditions, the corrected peak demand was found to be **1796 MW.**

GENERATION TYPE	2009/10
Centrally Dispatched Generating Units + Interconnectors	1547 MW
Renewable Generation	275 MW
Customer Private Generation	44 MW
System Maximum Demand	1866 MW
ACS Corrected System Maximum Demand	**1796 MW**

Table 5.1: NI 2009/10 ACS System Maximum Demand

[21] M. Smyth: First Trust Bank economic outlook and business review 25.4 December 2010

This 2009/10 ACS peak demand of **1796 MW** is a reduction from the 2008/09 ACS peak demand value of **1824 MW** reflecting the downturn in the NI economy. The 2010/11 ACS peak of **1796 MW** ties in well with the forecasted 2010/11 ACS peak that was based on the 2008/09 data of **1793 MW.**

The generated SMD profile for 2009/10, including renewable generation, is 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.

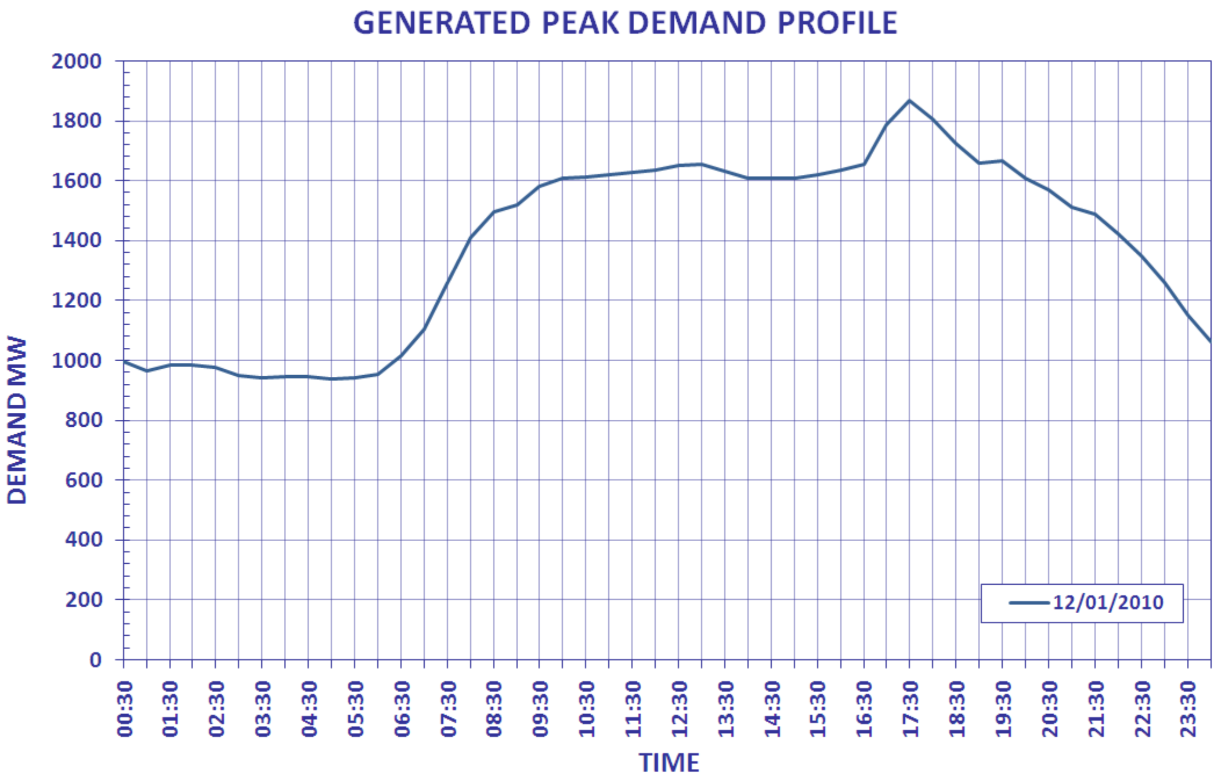


Figure 5.1: Generated Peak Demand Profile for 2009/10

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 2009/10. For the purposes of this statement these seasons defined as:

- **Winter Maximum**; the highest NI demand between December 2009 and January 2010 inclusive
- **Autumn Maximum**; the highest NI demand between September 2009 and November 2009 inclusive
- **Summer Maximum**; the highest NI demand between May 2009 and August 2009 inclusive
- **Summer Minimum**; the lowest NI demand between May 2009 and August 2009 inclusive

Note that the winter profiles do not include the demand that was suppressed by customer private generation.

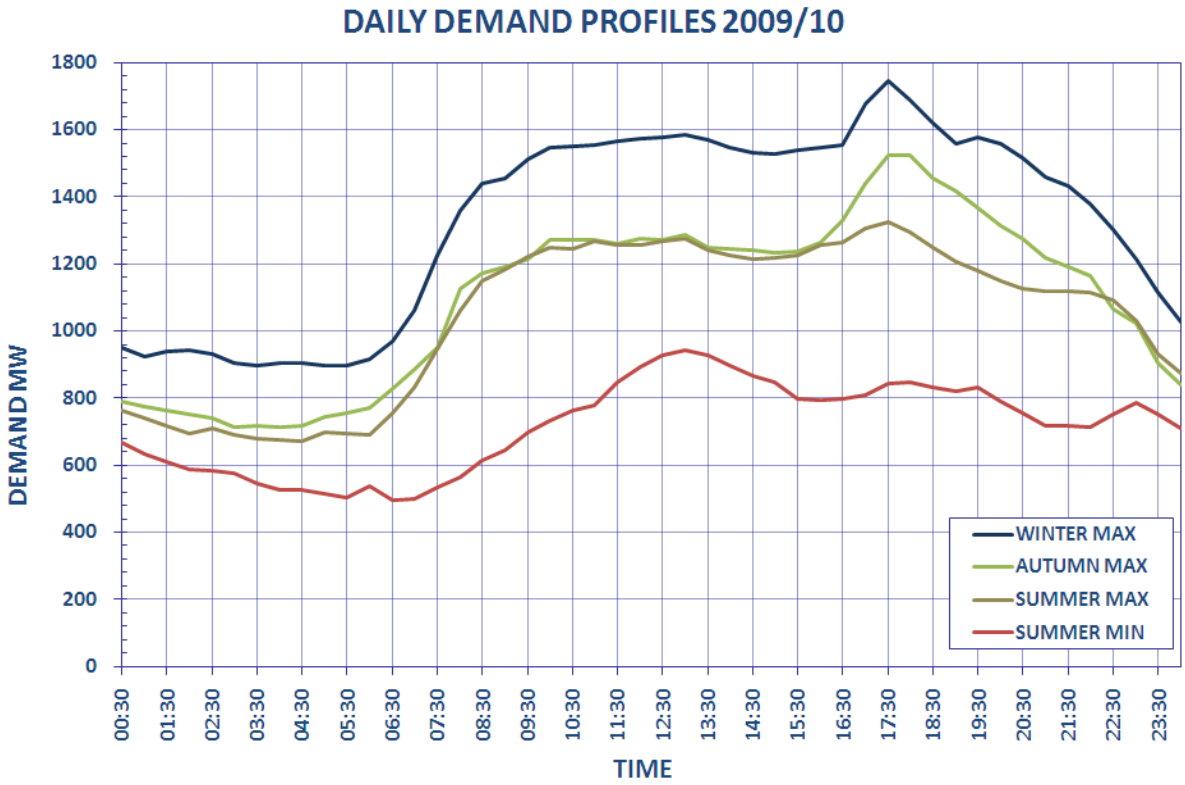


Figure 5.2: Daily Demand Profiles for 2009/10

5.2.1 WINTER

The winter profile is at similar levels to the profiles seen in previous years because of the low temperatures in the 2009/10 winter. As for the shape of the profile the night-time loads during winter are higher than in summer and autumn. Between the hours of 06:30 and 09:00 there is a sharp rise to reflect the build up to the working day, before demand flattens out until the evening time peak.

The time of peak demand for the winter 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.

5.2.2 AUTUMN & SUMMER MAXIMUM

Milder temperatures in autumn 2009 have highlighted the fact that the NI demand has fallen in 2009 compared with the previous year. When compared with the autumn 2008 the profile has dropped from winter maximum overnight levels closer to Summer Maximum profile.

The summer maximum profile is less 'peaky' than the autumn and winter profiles with a reduced load factor, generally reduced levels of demand at the tea time peak at (17:30) and the later onset of the lighting load, at 21:00.

5.2.4 SUMMER MINIMUM

The time of summer minimum demand occurred at 06.30am on Sunday the 12th of July 2009. This is reflected in the fact that the time of peak demand is around 13:00, due to the increased lunchtime cooking load. The summer minimum time period is becoming increasingly important from an operational planning perspective. At reduced load levels achieving the minimum generation capability with the correct mix of generation can become operationally problematic. This situation is exacerbated as distributed connected generation penetration levels increase. In 2009/10, the demand is around 29% of winter peak.

5.3 LOAD DURATION CURVE

Figure 5.3 shows the NI load duration curve for 2009/10. The curve shows the percentage of time in the year that a particular demand value was exceeded. For example, demand exceeded 1000 MW for more than 54% of the time.

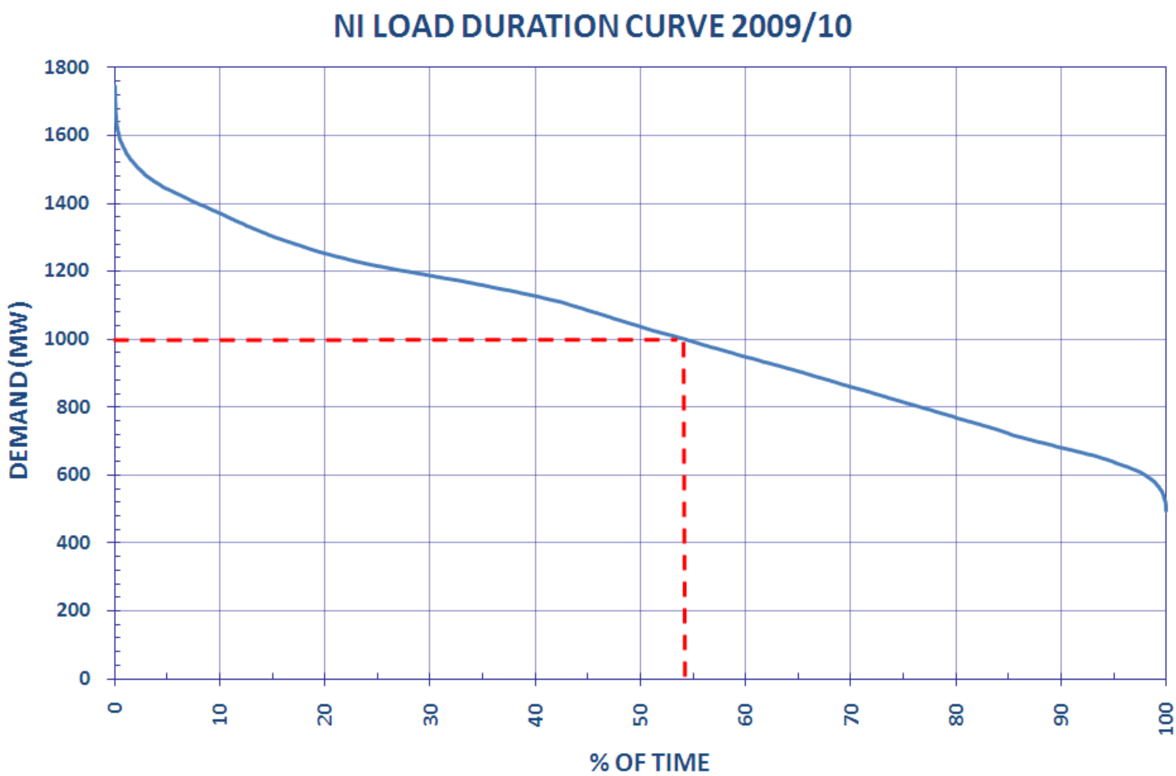


Figure 5.3: Load Duration Curve 2009/10

5.4 SYSTEM MAXIMUM DEMAND FORECAST

The graph in **Figure 5.4** plots the historic system peak demands for the past 30 years. The red line on the graph is a trend line, highlighting the average growth in peak demand over the 30 year period.

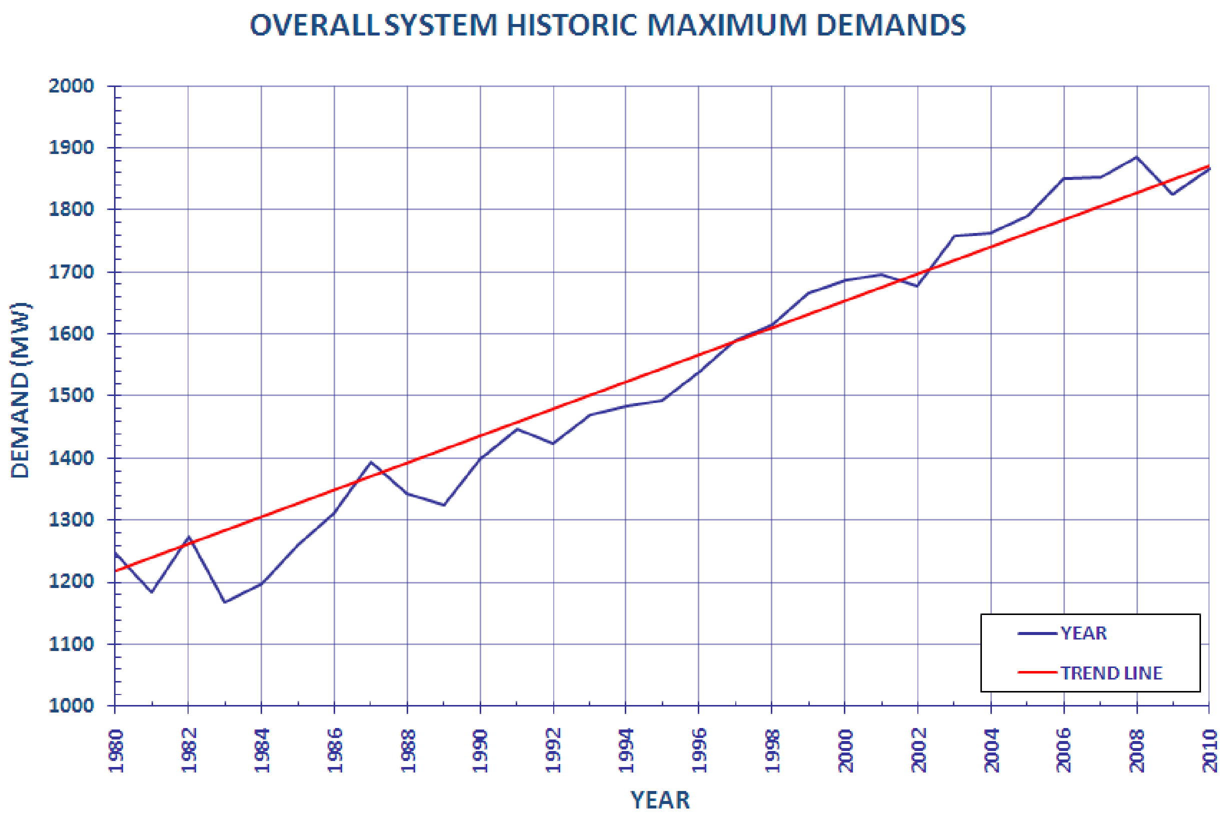


Figure 5.4: System Historic Peak Demand Profile

Figure 5.4 shows that between 2002/03 and 2007/08 the peak demand has been above average, the peak demand plot takes a sharp decline below the trend line in 2008/9. The 2009/10 peak is higher than the previous year because of the exceptionally cold temperatures experienced in NI in the winter of 2009/10.

Due to continued economic uncertainty, 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 economy makes 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 demand stays constant into 2011, 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 forecast scenarios and also shows the historic ACS peak demands from winter 2000/01 onwards.

SCENARIO	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
REALISTIC	1833	1857	1883	1911	1939	1967	1995
PESSIMISTIC	1799	1809	1824	1845	1866	1888	1909
OPTIMISTIC	1865	1898	1931	1965	1999	2034	2070

Table 5.2: Seven Year ACS Peak Demand Forecast

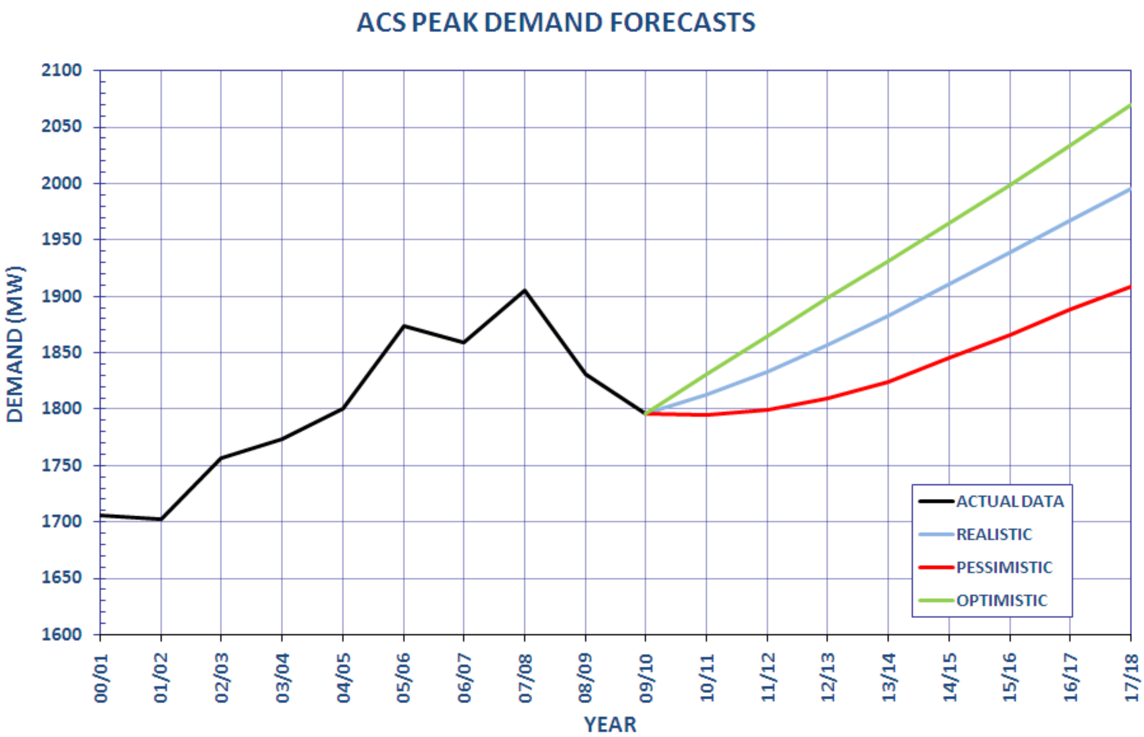


Figure 5.5: Three ACS corrected peak demand forecast scenarios

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

5.5 110/33 kV BULK SUPPLY POINT DEMAND

The BSP demand forecasts are provided by 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 winter, autumn and summer BSP total installed transformer capacity, substation firm capacity and predicted demands, in MVA, are given in **Tables D.1, D.3** and **D.4. Table D.1** presents the winter peak demand forecast, in MVA, at each substation, based on a single circuit outage. It has been necessary to use single circuit outage condition as this reflects the most onerous condition with respect to use of plant capacity.

The firm capacity is based on the loss of one in feed (or transformer) 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 capacity has been, or will be, exceeded over the seven year period.

Specifically these substations are:

- Drumnakelly
- Eden
- Lisaghmore
- Strabane
- Waringstown
- Knock
- Donegall Main (North)

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**.

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 and **D.4** present the demand forecast in MVA under single circuit outage conditions for the next seven years for Autumn Maximum and Summer Maximum.

In this TSCS, results of an investigation into the risk of thermal overload caused by renewable generation power flows at times of low system demand can be seen in **Table D.5**. This analysis has been carried out at substations where there are high levels of distribution connected wind generation for 2011, 2014 and 2017.

A negative loading in **Table D.5** indicates that the renewable generation is supplying the distribution connected load at the BSP and is supplying power onto the NI Transmission System.

Table D.6 gives an indication of the available capacity at the BSPs under Summer Minimum load conditions with maximum wind generation. Like **Table D.2** the purpose of this table is to assist network users in assessing connection opportunities. **Table D.6** shows that power flows at the Aghyoule and Omagh BSPs exceed the substation ratings.

6 TRANSMISSION SYSTEM POWER FLOWS

6 TRANSMISSION SYSTEM POWER FLOWS

The power flows are represented on schematic diagrams of the 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 as specified in the Transmission and Distribution System Security and Planning Standards.

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 power flow studies for the forthcoming seven year period.

Power flows are provided for the NI transmission system for the years 2011/12, 2014/15 and 2017/18. The power flows display network voltages for all system 275, 110 and 33 kV 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 TSCS considers three representative seasonal power flows for each of the years above. The seasons and load conditions are:

- Winter maximum load condition (100% of the ACS Winter Peak)
- Summer maximum load condition (77% of the ACS Winter Peak)
- Summer minimum load condition (29% of the ACS Winter Peak)

The power flow studies represent normal system conditions with no transmission or generator 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 projects described between **Sections 3.4 - 3.9**. 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 economic basis, with power flows across the existing 275 kV and planned 400 kV tie lines maintained within capacity and transfer limits. As is common operational practice, reactive power transfers across the tie-lines are kept to a minimum. The 110 kV connections between NI and 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 TSCS. In line with what has been observed flowing on Moyle throughout the last year, the following assumptions have been used in this section:

SCENARIO	POWER FLOW (GB-NI)
WINTER MAX	325 MW
SUMMER MAX	317 MW
SUMMER MIN	235 MW

Table 6.1: Moyle Interconnector Assumed Flows

It should be noted that these assumed flows are larger than assumed in previous statements the implications of the larger Moyle flows particularly for the Summer Minimum condition are discussed in **Section 6.2**.

In all power flows, from H1 to H9, wind is running at 30% of installed capacity this approximates to the expected load factor for NI wind generation. Details on wind farm locations and capacities can be found in **Appendix C.4**.

Since the previous TSCS the key changes to the transmission system model for power flows studies include:

- Modelling of the 33 kV network between BSPs and planned/existing WFPS connections.
- Modelling of BSP loads with seasonal power factors. This change generally reduces the reactive power required from the NI Thermal Plant in the power flows when compared to the previous statement. This change has been validated by analysis SONI has carried out on BSP metering at different times of the year.
- The calculation of house loads for the different generator output levels enables accurate representation of the system demand conditions in the TSCS study files.
- The modelling of cluster substations to connect new WFPSs

These key changes result in more accurate power flow conditions and more representative results.

6.2 POWER FLOWS FOR 2011/12

The three power flows presented for the study year 2011/12 can be found in **Appendix H** and are as follows:

- **Figure H1**: Summer Maximum, 2011
- **Figure H2**: Summer Minimum, 2011
- **Figure H3**: Winter Maximum, 2011/12

Key projects in the 2011/12 power flows include:

- Tamnamore Phase 1: the establishment of a new 275/110 kV substation
- Dungannon-Omagh Phase 1: upgrade of the Dungannon-Omagh circuits to the dynamic line rating value of 120 MVA for Summer and Autumn 2011.
- Dungannon-Omagh Phase 2. The rating of both Dungannon-Omagh circuits are increased to 190/200/210 MVA by Winter 2011/12*
- The 3rd Hannahstown IBTX is included in the Winter 2011/12 file

The 2011 Summer Minimum power flow shows an export of circa 240 MW to the Republic of Ireland (RoI), this is an increase from the 27 MW export observed on the Tandragee-Louth 275 kV double circuit in the Summer Minimum power flow from the previous statement. This increased North-South flow can be attributed to:

- Higher minimum generation level of the 3 NI thermal machines due to AES Kilroot increasing the minimum stable generation level of K1 and K2 to 110 MW (generated)[22]
- The increased assumed power flow from Great Britain (GB) on the Moyle interconnector

As with the previous statement at Summer Minimum load conditions; Power flows can be seen on the Coolkeeragh to Magherafelt 275 kV double circuit. Similar flows can be observed on the 110 kV Kells-Coleraine and Dungannon-Omagh circuits. These power flows from the North-West are a result of the generation in the North-West region exceeding the local demand

The 2011/12 Winter Maximum power flow shows an import of roughly 120 MW from RoI. This is due to about 1000 MW of new high merit order CCGT plant operating in RoI, coupled with the NI wind generation displacing older, less efficient plant in NI.

[22] http://www.uregni.gov.uk/uploads/publications/100610_GUA_Cancellation_Decision_Paper_Final.pdf

*After the data freeze date NIE have notified SONI that 110 kV Invar and Gap conductor will be rated at 177/181/183 MVA instead of 190/200/210 MVA

6.3 POWER FLOWS FOR 2014/15

The three power flows presented for 2014/15 can be found in **Appendix H** and are as follows:

Figure H4: Summer Maximum, 2014
Figure H5: Summer Minimum, 2014
Figure H6: Winter Maximum, 2014/15

By winter 2014/15 NI wind generation capacity has increased from winter 2011/12 levels of 398 MW to 685 MW. Three significant, unapproved projects are included in the 2014/15 TSCS study files to accommodate this increase in wind generation capacity. In brief, these are:

- Tamnamore Phase 2, completion of the 275/110 kV substation
- Construction of a 3rd 110 kV circuit between Omagh and Tamnamore
- Introduction of Reactive Compensation Schemes at Castlereagh, Tandragee and Coolkeeragh

The completion of Tamnamore substation results in an operational requirement to run the Drumnakelly to Tamnamore 110 kV circuits open. This operational change is driven by the need to ensure the power flows, created by wind generation in the North West are transferred up onto the 275 kV transmission network at the Tamnamore node.

By winter 2014/15 there is 685 MW of NI wind generation capacity in the study files. This wind generation is made up of approved and unapproved connections. The unapproved wind generation can be seen modelled at 'xx' generators.

NI wind generation is modelled in power factor control mode with a target power factor of 0.98. This WFPS control regime results in an increased reactive power demand on the NI Transmission System in 2014/15 compared to 2011/12. The Network Reactive Compensation Schemes, (described in **Section 3.4.4**) located at Castlereagh, Coolkeeragh and Tandragee partially supply this increased reactive power load. These schemes reduce the reactive power flows that would otherwise be seen flowing across the NI Transmission System from generation sources in the East. It can be seen that in winter 2014/15 the reactive compensation schemes are supplying 125 MVAr to the NI Transmission System.

The 110/33 kV wind cluster substations (see **Section 4.2.2**) can be seen in the 2014/15 network diagrams. The Mid-Antrim, Pomeroy and Fallaghearn clusters are connected into existing 110 kV circuits. Magherakeel and Altahullion clusters are connected by single 110 kV lines to Omagh and Limavady respectively.

6.4 POWER FLOWS FOR 2017/18

The three power flows presented for 2017/18 can be found in **Appendix H** and are as follows:

Figure H7: Summer Maximum, 2017
Figure H8: Summer Minimum, 2017
Figure H9: Winter Maximum, 2017/18

The most significant change to the NI Transmission System by 2017 is the introduction of the new Turleenan – Mid-Cavan 400 kV tie line with RoI. This 400 kV line and associated 400/275 kV substation at Turleenan is due to be established in winter 2016/17.

The Phase 2 plant at Ballylumford Power Station B4, B5 and B6 are no longer assumed to be in use from December 2015 due to EU legislation on emissions. The CCGT at Kilroot that was included in the previous TSCS has not been included in these power flow studies as discussed in **Section 4.1.3**.

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 4.7**). It has been suggested that after the establishment of the Turleenan – Mid-Cavan 400 kV tie line; this rule can be relaxed to a minimum of two generating units. Detailed analysis has still to be completed to verify this. In this TSCS, the summer minimum case in 2017 has still been dispatched with three machines. System studies have shown that these machines must include a Coolkeeragh machine and a Kilroot machine to maintain voltage stability.

In all 2017/18 power flow cases, circulating power flows can be seen on the connections with RoI. As was the case in the previous TSCS power is generally imported on the 400 kV line and exported on the 275 kV line details can be seen in **Table 6.2** below.

Scenario	Tandragee – Louth 275 kV	Turleenan – Mid-Cavan 400 kV	Net North South Flow
Summer Minimum 2017	-240 MW	137 MW	-103 MW
Summer Maximum 2017	-94 MW	133 MW	39 MW
Winter Maximum 2017/18	-105 MW	162 MW	57 MW

Table 6.2: 2017/18 Net North-South Power Flows[23]

When the WFPSs are dispatched at 30% output; transmission loadings remain within circuit ratings. Under certain contingencies, overloads can be seen; this is investigated in **Section 8** - Transmission System Capability.

[23] A Negative flow indicates an export from NI to RoI

6.5 POWER FLOWS FOR 2017/18 WITH MAXIMUM WIND

This section of the report has been included to highlight the effects of significant wind generation on the NI transmission system. In summer 2017, 951.1 MW of wind capacity is connected to the NI Transmission System, this figure increases to 1040.2 MW by winter 2017/18. In all cases the wind generators are operating at 100% active power output in power factor control mode with a target p.f. of 0.98 leading.

The three power flows presented for the maximum wind studies in 2017/18 can be found in **Appendix H** and are as follows:

Figure H10: Summer Maximum, 2017
Figure H11: Summer Minimum, 2017
Figure H12: Winter Maximum, 2017/18

To accommodate this wind under the Summer Minimum loading conditions; the Moyle Interconnector flow has been reduced from the assumptions stated in **Table 6.1**. In Summer Minimum power flow, Moyle is exporting 150 MW to GB. There is a net flow of 588 MW to RoI in the summer minimum power flow.

The large amount of wind generation in NI, particularly in the Northern and Western regions of the country, drives significant flows of power from the North-West to the East; details of these increased power flows can be seen in **Table 6.3**.

SCENARIO	KEY NETWORK FLOWS (MW)		
	Coolkeeragh - Magherafelt 275 kV	Omagh[24] - Tamnamore 110 kV	Mid-Antrim - Kells 110 kV
Summer Minimum 30% Wind	240	110	29
Summer Minimum 100 % Wind	480	255	88

Table 6.3: Increasing Power Flows from the North-West

The increased wind output also reduces the voltage at nodes with high levels of wind generation. For example the Omagh 110 kV bus voltage in is 1.038 p.u. in power flow **H8** with 30% wind; this Omagh bus voltage falls to 1.010 p.u. when wind output is increased to 100 % in summer minimum power flow **H11.**

The power flows with maximum wind show large reactive power flows from the transmission system onto the distribution system. These power flows increase the active and reactive power

[24] Power flows on the Omagh/Pomeroy/Fallaghearn to Tamnamore 110 kV circuits netted together

losses on the NI transmission system dramatically. There is an extra 100 MVAr of reactive power losses in the **H11** power flow compared with the **H8** power flow that has a 30% wind dispatch.

SONI has notified NIE (the Transmission Owner) of concerns regarding voltage control and voltage stability in these high wind scenarios. It is hoped that any future Transmission Investment Plans and cluster proposals address these issues.

As is discussed in **Section 4.2.3**, ambitious renewable generation targets are being set for NI; investigation into how this extra generation can 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 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 2011/12
- Summer Min 2011
- Winter Max 2017/18
- Summer Min 2017

Only the NI transmission nodes are published in this Statement, though the analysis is based on an all-island model as both the NI and RoI systems will contribute to fault levels in either jurisdiction.

Winter peak and summer minimum demand scenarios have been studied, as they should be indicative of the full range of anticipated fault levels. Two years have been considered for study; 2011/12 highlights issues with the current network, while 2017/18 considers a future network with additional expected 400 kV interconnection and generation levels etc.

In this section summary of the results will be presented and consideration is given to the areas where specific issues arise and need to be addressed by 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 0 MW 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 2011/12 and Winter Maximum 2017/18. 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 2011/12 and 2017/18 are discussed in **Sections 7.3 and 7.4**.

7.3 WINTER 2011/12 RESULTS

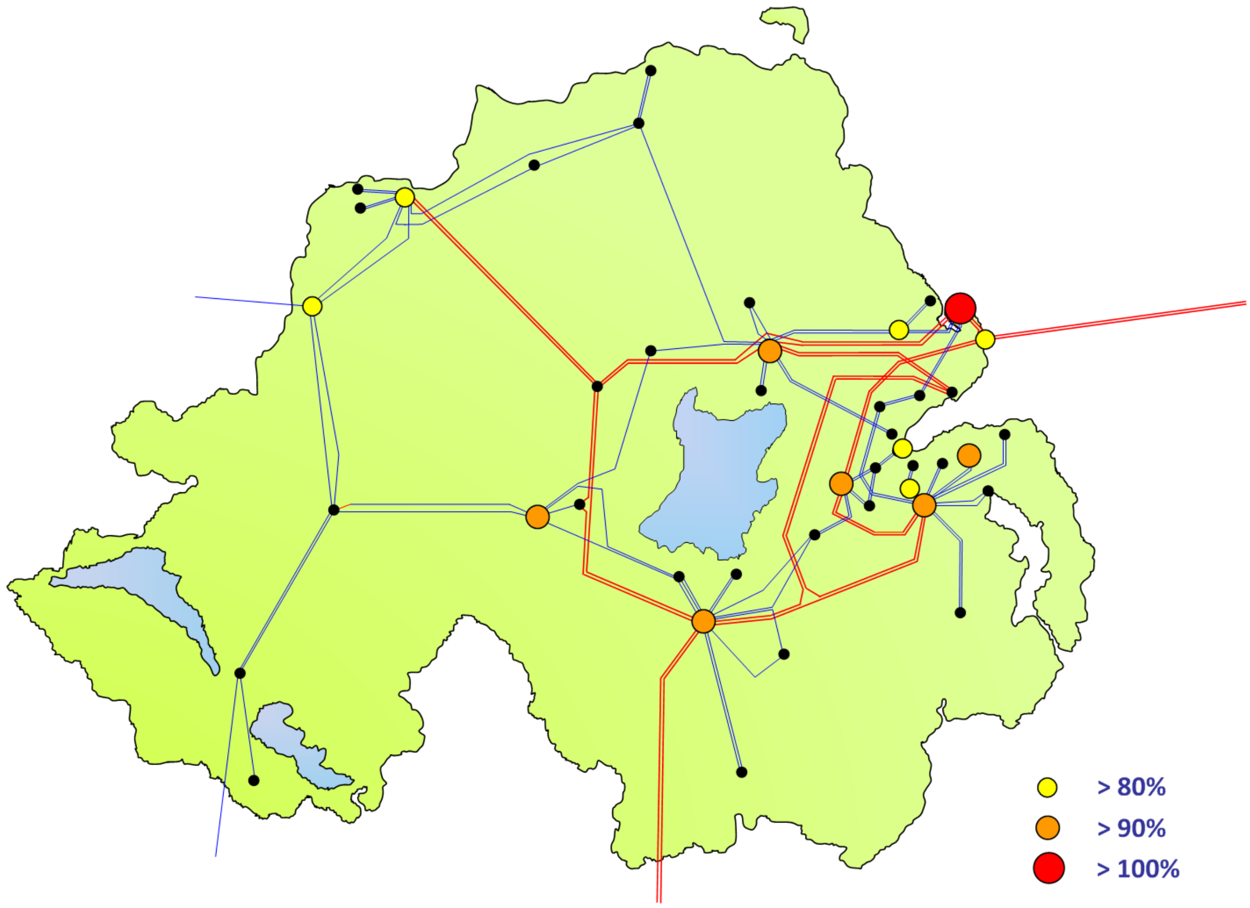


Figure 7.1: Winter Max 2011/12 Fault Levels

The map in **Figure 7.1** indicates that a significant number of 110 kV transmission nodes in NI experience short circuit currents in excess of 80% of their rated capability. The Ballylumford 110 kV node experiences fault levels in excess of 100% of its rated capability. **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
>90	BALLYLUMFORD	275
	CASTLEREAGH	110
	DUNGANNON	110
	HANNAHSTOWN	110
	KELLS	110
	KNOCK	110
	TANDRAGEE	110

Table 7.1: 2011/12 Nodes Approaching or Exceeding Rating

These nodes are spread geographically across NI; from Dungannon in the West, to Knock 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 such as circuit reconfiguration have been employed by SONI.

7.3.1 SUBSTATIONS WHERE THE RATING HAS BEEN EXCEEDED

BALLYLUMFORD 110 kV

The fault levels at the 110 kV 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 275/110 kV interbus transformers (IBTXs) are in service. The substation is programmed to be replaced with a new 110 kV GIS switchboard, with work due to be completed by Winter 2013/14. In the interim, SONI 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 110 kV network around Ballylumford is also used to manage fault levels.

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

CASTLEREAGH 110 kV

The rating of Castlereagh 110 kV substation is limited by the disconnectors which have a certified rating of 26.2 kA. With all available generation in service, the fault level of 26.17 kA is within 5% of the disconnector rating. The 110 kV substation is presently being rebuilt with the disconnectors scheduled for replacement with 40 kA equipment within the next three years.

KELLS 110 kV

The fault level at Kells 110 kV node is approaching the substation rating, being within 3% of the rated value. The refurbishment of the Kells 110 kV substation is due to be completed by Winter 2016/17. After the refurbishment work is complete the substation equipment will be rated for 40 kA.

7.3.3 WINTER 2011/12 CONCLUSIONS

This analysis indicates that fault levels are particularly high at a number of nodes geographically spread across NI as detailed in **Table 7.1**. Any potential generation connections will require careful and detailed fault level analysis to determine the impact on 275 kV and 110 kV plant and equipment ratings across the NI transmission network. Plans are in place at Ballylumford, Castlereagh, and Kells to improve the substation ratings

7.4 WINTER 2017/18 RESULTS

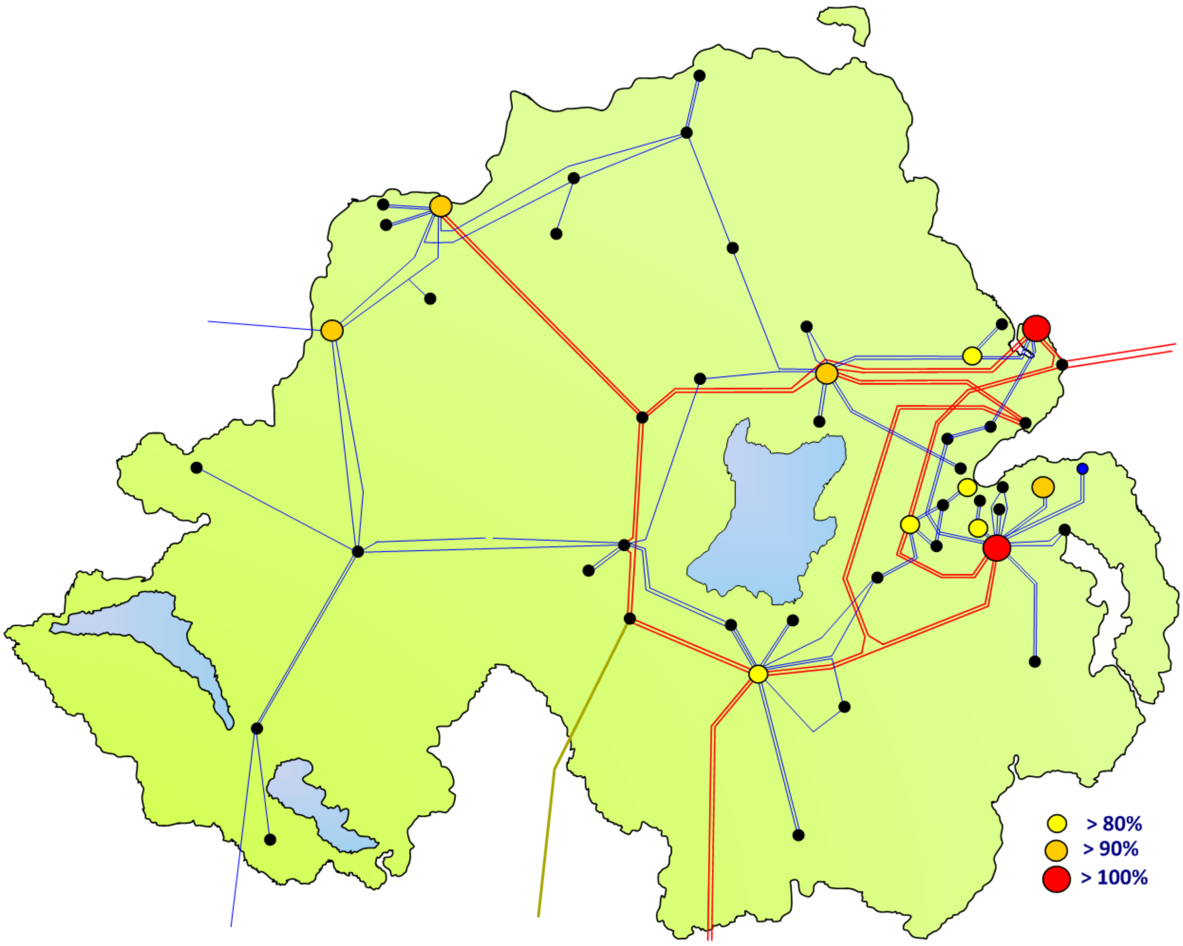


Figure 7.3: Winter Max 2017/18 Fault Levels

As can be seen from **Figure 7.3**, by 2017/18 there will be two 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	NODE	kV
>100	BALLYLUMFORD	110
	CASTLEREAGH	110
>90	COOLKEERAGH	110
	KELLS	110
	KNOCK	110
	STRABANE	110

Table 7.2: 2017/18 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 110 kV

Tables E.3 and **E.7** show that the fault levels at Ballylumford 110 kV node in 2011/12 and 2017/18 are very similar. This is because, despite the loss of short circuit current contributions from B4, B5 and B6, which are assumed to be decommissioned, there are increased contributions from the wind generation. Whilst **Table E.7** details the present rating, it is planned that, by 2017, the switchgear will be replaced with 40 kA equipment.

CASTLEREAGH 110 kV

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 26.2 kA 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 2017, the disconnectors will have been replaced.

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

COOLKEERAGH 110 kV

Fault levels at Coolkeeragh 110 kV substation now exceed 95% of the substation assigned rating by 2017/18. This is mainly a result of additional wind generation connected to the North-West and as a result of the new 400 kV Turleenan – Mid-Cavan tie line. It is important that NIE address these concerns as the 95% tolerance limit is exceeded in 2017/18.

KELLS 110 kV

Fault levels at Kells 110 kV substation exceed 99% of the substation assigned rating by 2017/18. Kells 110 kV substation is to be refurbished, with work due to be completed by winter 2016/17. The substation equipment will then have a rating of 40 kA.

STRABANE 110 kV

At Strabane, high fault levels are seen at the 110 kV substation for a single-phase fault, where the fault level is now at more than 96% of the rating. This is mainly a result of additional wind generation connected to the North West and as a result of the new 400 kV Turleenan – Mid-Cavan tie line. It is important that NIE address these concerns as the 95% tolerance limit is exceeded in 2017/18.

7.4.3 WINTER 2017/18 CONCLUSIONS

As expected, fault levels have generally risen by 2017/18, due to factors including demand growth, increased wind and the new 400 kV tie line with the RoI. However, with the decommissioning of B4, B5 and B6 at Ballylumford, the fault levels at the 275 kV substations in the East have dropped by circa 15%.

NIE have in place plans to uprate equipment at Ballylumford, Castlereagh, and Kells by 2017/18, as equipment margins are reduced. SONI are particularly concerned that the 5% tolerance limits are exceeded at Coolkeeragh and Strabane 110 kV substations. Potential generation connections will require careful analysis to determine the impact on the NI transmission system.

7.5 SUMMER MINIMUM RESULTS

As expected the summer minimum fault level results shown in **Appendix E4.2** and **E4.4** show no substation ratings are exceeded. The summer minimum fault level analysis facilitates 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.

8 TRANSMISSION SYSTEM CAPABILITY

8 TRANSMISSION SYSTEM CAPABILITY

This section of the Transmission System Capacity Statement (TSCS) presents the results of the 2017/18 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 as well as tabularised results can be found in **Appendix F**.

The basis of the transmission system capability analysis is the incremental increase of generation at transmission nodes; the NI Transmission System is then tested for a number of contingencies.

The results of the 275/110/33 kV capability studies for the year 2017/18 are presented in the following section. The NI Transmission System is tested for three scenarios; the new generation added to the nodes is absorbed by increasing either:

- The existing NI load
- The RoI load or
- The load in Great Britain (GB)

Transmission system capability is displayed geographically in **Figures 8.1 to 8.3**. More detailed maps and schematics containing full substation names etc. can be found in **Appendix B**. The maximum generation that can be accepted at each node is the minimum transfer capability of the 3 scenarios.

The results presented in this section and in **Appendix F** 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 TRANSMISSION SYSTEM CAPABILITY RESULTS

8.1.1 RESULTS AT 275 kV

Figure 8.1 displays the results for the analysis at 275 kV nodes, for the year 2017/18. The map shows the capability for power transfers on the transmission system for the connection of new generation at a 275 kV 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.

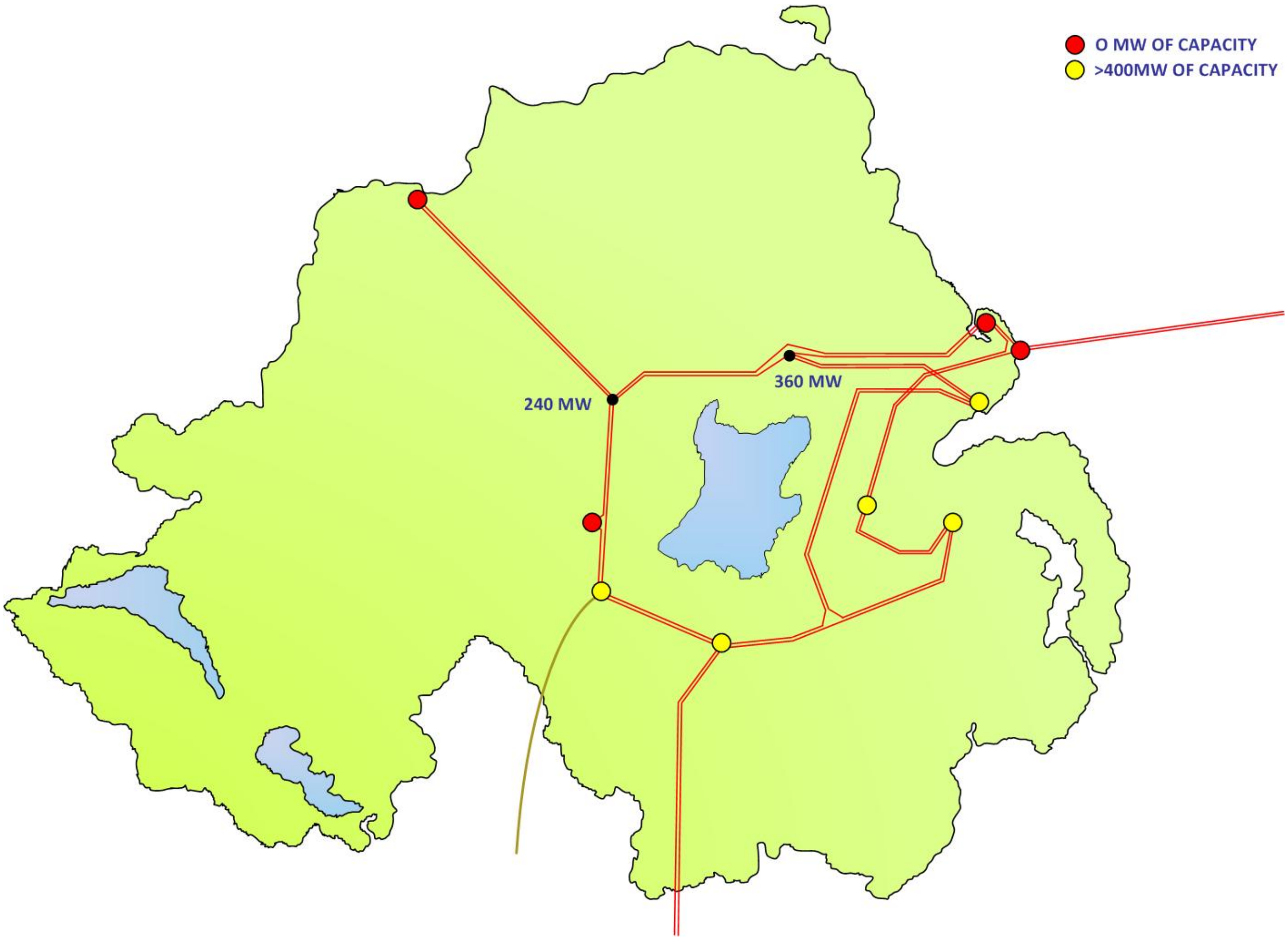


Figure 8.1 Transmission System Capabilities at 275 kV

Detailed 275 kV capability results can be found in **Table F.4**. **Table F.5** provides information on the constraints and contingencies that limit the capability at each 275 kV station.

8.1.2 RESULTS AT 110 kV AND 33 kV

This section looks at the ability of the 110 kV stations to accept the connection of smaller renewable generation particularity WFPSs. For this TSCS, all 110 kV stations on the NI transmission system were examined for the year 2017/18.

The results are displayed in **Figure 8.2**. Since renewable generation in NI is predominantly connected at 33 kV level, an analysis of all 33 kV nodes at Bulk Supply Points (BSPs) and WFPS cluster substations are also included. These results are displayed in **Figure 8.3.**

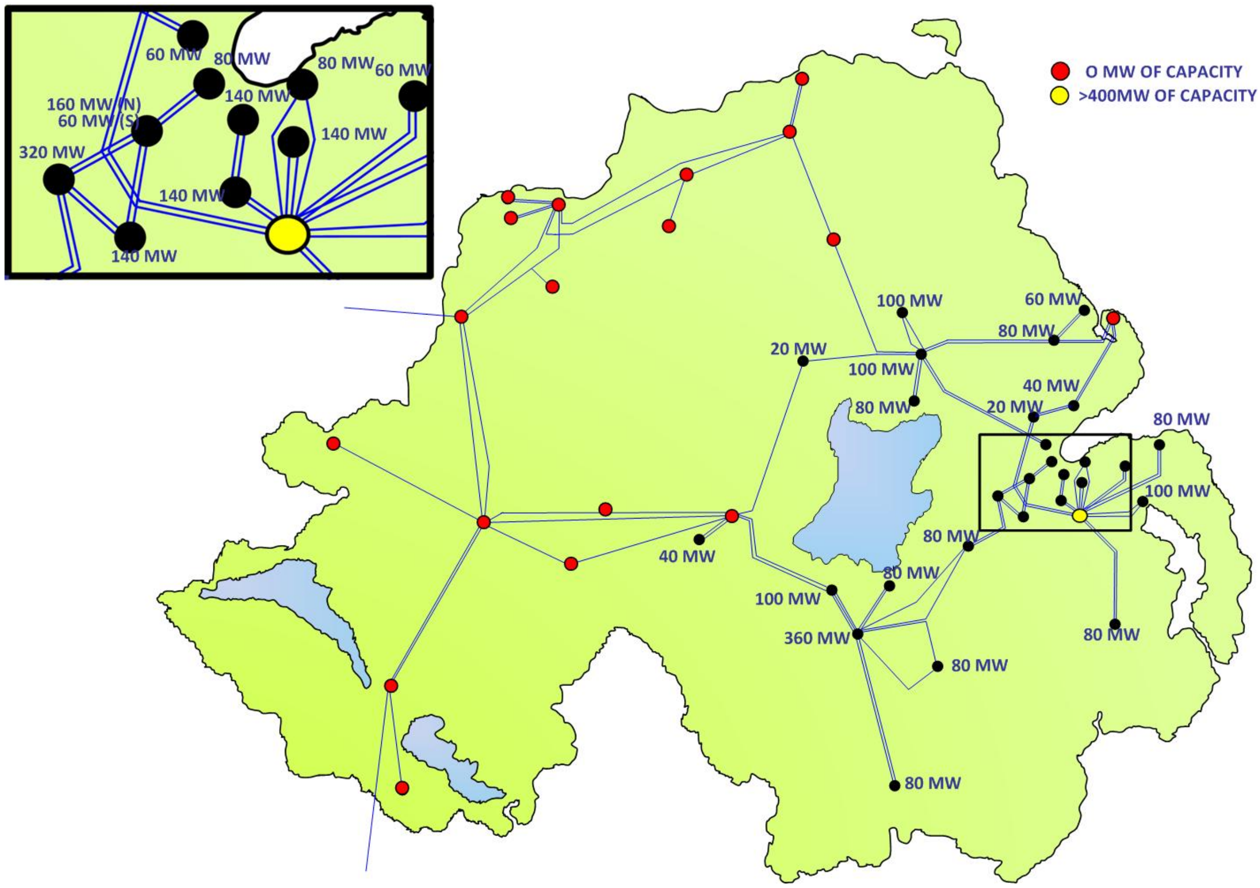


Figure 8.2 Transmission System Capabilities at 110 kV

It must be stressed that these results assess the ability to connect generation at each individual 110/33 kV 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 new generation connected to the system at any time.

Detailed 110 and 33 kV capability results can be found in **Tables F.6** and F.**8.** Also **Tables F.7** and **F.9** provide information on the constraints and contingencies that limit the capability at each 110 kV and 33 kV station respectively.

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.

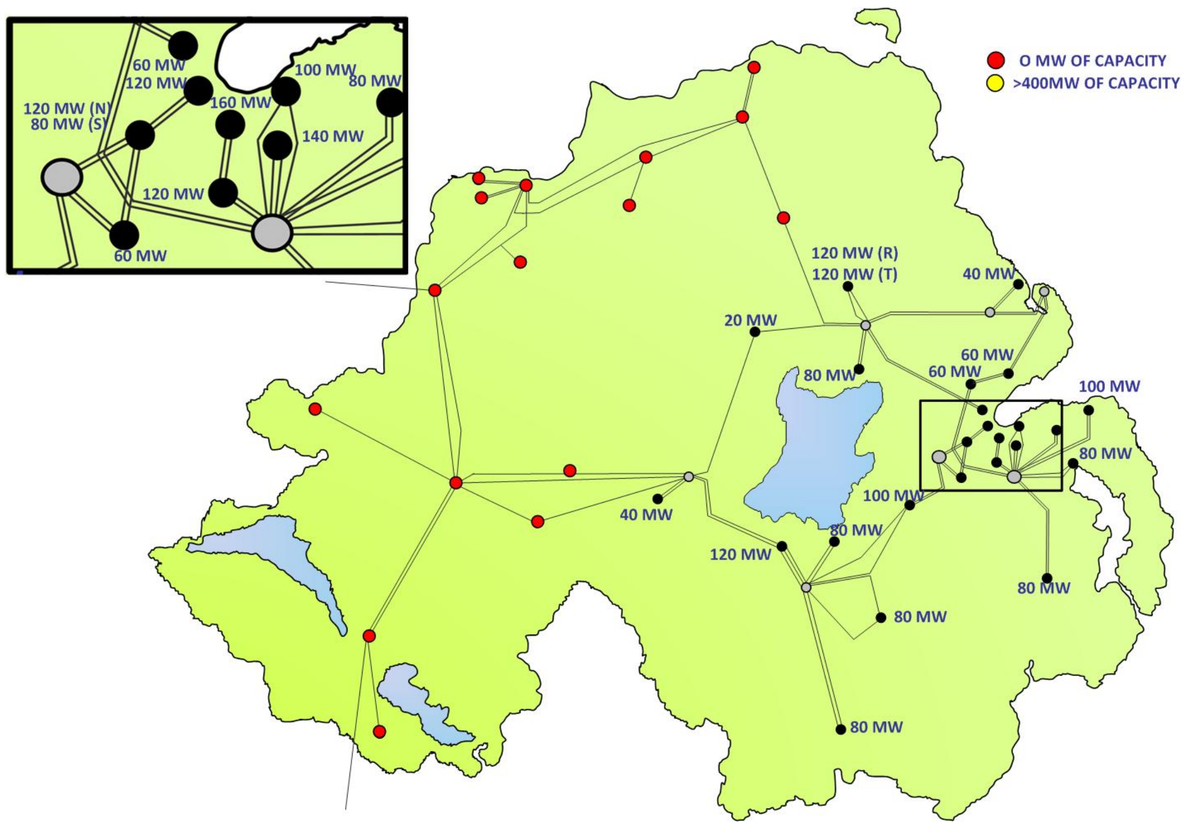


Figure 8.3 Transmission System Capabilities at 33 kV

8.2 DISCUSSION OF RESULTS

SATURATION OF THE NORTH WEST

The most striking feature of this year's transmission system capability results is that the North-West of the Provence is saturated and unable to accommodate the connection of further generation. The predominant power flows driving this saturation are from Coleraine, Coolkeeragh and Omagh in the North-West to Kells, Magherafelt and Tamnamore in the East. These congested corridors can be seen in Figure 8.4.

For 2017 summer minimum conditions with circa 950 MW of wind connected to the NI Transmission System; the Coolkeeragh-Magherafelt 275 kV double circuit contingency results in the overload of the Pomeroy to Tamnamore 110 kV circuit and both of the Tamnamore 275/110 kV Transformers. These overloads are seen despite the fact that the Coolkeeragh Run-Back Scheme is modelled (see **Appendix F.2.5** for details).

By Winter 2017/18 over 1000 MW of wind is connected in the North-West of the province. For the loss of the Coolkeeragh-Magherafelt 275 kV double circuit the North-West must be evacuated via the Omagh-Tamnamore and Coleraine-Kells 110 kV network corridors. It is clear that 1000 MW of wind generation cannot be accommodated without major reinforcement beyond the network developments described in **Section 3.4.** Specifically additional 275 kV circuits are required into the North-West.

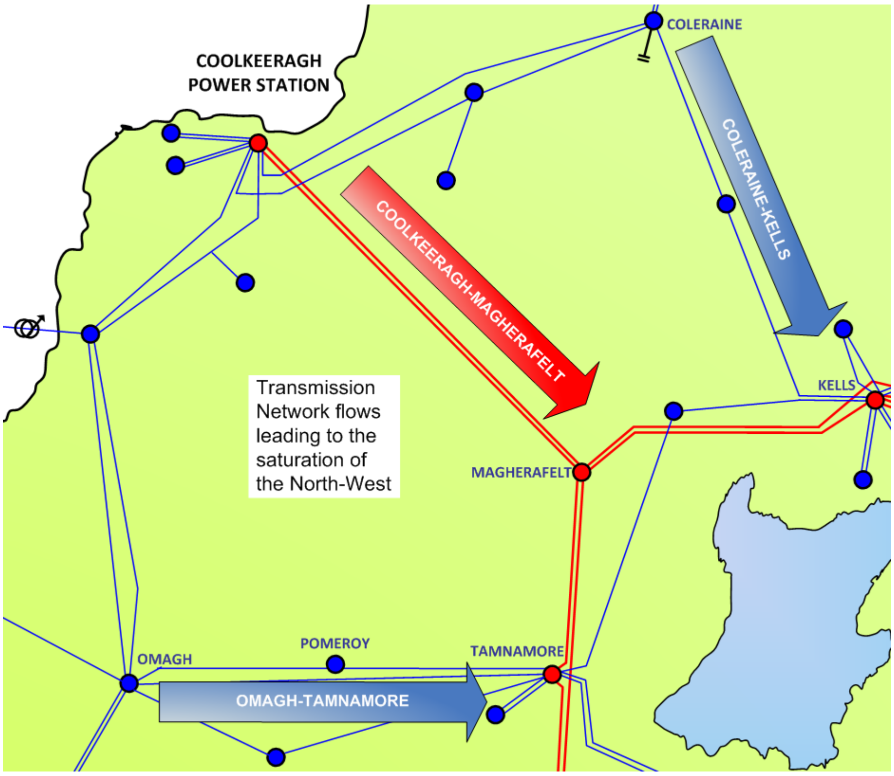


Figure 8.4: Network power flows driven by high wind levels

An implication of this limiting constraint is that the addition of generation at nodes to the North and West of this constraint will exacerbate the overloads caused. Nodes in this 'North-West' region are marked with the code 'NW' in the results tables in **Appendix F.**

Without major reinforcement of the Transmission System in the North-West, there will have to be significant constraints applied to wind generation towards the latter years covered by this statement. The costs of these constraints will have to be considered along with the implications on the cost of energy in the SEM on the Island of Ireland.

8.2.1 RESULTS AT 275 kV

BELFAST (CASTLEREAGH AND HANNAHSTOWN)

The 2009 TSCS identified that the capacity of the Hannahstown and Castlereagh 275 kV nodes was limited by the overload of the Hannahstown-Lisburn 110 kV circuits under certain contingencies. The planned upgrade of these 110 kV circuits detailed NIEs TIP and in **Section 3** of this statement, has increased the capability of Castlereagh and Hannahstown 275 kV substations. There is now over 400 MW of generation capacity at these substations.

TAMNAMORE

There is no generation capacity available at the Tamnamore 275 kV node. The critical contingency is the n-m-t of the Tamnamore-Magherafelt and Tamnamore-Turleenan 275 kV circuits. Under this contingency, all of the power flowing from Omagh is forced to be transferred on the 110 kV network, overloading the Tamnamore-Drumnakelly 110 kV circuits. SONI have outlined their preference to NIE that all four 275 kV circuits are turned into Tamnamore in order to minimise the constraint of generation in the North-West.

ISLANDMAGEE (BALLYLUMFORD AND MOYLE)

The capability analysis highlights that there is no incremental capacity available at the Ballylumford and Moyle 275 kV substations. This is despite the fact it has been assumed that units B4, B5 and B6 are decommissioned due to E.U. Heavy Fuel Oil Directive. It is assumed that by 2017/18 the Moyle HVDC interconnector will be capable of importing 500 MW from GB.

The 2009 TSCS highlighted that the loss of the Ballylumford-Kells/Magherafelt 275 kV circuits leads to overloads on the 110 kV circuits out of Ballylumford. These overloads have been addressed by the planned upgrade of the 110 kV circuits between Ballylumford, Eden and Carnmoney. Despite these 110 kV circuits being upgraded, the Ballylumford and Moyle 275 kV substations are saturated for the connection of additional generation; the loss of Ballylumford-Kells/Magherafelt 275 kV circuits leads to overloads on the 110 kV Ballylumford-Ballyvallagh circuits under certain load conditions.

It should be realised that SONI is concerned that a number of critical contingencies out of Ballylumford may cause voltage instability on the NI Transmission System. SONI believe the NI Transmission System is close to the margin of voltage collapse for these critical outages. The 300 MVAr of Network Reactive Compensation that has been included in this TSCS has enabled SONI to identify the thermal capability issues. It is important that full priority is given to these key reactive compensation projects.

KELLS AND MAGHERAFELT

The capacity of the Kells and Magherafelt 275 kV substations to accommodate additional generation without the need for network reinforcement is restricted to 360 MW and 240 MW respectively. When power is transferred to RoI, the loss of the Magherafelt-Turleenan 275 kV circuit causes overloads on the Tamnamore -Turleenan 275 kV circuit. These limitations are driven by the increasing levels of renewable generation in the North-West.

8.2.2 RESULTS AT 110 kV AND 33 kV

In the 2003 TSCS there was approximately 60 MW of wind generation capacity connected to the NI distribution system. By the 2011 base year of this report this figure has rapidly grown to circa 335 MW and is expected to increase further to 1040 MW by winter 2017/18. This large increase in wind penetration is dependent on key transmission projects (detailed in **Appendix F.1.3**) being delivered by NIE. The vast majority of this wind generation capacity is located in the North-West of

NI. The transmission capability analysis for 2017/18 shows that 110 kV nodes in the North-West have no capacity for additional generation. An important point to make is that there may in fact be additional generation capacity locally at these 110/33 kV substations; the zero capacities shown in this TSCS are a result of the limited Transmission System capacity on the 110 kV corridors between the North-West and the rest of the NI Transmission System.

In contrast, the East of the province is expected to have lower renewable generation penetration in 2017 and has more transmission network infrastructure; the demand at BSPs in the East of the province is also higher. The amount of generation capacity at nodes in the East of the province is generally dependent on the thermal rating of circuits and transformers which supply the substations.

Each 110 and 33 kV node must be considered individually to determine its individual characteristics and the resulting maximum generation capacity. Radially fed 110/33 kV substations will be limited by the loss of a single circuit or transformer, and the capability of the radial substation will be constrained by the capacity of the remaining circuit. Interconnected 110 kV and 33 kV substations have a variety of critical outages which limit the generation capacity. These are listed in **Appendix F.3.4** and **Appendix F.3.6**.

A number of WFPS cluster substations feed into the NI transmission system via a single 110 kV branch or transformer. Whilst capability analysis can be carried out at these clusters; it should be noted that generation connecting to these radial nodes will be isolated from the grid by an n-1 contingency. These radial circuits are considered to be connection assets.

8.3 SUMMARY TRANSMISSION SYSTEM CAPABILITY RESULTS

Islandmagee is an important generation source, with Moyle and Ballylumford providing over 1200 MW of electrical capacity in 2017/18. As in previous TSCS, these capability studies once again highlight that 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, North-South exports and NI System Demand increase.

These transmission capability studies are based on an assumed automatic tripping scheme being installed on the 110 kV circuits out of Ballylumford, in particular the Carnmoney-Castlereagh and Ballyvallagh-Kells circuits. This TSCS highlights the need to upgrade the 110 kV circuits between Ballylumford, Ballyvallagh and Kells.

The planned asset replacement of the Hannahstown-Lisburn 110 kV circuits will increase the transfer capacity at Castlereagh and Hannahstown 275 kV substations in Belfast. These 275 kV substations are no longer limited by overloads on the Hannahstown - Lisburn 110 kV circuits under outage conditions.

SONI highlighted voltage stability concerns for some critical contingencies in the Islandmagee area in the 2009 TSCS. Subsequently NIE have developed proposals in their TIP to address these system issues. SONI believe that it is essential that these proposals are given priority in the initial years of this TSCS. The delivery of these proposals will enable SONI to optimise the dispatch of conventional generation in NI.

In this TSCS WFPSs are modelled in power factor control mode (0.98 leading). It is questionable if this will be the most beneficial WFPS voltage control regime for the NI Transmission System in 2017/18. It is important that a holistic voltage control philosophy is employed at WFPS cluster substations; this will ensure that the impact to both the NI Transmission and Distribution system voltage will be addressed. The voltage control systems on WFPSs could improve the voltage stability and control the reactive power requirements of the NI Transmission System. Both SONI and NIE are currently considering alternative WFPS voltage control schemes.

The major change that has occurred in recent years is the increased wind penetration, particularly in the North-West of NI. In 2017, when wind generation is at maximum output, under Summer Minimum loading conditions, there is not enough transmission network capacity to transport power from the North-West for the loss of the Coolkeeragh-Magherafelt double circuit tower line. SONI is concerned that even if the planned reinforcements of Kells-Coleraine and Omagh-Tamnamore corridors are in place by 2017/18, there is no transmission capacity for further renewable generation connections in the North-West of the network. The capacity of these key power flow routes needs to be addressed.

Grid Code compliance of the new WFPS connections to the NI Transmission and Distribution systems is of utmost importance to SONI. It is essential that there is full voltage and frequency control at these sites to ensure system security as levels of wind generation increase in the future.

The need for development of the NI Transmission system is driven by government policy; The Strategic Energy Framework (SEF) 2010 states that 40% of electricity consumption in NI should come from renewable sources by the year 2020 also 'The Offshore Wind and Marine Renewable Energy in NI Strategic Environmental Assessment (SEA) 2009' identifies the fact that although offshore renewables could make a significant contribution to the 40% target; onshore wind is the most readily available and currently least costly renewable technology.

SONI are continually reviewing the potential impact of small scale generation and storage schemes on the NI demand; any change to the demand will impact on the amount of renewable generation required to meet government targets.

It is clear that if government targets are to be realised, renewable penetration will increase on the NI Transmission System in next seven years. SONI are monitoring the development of alternative renewable technologies however; renewable planning applications and connection information from NIE indicate that onshore wind will be the dominant renewable generation technology up to and beyond 2017/18. Most will be located in the North-West region. Without significant strategic investment to improve transmission capacity, network constraints will rise and it will not be possible to meet the 40% government target. Both SONI and EirGrid are currently performing further all-island studies and are determining strategies to manage the operational challenges in delivering such a target.

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 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 2017/18, there are several locations on the transmission network where a large 400 MW generator could connect without the need for reinforcements.

9.1.1 GENERATION OPPORTUNITIES AT 275 kV

The results of the capability analysis in this TSCS show that spare capacity for the connection of a new large generator exists at several locations on the grid in 2017/18. The Castlereagh, Hannahstown, Kilroot and Tandragee 275 kV substations, as well as the new 275 kV substation at Turleenan, could all accommodate a 400 MW generator.

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 TSCS. The Tamnamore 275 kV node also has no capacity; the capacity Tamnamore 275 kV could be increased if the second 275 kV circuit from Magherafelt to Turleenan was diverted into the substation. No new generation could be connected at any of these nodes without significant reinforcements to the transmission system.

Generation connections at other 275 kV locations would likely require varying degrees of transmission network reinforcement to enable them to connect.

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. Details of the 275 generation opportunities can be seen in **Figure 8.1.**

9.1.2 GENERATION OPPORTUNITIES AT 110 kV

Connection of smaller generators would take place at 110 kV. In the capability studies, the connection of up to 200 MW of generation at each node was investigated. The results are shown below in **Figure 8.2**.

There are no opportunities for new generation in the North-West of the country without reinforcement of the key 110 kV corridors or additional 275 kV circuits in the North-West.

Towards the East of the country, opportunities for generation become more substantial. In particular, both Tandragee and Castlereagh 110 kV nodes are shown to be able to accept generation above 300 MW 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 20 MW at Creagh 110 kV substation, while Kells 110 kV can accommodate 100 MW.

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.

9.1.3 GENERATION OPPORTUNITIES AT 33 kV

At the time of writing in Northern Ireland; renewable generation has connected at exclusively to the 33 kV network and at lower distribution voltage levels. Although NIE are responsible for the capability of the 33 kV network, in this TSCS SONI have analysed the capability of the transmission system to accept new generation at 33 kV level, connected to the transmission system via 110/33 kV Bulk Supply Points (BSPs). The results are presented in **Figure 8.3.**

9.1.4 GENERATION OPPORTUNITIES 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 North-West region cannot accept further generation capacity without major reinforcement. It should also be noted that all the capabilities shown are very much dependent on the installation of the planned 110 kV reinforcements and the delivery of the Network Reactive Compensation Schemes. The best opportunities for new generation are to be found at transmission nodes on the 275 kV 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

It is expected that in by the end of 2011/12 demand growth will resume in NI after the recent recession (as discussed in **Section 5.4**). 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 cater for 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 33 kV level or below. The largest customer demand is currently around 20 MW. The transmission system could cope with continued small scale customer connections at 33 kV 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 110/33 kV nodes. A comparison is made between substation firm capacity and expected load growth. Consideration has been given in this statement to the risk of overload posed by reverse power flows caused by high wind and low demand this issue will become increasingly prevalent in the future as wind capacity increases.

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 at times of low renewable generation output. SONI operate the NI Transmission System so any generation/demand scenario can be catered for.

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

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

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		
70010	AGHY1-	AGHYOULE	110		
70030	AGHY3-		33	8.37	1.70
70031	GORT3-		33	2.24	0.45
70032	DYLN3-		33	2.33	0.47
70033	DYLN3C		33		
70080	DUMY3-		33		
70090	WIND_AGHY	AGHYOULE WIND	33		
70091	WIND_SNUGBO		33		
70092	WIND_RUSHEN		33		
70093	WIND_RUSH-1		33		
70094	WIND_RUSH-2		33		
70311	ANTR1A	ANTRIM	110		
70312	ANTR1B		110		
70330	ANTR3-		33	43.38	8.81
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
70514	BAFD_GB		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		
71011	BAME1A	BALLYMENA	110		
71012	BAME1B		110		
71031	BAME3T		33	45.01	9.14
71032	BAME3R		33	32.40	6.58
71033	CBKY3-		33	4.04	0.82
71034	CMIL3-		33	7.07	1.44
71035	KREA3-		33	5.55	1.13

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
71080	DUMY3-	BALLYMENA	33		
71091	WIND_CORKEY	BALLYMENA WIND	33		
71092	WIND_SLVNAH		33		
71511	BANB1A	BANBRIDGE	110		
71512	BANB1B		110		
71530	BANB3-		33	43.27	8.79
71590	WIND_BANB		33		
72010	BAVA1-	BALLYVALLAGH	110		
72511	BNCH1A	BALLYNAHINCH	110		
72512	BNCH1B		110		
72530	BNCH3-		33	60.76	12.34
72590	WIND_BNCH		33		
73521	CACO2A		275		
73522	CACO2B		275		
74011	CARN1A	CARNMONEY	110		
74012	CARN1B		110		
74030	CARN3-		33	33.31	6.76
74511	CAST1A	CASTLEREAGH	110		
74512	CAST1B		110		
74520	CAST2-		275		
74561	CAST6P		22		
74562	CAST6Q		22		
74563	CAST6R		22		
74711	CENT1A	BELFAST CENTRAL	110		
74712	CENT1B		110		
74730	CENT3-		33	61.99	12.59
75010	COLE1-	COLERAINE	110		
75011	COLE1C		110		
75030	COLE3-		33	23.94	4.86
75031	BMNY3-		33	15.19	3.08
75032	GRVN3-		33	5.07	1.03
75080	DUMY3-		33		
75090	WIND_COLE	COLERAINE WIND	33		
75091	WIND_RIGGED		33		
75092	WIND_GRUIG		33		
75093	WIND_GARVES		33		
75508	COOLG8-	COOLKEERAGH	11		
75510	COOL1-		110		
75514	COOL1C		110		

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
75515	COOLST-	COOLKEERAGH	15.75	3.41	1.14
75516	COOLGT-		15.75	5.69	1.90
75520	COOL2-		275		
75530	COOL3-		33	32.82	6.66
75561	COOL6P		22		
75562	COOL6Q		22		
75810	CREA1-	CREAGH	110		
75830	CREA3-		33	25.51	5.18
75890	WIND_CREA		33		
75911	CREC1A	CREGAGH	110		
75912	CREC1B		110		
76011	CREG1A		110		
76012	CREG1B		110		
76031	CREG3A		33	29.74	6.04
76032	CREG3B		33	14.20	2.88
76511	DONE1C	DONEGALL	110		
76512	DONE1B		110		
76513	DONE1D		110		
76514	DONE1A		110		
76531	DONE3AS		33	55.28	11.23
76532	DONE3N		33	49.82	10.12
76533	DONE3BS		33	9.32	1.89
77010	DRUM1-	DRUMNAKELLY	110		
77030	DRUM3-		33	101.84	20.68
77090	WIND_DRUM		33		
77510	DUNG1-	DUNGANNON	110		
77530	DUNG3-		33	79.29	16.10
77531	TULY3-		33	3.29	0.67
77590	WIND_DUNG	DUNGANNON WIND	33		
77591	WIND_CROCKA		33		
78030	DUNM3-	DUNMORE	33	26.92	5.47
78511	EDEN1A	EDEN	110		
78512	EDEN1B		110		
78530	EDEN3-		33	33.13	6.73
79010	ENNK1_	ENNISKILLEN	110		
79015	ENNKPFA		110		
79016	ENNKPFB		110		
79030	ENNK3-		33	37.93	7.70
79031	EKNW3-		33	10.10	2.05

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
79032	BELK3-	ENNISKILLEN	33	1.92	0.39
79081	DUMY31		33		
79082	DUMY32		33		
79083	DUMY33		33		
79090	WIND_ENNK	ENNISKILLEN WIND	33		
79091	WIND_CALAGH		33		
80011	FINY1A	FINAGHY	110		
80012	FINY1B		110		
80030	FINY3-		33	36.79	7.47
80511	GLEN1A	GLENGORMLEY	110		
80512	GLEN1B		110		
80531	GLEN3A		33	16.30	3.31
80532	GLEN3B		33	8.57	1.74
81010	HANA1A	HANNAHSTOWN	110		
81020	HANA2A		275		
81061	HANA6P		22		
81062	HANA6Q		22		
81510	KELS1-	KELLS	110		
81520	KELS2-		275		
81561	KELS6P		22		
81562	KELS6Q		22		
82001	KILRG1-	KILROOT	17	13.65	4.55
82002	KILRG2-		17	13.65	4.55
82003	KILRG3		11.5		
82004	KILRG4		11.5		
82011	KPS_AUX1		11		
82012	KPS_AUX2		11		
82020	KILR2-		275		
82511	KNCK1A	KNOCK	110		
82512	KNCK1B		110		
82530	KNCK3-		33		
83011	LARN1A	LARNE	110		
83012	LARN1B		110		
83030	LARN3-		33	41.12	8.35
83031	BALC3-		33	1.80	0.37
83090	WIND_LARN	LARNE WIND	33		
83091	WIND_EH&WB		33		
83510	LIMA1-	LIMAVADY	110		
83530	LIMA3-		33	18.40	3.74

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
83531	DNGV3-	LIMAVADY	33	6.08	1.24
83590	WIND_LIMA	LIMAVADY WIND	33		
83591	WIND_ALTA-1		33		
83592	WIND_ALTA-2		33		
84011	LISB1A	LISBURN	110		
84012	LISB1B		110		
84030	LISB3-		33	68.1348	13.8354
84411	LSMR1A	LISAGHMORE	110		
84412	LSMR1B		110		
84430	LSMR3-		33	50.88	10.33
84490	WIND_LSMR		33		
84511	LOGE1A	LOGUESTOWN	110		
84512	LOGE1B		110		
84530	LOGE3-		33	38.79	7.88
84590	WIND_LOGE		33		
85020	MAGF2-	MAGHERAFELT	275		
86030	MOUN3-	MOUNTPOTTINGER	33	34.65	7.04
86220	MOYL2-	MOYLE	275		
86221	SCOT2-		275		
86311	NARD1A	NEWTOWNARDS	110		
86312	NARD1B		110		
86330	NARD3-		33	45.49	9.24
86511	NEWY1A	NEWRY	110		
86512	NEWY1B		110		
86530	NEWY3-		33	80.31	16.31
86590	WIND_NEWY		33		
87510	OMAH1-	OMAGH	110		
87530	OMAH3-		33	19.83	4.03
87531	BLGY3-		33	3.96	0.80
87532	DROM3-		33	6.23	1.27
87533	FMTC3-		33	8.50	1.73
87534	LARA3-		33	3.96	0.80
87535	OMAE3-		33	13.04	2.65
87581	DUMY31		33		
87582	DUMY32		33		
87583	DUMY33		33		
87584	DUMY34		33		
87585	DUMY35		33		
87590	WIND_OMAG	OMAGH WIND	33		

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
87591	WIND_TAPPA	OMAGH WIND	33		
87592	WIND_HUNTER		33		
87593	WIND_BESSEY		33		
87594	WIND_LENDRM		33		
87595	WIND_DIVENA		33		
88011	RATH1A	RATHGAEL	110		
88012	RATH1B		110		
88030	RATH3-		33	66.68	13.54
88511	ROSE1A	ROSEBANK	110		
88512	ROSE1B		110		
88530	ROSE3-		33	32.00	6.50
89030	SKEG3-	SKEGONEILL	33	25.62	5.20
89311	SPRN1A	SPRINGTOWN	110		
89312	SPRN1B		110		
89330	SPRN3-		33	32.51	6.60
89510	STRA1-	STRABANE	110		
89515	STRPFCA		110		
89516	STRPFCB		110		
89530	STRA3-		33	20.38	4.14
89531	ARDS3-		33	5.07	1.03
89532	CDRG3-		33	5.57	1.13
89533	CLDY3-		33	2.02	0.41
89534	PLUM3-		33	1.52	0.31
89535	SION3-		33	1.52	0.31
89581	DUMY31		33		
89582	DUMY32		33		
89583	DUMY33		33		
89584	DUMY34		33		
89590	WIND_STRA	STRABANE WIND	33		
89591	WIND_OWENRE		33		
89592	WIND_BINMTN		33		
89593	WIND_LHILL		33		
90011	TAND1A	TANDRAGEE	110		
90012	TAND1B		110		
90020	TAND2-		275		
90061	TAND6P		22		
90062	TAND6Q		22		
90063	TAND6R		22		
90310	TAMN1-	TAMNAMORE	110		

TABLE A.1: BUS DATA

TABLE A.1 BUS DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	P LOAD (MW)	Q LOAD (MVAr)
90320	TAMN2-	TAMNAMORE	275		
90361	TAMN6P		22		
90511	WARN1A	WARINGSTOWN	110		
90512	WARN1B		110		
90530	WARN3-		33	52.86	10.73
91011	WEST1A	POWER STATION WEST	110		
91012	WEST1B		110		
91031	WEST3A		33		
91032	WEST3B		33		

TABLE A.1: BUS DATA

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	124	115	106
LETRKENY	STRPFCB	1	0.03449	0.07653	0.00709	126	119	107
LOUTH5 A	LOUTH5 B	1	0.00000	0.00010	0.00000	0	0	0
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
AGHY1-	ENNK1_	1	0.03951	0.09481	0.01982	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
AGHY3-	WIND_AGHY	1	0.00000	0.00010	0.00000	0	0	0
DYLN3-	DYLN3C	1	0.00000	0.00010	0.00000	0	0	0
DYLN3-	DUMY31	1	0.30140	0.75351	0.00097	30	30	30
DYLN3-	DUMY32	1	0.23436	0.58590	0.00075	30	30	30
DUMY3-	WIND_AGHY	1	0.06125	0.07971	0.00105	0	0	0
DUMY3-	WIND_SNUGBO	1	0.04435	0.08070	0.00019	0	0	0
DUMY3-	WIND_RUSHEN	1	0.01047	0.01301	0.00001	0	0	0
WIND_AGHY	WIND_RUSH-1	1	0.03903	0.09750	0.00013	0	0	0
WIND_AGHY	WIND_RUSH-2	1	0.03269	0.08160	0.00011	0	0	0
ANTR1A	KELS1-	1	0.01162	0.02994	0.00303	103	95	82
ANTR1B	KELS1-	1	0.01162	0.02994	0.00303	103	95	82
BAFD1-	BAVA1-	1	0.02259	0.05820	0.00589	103	95	82
BAFD1-	BAVA1-	2	0.02259	0.05820	0.00589	103	95	82
BAFD1-	EDEN1A	1	0.02283	0.05361	0.00487	86	80	69
BAFD1-	EDEN1B	1	0.02271	0.05291	0.00490	87	81	70
BAFD2-	HANA2A	2	0.00230	0.01960	0.12700	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	0.00004	0.00034	0.00201	881	820	710
BAME1A	KELS1-	1	0.01306	0.03455	0.00332	124	119	109
BAME1B	KELS1-	1	0.01502	0.03973	0.00381	124	119	109
BAME3R	WIND_BAME	1	0.00000	0.00010	0.00000	0	0	0
CBKY3-	CMIL3-	1	0.52560	0.52560	0.00059	0	0	0
CBKY3-	WIND_BAME	1	0.12030	0.14560	0.00014	0	0	0
CMIL3-	KREA3-	1	0.46050	0.46050	0.00052	0	0	0
CMIL3-	DUMY3-	1	0.26740	0.19790	0.00016	0	0	0
KREA3-	WIND_BAME	1	0.38850	0.61700	0.00060	0	0	0
DUMY3-	WIND_CORKEY	1	0.04180	0.03360	0.00002	0	0	0
DUMY3-	WIND_SLVNAH	1	0.08150	0.06030	0.00004	0	0	0
BANB1A	TAND1B	1	0.02403	0.06239	0.00622	103	95	82

TABLE A.2: BRANCH DATA

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
BANB1B	TAND1B	1	0.01855	0.04902	0.00471	103	95	82
BANB3-	WIND_BANB	1	0.00000	0.00010	0.00000	0	0	0
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	79
BAVA1-	LARN1B	1	0.00720	0.02340	0.00250	113	96	79
BNCH1A	CAST1B	1	0.02769	0.07132	0.00722	103	95	82
BNCH1B	CAST1B	1	0.02769	0.07132	0.00722	103	95	82
BNCH3-	WIND_BNCH	1	0.00000	0.00010	0.00000	0	0	0
CACO2A	COOL2-	1	0.00010	0.00010	0.02277	837	761	761
CACO2A	MAGF2-	1	0.00670	0.02540	0.14950	513	477	412
CACO2B	COOL2-	1	0.00009	0.00009	0.01935	837	761	761
CACO2B	MAGF2-	1	0.00670	0.02540	0.14950	513	477	412
CARN1A	CAST1A	1	0.03714	0.08750	0.00798	86	80	69
CARN1A	EDEN1A	1	0.01865	0.04345	0.00402	87	81	70
CARN1B	CAST1A	1	0.03695	0.08641	0.00803	87	81	70
CARN1B	EDEN1B	1	0.01875	0.04402	0.00400	86	80	69
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	0	0	0
CAST1A	CAST1B	2	0.00000	0.00010	0.00000	0	0	0
CAST1A	CREG1A	1	0.00116	0.00357	0.05954	145	132	132
CAST1A	CREG1B	1	0.00116	0.00357	0.05954	145	132	132
CAST1A	KNCK1A	1	0.00532	0.00449	0.04470	73	66	66
CAST1A	KNCK1B	1	0.00532	0.00449	0.04470	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	0.06358	0.00644	103	95	82
CAST1B	RATH1B	1	0.02468	0.06358	0.00644	103	95	82
CAST1B	ROSE1A	1	0.00086	0.00171	0.02399	128	117	117
CAST1B	ROSE1B	1	0.00086	0.00171	0.02399	128	117	117
CAST2-	HANA2A	1	0.00090	0.00780	0.05060	881	820	710
CAST2-	HANA2A	2	0.00090	0.00780	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
CENT1A	CREG1A	1	0.00113	0.00437	0.03032	144	144	144
CENT1B	CREG1B	1	0.00113	0.00437	0.03032	144	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

TABLE A.2: BRANCH DATA

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
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	0.06086	0.16057	0.01549	103	95	82
COLE1-	KELS1-	1	0.07010	0.20097	0.01991	124	119	109
COLE1-	LIMA1-	1	0.02433	0.06431	0.00618	103	95	82
COLE1-	LOGE1A	1	0.01058	0.02725	0.00276	103	95	82
COLE1-	LOGE1B	1	0.01058	0.02725	0.00276	103	95	82
COLE3-	WIND_COLE	1	0.00000	0.00010	0.00000	0	0	0
BMNY3-	WIND_COLE	1	0.16080	0.40200	0.00053	0	0	0
BMNY3-	WIND_COLE	2	0.19290	0.48230	0.00063	0	0	0
BMNY3-	WIND_GRUIG	1	0.26990	0.67140	0.00130	0	0	0
BMNY3-	WIND_GARVES	1	0.12300	0.30110	0.00120	0	0	0
GRVN3-	DUMY3-	1	0.28310	0.26010	0.00112	0	0	0
DUMY3-	WIND_COLE	1	0.26330	0.30730	0.00037	0	0	0
DUMY3-	WIND_RIGGED	1	0.27660	0.30150	0.00029	0	0	0
COOL1-	COOL1C	1	0.00000	0.00010	0.00000	0	0	0
COOL1-	LIMA1-	1	0.03853	0.10139	0.00983	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-	SPRN1A	1	0.01095	0.02871	0.01196	103	95	82
COOL1-	SPRN1B	1	0.01095	0.02871	0.01196	103	95	82
COOL1-	STRA1-	1	0.01818	0.05288	0.01685	166	158	143
COOL1-	STRA1-	2	0.01961	0.08465	0.00905	166	158	143
CREA1-	CREC1A	1	0.00022	0.00083	0.00578	144	144	144
CREA1-	CREC1B	1	0.00022	0.00083	0.00578	144	144	144
CREA3-	WIND_CREA	1	0.00000	0.00010	0.00000	0	0	0
CREC1A	KELS1-	1	0.02912	0.07589	0.00751	103	95	82
CREC1B	DUNG1-	1	0.04715	0.12432	0.01201	103	95	82
CREG3A	CREG3B	1	0.00000	0.00010	0.00000	0	0	0
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	0.00162	0.00452	0.13972	158	144	144
DONE1C	WEST1A	1	0.00592	0.00567	0.06558	82	75	75
DONE1B	HANA1A	1	0.00162	0.00452	0.13972	158	144	144
DONE1B	WEST1B	1	0.00592	0.00567	0.06558	82	75	75
DONE1D	FINY1B	1	0.00440	0.01101	0.00755	86	80	69
DONE1A	FINY1A	1	0.00449	0.01119	0.00758	86	80	69
DONE3AS	DONE3BS	1	0.00000	0.00010	0.00000	0	0	0

TABLE A.2: BRANCH DATA

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
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
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	96	79
DRUM1-	TAND1A	2	0.00460	0.01480	0.00160	113	96	79
DRUM1-	TAND1A	3	0.00478	0.01360	0.00142	119	106	96
DRUM3-	WIND_DRUM	1	0.00000	0.00010	0.00000	0	0	0
DUNG1-	OMAH1-	1	0.04715	0.12473	0.01197	135	130	109
DUNG1-	OMAH1-	2	0.05133	0.13578	0.01303	120	120	109
DUNG3-	WIND_DUNG	1	0.00000	0.00010	0.00000	0	0	0
TULY3-	WIND_DUNG	1	0.21790	0.27230	0.00032	0	0	0
TULY3-	WIND_DUNG	2	0.08390	0.11990	0.00147	0	0	0
TULY3-	WIND_CROCKA	1	0.13820	0.32860	0.00250	0	0	0
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	30	30
DUNM3-	WEST3B	1	0.02030	0.27090	0.00300	33	30	30
ENNK1_	OMAH1-	1	0.04401	0.11337	0.01148	103	95	82
ENNK1_	OMAH1-	2	0.04401	0.11337	0.01148	103	95	82
ENNK3-	DUMY31	1	0.06514	0.09471	0.00007	20	20	20
ENNK3-	DUMY32	1	0.16314	0.23719	0.00017	20	20	20
ENNK3-	WIND_ENNK	1	0.00000	0.00010	0.00000	0	0	0
EKNW3-	DUMY33	1	0.58150	0.90520	0.00130	0	0	0
EKNW3-	WIND_ENNK	1	0.10780	0.10780	0.00012	0	0	0
EKNW3-	WIND_ENNK	2	0.28920	0.29200	0.00082	0	0	0
BELK3-	DUMY33	1	0.24480	0.30610	0.00035	0	0	0
DUMY33	WIND_CALAGH	1	0.02560	0.06400	0.00009	0	0	0
FINY1A	HANA1A	1	0.00084	0.00322	0.02238	144	144	144
FINY1B	HANA1A	1	0.00084	0.00322	0.02238	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	0	0	0
HANA1A	LISB1A	1	0.00974	0.02647	0.01820	103	95	82
HANA1A	LISB1B	1	0.00864	0.02630	0.01795	100	93	80
HANA2A	MOYL2-	1	0.00200	0.01875	0.11181	881	820	710
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
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

TABLE A.2: BRANCH DATA

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
LARN3-	WIND_LARN	1	0.00000	0.00010	0.00000	0	0	0
BALC3-	WIND_LARN	1	0.21670	0.47050	0.00038	0	0	0
BALC3-	WIND_LARN	2	0.21670	0.47050	0.00038	0	0	0
BALC3-	WIND_EH&WB	1	0.30340	0.55790	0.00049	0	0	0
LIMA3-	WIND_LIMA	1	0.00000	0.00010	0.00000	0	0	0
DNGV3-	WIND_LIMA	1	0.34830	0.35859	0.00030	0	0	0
DNGV3-	WIND_LIMA	2	0.41479	0.41479	0.00047	0	0	0
DNGV3-	WIND_ALTA-2	1	0.10689	0.26098	0.00113	0	0	0
WIND_LIMA	WIND_ALTA-1	1	0.12350	0.30680	0.00065	0	0	0
LISB1A	TAND1A	1	0.04049	0.10592	0.01040	103	95	82
LISB1B	TAND1A	1	0.03393	0.10022	0.00870	100	93	80
LSMR3-	WIND_LSMR	1	0.00000	0.00010	0.00000	0	0	0
LOGE3-	WIND_LOGE	1	0.00000	0.00010	0.00000	0	0	0
MAGF2-	TAND2-	1	0.00231	0.02166	0.13620	881	820	710
MAGF2-	TAMN2-	1	0.00115	0.01077	0.06770	881	820	710
NEWY1A	NEWY1B	1	0.00000	0.00010	0.00000	0	0	0
NEWY1A	TAND1B	1	0.03121	0.08040	0.00814	103	95	82
NEWY1B	TAND1B	1	0.03121	0.08040	0.00814	103	95	82
NEWY3-	WIND_NEWY	1	0.00000	0.00010	0.00000	0	0	0
OMAH1-	STRA1-	1	0.04636	0.12265	0.01177	124	119	109
OMAH1-	STRA1-	2	0.04715	0.12469	0.01197	103	95	82
OMAH3-	WIND_OMAG	1	0.00000	0.00010	0.00000	0	0	0
BLGY3-	DUMY35	1	0.17080	0.21180	0.00025	0	0	0
DROM3-	DUMY31	1	0.13790	0.13790	0.00015	0	0	0
FMTC3-	DUMY33	1	0.25380	0.25380	0.00028	0	0	0
LARA3-	DUMY34	1	0.02920	0.03650	0.00004	0	0	0
OMAE3-	DUMY32	1	0.01440	0.02310	0.00160	0	0	0
OMAE3-	DUMY32	2	0.07430	0.07430	0.00008	0	0	0
OMAE3-	WIND_OMAG	1	0.03100	0.05000	0.00351	0	0	0
OMAE3-	WIND_OMAG	2	0.17340	0.17340	0.00048	0	0	0
DUMY31	WIND_OMAG	1	0.09780	0.24090	0.00036	0	0	0
DUMY31	WIND_TAPPA	1	0.14400	0.36000	0.00048	0	0	0
DUMY32	WIND_BESSEY	1	0.14670	0.32870	0.00046	0	0	0
DUMY33	WIND_OMAG	1	0.53870	0.56430	0.00096	0	0	0
DUMY33	WIND_LENDRM	1	0.04450	0.05560	0.00007	0	0	0
DUMY34	DUMY35	1	0.11130	0.27830	0.00037	0	0	0
DUMY34	WIND_OMAG	1	0.07980	0.19550	0.00026	0	0	0
DUMY35	WIND_DIVENA	1	0.02300	0.05620	0.00053	0	0	0
WIND_OMAG	WIND_HUNTER	1	0.21140	0.50990	0.00291	0	0	0
SKEG3-	WEST3A	1	0.02600	0.26760	0.00300	33	33	30
SKEG3-	WEST3B	1	0.01820	0.26880	0.00300	33	33	30

TABLE A.2: BRANCH DATA

TABLE A.2: BRANCH DATA

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
STRA3-	WIND_STRA	1	0.00000	0.00010	0.00000	0	0	0
ARDS3-	SION3-	1	0.26570	0.26570	0.00031	0	0	0
ARDS3-	DUMY33	1	0.26940	0.33670	0.00038	0	0	0
ARDS3-	WIND_STRA	1	0.62660	0.68520	0.00078	0	0	0
CDRG3-	DUMY33	1	0.02080	0.02610	0.00030	0	0	0
CLDY3-	DUMY31	1	0.36510	0.37420	0.00041	0	0	0
PLUM3-	DUMY32	1	0.06920	0.08620	0.00010	0	0	0
SION3-	WIND_STRA	1	0.26120	0.30010	0.00034	0	0	0
DUMY31	DUMY32	1	0.34270	0.39540	0.00077	0	0	0
DUMY31	WIND_STRA	1	0.30680	0.30680	0.00004	0	0	0
DUMY32	WIND_OWENRE	1	0.13130	0.16430	0.00019	0	0	0
DUMY33	DUMY34	1	0.09930	0.24780	0.00037	0	0	0
DUMY34	WIND_BINMTN	1	0.00210	0.00330	0.00024	0	0	0
DUMY34	WIND_LHILL	1	0.00750	0.01210	0.00085	0	0	0
TAND1A	TAND1B	1	0.00000	0.00010	0.00000	0	0	0
TAND1A	WARN1A	1	0.01280	0.04180	0.00440	113	96	79
TAND1A	WARN1B	1	0.01280	0.04180	0.00440	113	96	79
TAND2-	TAMN2-	1	0.00116	0.01089	0.06850	881	820	710
WEST3A	WEST3B	1	0.00400	0.21260	0.00000	38	38	38

TABLE A.2: BRANCH DATA

TABLE A.3 BRANCH DATA CHANGES

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
Summer 2011 Add								
DUNG1-	TAMN1-	1	0.00419	0.01556	0.00214	144	144	144
Autumn 2011 Add								
COOL1-	KILL1-CL	1	0.01105	0.04804	0.00518	166	158	143
KILL1-CL	SKWF1-	1	0.00433	0.01627	0.00614	144	144	143
KILL1-CL	STRA1-	1	0.00833	0.03661	0.00387	166	158	143
Autumn 2011 Delete								
COOL1-	STRA1-	2	0.01961	0.08465	0.00905	166	158	143
Winter 2011/12 Add								
DUNG1-	OMAH1-	1	0.04570	0.12473	0.01197	210	200	190
DUNG1-	OMAH1-	2	0.04975	0.13578	0.01303	210	200	190
Winter 2011/12 Delete								
DUNG1-	OMAH1-	1	0.04715	0.12473	0.01197	135	130	109
DUNG1-	OMAH1-	2	0.05133	0.13578	0.01303	120	120	109
Summer 2012 Add								
MAKL1-CL	OMAH1-	1	0.02907	0.10792	0.01482	144	144	143
WIND_CARN	WIND_CNHILL	1	0.08120	0.18420	0.00260	0	0	0
Winter 12/13 Add								
BAFD1-	EDEN1A	1	0.00905	0.05064	0.05341	210	200	190
BAFD1-	EDEN1B	1	0.00905	0.05064	0.05341	210	200	190
CAST1B	CAST1_SVC	1	0.00000	0.00010	0.00000	0	0	0
CAST1_SVC	CAST1_FIX1	1	0.00000	0.00010	0.00000	0	0	0
CAST1_SVC	CAST1_FIX2	1	0.00000	0.00010	0.00000	0	0	0
COOL1-	COOL1_SVC	1	0.00000	0.00010	0.00000	0	0	0
COOL1_SVC	COOL1_FIX1	1	0.00000	0.00010	0.00000	0	0	0
COOL1_SVC	COOL1_FIX2	1	0.00000	0.00010	0.00000	0	0	0
TAND1B	TAND1_SVC	1	0.00000	0.00010	0.00000	0	0	0
TAND1_SVC	TAND1_FIX1	1	0.00000	0.00010	0.00000	0	0	0
TAND1_SVC	TAND1_FIX2	1	0.00000	0.00010	0.00000	0	0	0
COLE1-	KELS1-	1	0.06726	0.20105	0.01988	124	119	109
Winter 12/13 Delete								
BAFD1-	EDEN1A	1	0.02283	0.05361	0.00487	86	80	69
BAFD1-	EDEN1B	1	0.02271	0.05291	0.00490	87	81	70
COLE1-	KELS1-	1	0.07010	0.20097	0.01991	124	119	109
Summer 2013 add								
MAKL3-CL	WIND_CHURCH	1	0.01200	0.03000	0.00004	0	0	0
MAKL3-CL	WIND_CRIGSH	1	0.07420	0.17280	0.00180	0	0	0

TABLE A.3 BRANCH DATA CHANGES

TABLE A.3 BRANCH DATA CHANGES

FROM BUS	TO BUS	ID	PARAMETERS PU ON 100MVA			RATING IN MVA		
			R	X	B	WINTER	AUTUMN	SUMMER
Summer 2013 Add								
MAKL3-CL	WIND_CRIGSH	2	0.07420	0.17280	0.00180	0	0	0
MAKL3-CL	WIND_THRNOG	1	0.18924	0.45417	0.00296	0	0	0
KILL3-CL	WIND_CARICK	1	0.03430	0.06340	0.00480	0	0	0
Winter 13/14 Add								
CREC1B	TAMN1-	1	0.04473	0.1186	0.01609	103	95	82
DRUM1-	TAMN1-	1	0.02841	0.07394	0.0121	103	95	82
DRUM1-	TAMN1-	2	0.02937	0.07549	0.00768	103	95	82
DUNG1A	TAMN1-	1	0.00419	0.01556	0.00214	144	144	144
DUNG1B	TAMN1-	2	0.00913	0.02342	0.00240	103	95	82
OMAH1-	POME1-CL	1	0.02697	0.07359	0.00706	210	200	190
POME1-CL	TAMN1-	1	0.02617	0.07999	0.02432	210	200	190
OMAH1-	TAMN1-	1	0.04909	0.14253	0.03032	210	200	190
FALL1-CL	OMAH1-	1	0.01022	0.06565	0.00630	213	204	188
FALL1-	TAMN1-	1	0.02044	0.13129	0.01260	213	204	188
FALL3-CL	WIND_DIVENA1	1	0.04310	0.10140	0.00092	0	0	0
FALL3-CL	WIND_DIVENA2	1	0.04310	0.10140	0.00092	0	0	0
CAST1B	ROSE1A	1	0.00060	0.00235	0.01436	144	144	144
CAST1B	ROSE1B	1	0.00060	0.00235	0.01436	144	144	144
AIRP1A	CAST1A	1	0.00855	0.02231	0.00377	103	95	82
AIRP1B	CAST1B	1	0.00855	0.02231	0.00377	103	95	82
BELN1A	DONE1C	1	0.00479	0.00459	0.05309	82	75	75
BELN1B	DONE1B	1	0.00479	0.00459	0.05309	82	75	75
BELN3A	BELN3B	1	0.00000	0.00010	0.00000	0	0	0
BELN3A	CENT3-	1	0.00620	0.00811	0.00191	30	30	30
BELN3A	CENT3-	2	0.00563	0.00736	0.00181	30	30	30
BELN3A	DUNM3-	1	0.01249	0.01291	0.00177	30	30	30
BELN3A	SKEG3-	1	0.01569	0.01062	0.00181	30	30	30
BELN3B	CENT3-	1	0.00871	0.00586	0.00181	30	30	30
BELN3B	CENT3-	2	0.00498	0.00650	0.00170	30	30	30
BELN3B	DUNM3-	1	0.01196	0.01232	0.00177	30	30	30
BELN3B	SKEG3-	1	0.01030	0.01064	0.00170	30	30	30
Winter 13/14 Delete								
CREC1B	DUNG1-	1	0.04715	0.12432	0.01201	103	95	82
DRUM1-	DUNG1-	1	0.0333	0.08663	0.0086	103	95	82
DRUM1-	DUNG1-	2	0.0367	0.0952	0.0095	103	95	82
DUNG1-	OMAH1-	1	0.04570	0.12473	0.01197	210	200	190
DUNG1-	OMAH1-	2	0.04975	0.13578	0.01303	210	200	190

TABLE A.3 BRANCH DATA CHANGES

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 13/14 Delete								
CAST1B	ROSE1A	1	0.00086	0.00171	0.02399	128	117	117
CAST1B	ROSE1B	1	0.00086	0.00171	0.02399	128	117	117
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
DONE1C	WEST1A	1	0.00592	0.00567	0.06558	82	75	75
DONE1B	WEST1B	1	0.00592	0.00567	0.06558	82	75	75
DUNM3-	WEST3A	1	0.02120	0.27190	0.00300	33	30	30
DUNM3-	WEST3B	1	0.02030	0.27090	0.00300	33	30	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 14/15 Add								
ALTA1-CL	LIMA1-	1	0.00995	0.03692	0.00507	144	144	144
COLE1-	MANT1-CL	1	0.03337	0.08996	0.00861	124	119	109
KELS1-	MANT1-CL	1	0.04630	0.15376	0.01516	210	200	190
Winter 14/15 Delete								
COLE1-	KELS1-	1	0.06726	0.20105	0.01988	124	119	109
Summer 15 Add								
MANT3-CL	WIND_LONGMT	1	0.06570	0.16100	0.00100	0	0	0
Winter 15/16 Add								
COLE1-	MANT1-CL	1	0.03091	0.08987	0.00864	210	200	190
ENNK1_	OMAH1-	1	0.04401	0.11337	0.01148	124	119	109
ENNK1_	OMAH1-	2	0.04401	0.11337	0.01148	124	119	109
COLE1-	COOL1-	1	0.06086	0.16057	0.01549	103	95	82
COOL1-	LIMA1-	1	0.03196	0.10130	0.00991	210	200	190
COLE1-	LIMA1-	1	0.02201	0.06430	0.00619	210	200	190
CACO2A	MAGF2-	1	0.00210	0.02355	0.14039	837	761	761
CACO2B	MAGF2-	1	0.00210	0.02355	0.14039	837	761	761
Winter 15/16 Delete								
COLE1-	MANT1-CL	1	0.03337	0.08996	0.00861	124	124	124
ENNK1_	OMAH1-	1	0.04401	0.11337	0.01148	103	95	82
ENNK1_	OMAH1-	2	0.04401	0.11337	0.01148	103	95	82
COLE1-	COOL1-	1	0.06086	0.16057	0.01549	103	95	82

TABLE A.3 BRANCH DATA CHANGES

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 15/16 Delete								
COLE1-	LIMA1-	1	0.02433	0.06431	0.00618	103	95	82
COOL1-	LIMA1-	1	0.03853	0.10139	0.00983	103	95	82
CACO2A	MAGF2-	1	0.00670	0.02540	0.14950	513	477	412
CACO2B	MAGF2-	1	0.00670	0.02540	0.14950	513	477	412
Winter 16/17 Add								
MIDCAVAN	TURL4-	1	0.00160	0.01830	0.41390	1713	1566	1424
HANA1A	LISB1A	1	0.00595	0.02558	0.01835	144	144	144
HANA1A	LISB1B	1	0.00595	0.02558	0.01835	144	144	144
Winter 16/17 Delete								
HANA1A	LISB1A	1	0.00974	0.02647	0.01820	103	95	82
HANA1A	LISB1B	1	0.00864	0.02630	0.01795	100	93	80

TABLE A.3 BRANCH DATA CHANGES

TABLE A.4 TRANSFORMER DATA

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NO. 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	0.00390	0.24640	90	1.10000	0.80000	19
ANTR1A	110	ANTR3-	33	1	0.00390	0.24640	90	1.10000	0.80000	19
ANTR1B	110	ANTR3-	33	1	0.00390	0.24730	90	1.10000	0.80000	19
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	BAME3T	33	1	0.00650	0.28930	60	1.15000	0.85000	19
BAME1A	110	BAME3R	33	1	0.01260	0.19400	45	1.10000	0.80000	16
BAME1B	110	BAME3T	33	1	0.00650	0.28670	60	1.15000	0.85000	19
BAME1B	110	BAME3R	33	1	0.01400	0.26490	45	1.10000	0.80000	16
BANB1A	110	BANB3-	33	1	0.01710	0.41330	30	1.10000	0.90000	15
BANB1A	110	BANB3-	33	2	0.01900	0.41400	30	1.10000	0.90000	15
BANB1B	110	BANB3-	33	1	0.01900	0.41670	30	1.10000	0.90000	15
BANB1B	110	BANB3-	33	2	0.01900	0.41500	30	1.10000	0.90000	15
BNCH1A	110	BNCH3-	33	1	0.00380	0.24190	90	1.10000	0.80000	19
BNCH1B	110	BNCH3-	33	1	0.00380	0.24130	90	1.10000	0.80000	19
CARN1A	110	CARN3-	33	1	0.01190	0.22830	60	1.15000	0.85000	19
CARN1B	110	CARN3-	33	1	0.03070	0.44900	30	1.15000	0.85000	19
CARN1B	110	CARN3-	33	2	0.03070	0.44730	30	1.15000	0.85000	19
CENT1A	110	CENT3-	33	1	0.00370	0.24220	90	1.15000	0.85000	19
CENT1B	110	CENT3-	33	1	0.00380	0.24190	90	1.15000	0.85000	19
COLE1-	110	COLE3-	33	1	0.00750	0.25120	60	1.10000	0.80000	19
COLE1-	110	COLE3-	33	2	0.00750	0.25080	60	1.10000	0.80000	19
COOLG8-	11	COOL1-	110	1	0.00680	0.20000	75	1.20000	0.98180	15
COOL1-	110	COOLST-	15.75	1	0.00302	0.07574	200	1.20000	0.98180	15
COOL1-	110	COOL3-	33	1	0.00870	0.25590	90	1.10000	0.80000	19
COOL1-	110	COOL3-	33	2	0.00870	0.25730	90	1.10000	0.80000	19
COOLGT-	15.75	COOL2-	275	1	0.00178	0.05187	300	1.18700	0.97100	15
CREA1-	110	CREA3-	33	1	0.00740	0.25150	60	1.10000	0.80000	19
CREA1-	110	CREA3-	33	2	0.00740	0.25080	60	1.10000	0.80000	19

TABLE A.4 TRANSFORMER DATA

TABLE A.4 TRANSFORMER DATA

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NO. OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
CREG1A	110	CREG3A	33	1	0.00910	0.19530	75	1.15000	0.85000	19
CREG1B	110	CREG3A	33	1	0.00910	0.19670	75	1.15000	0.85000	19
DONE1C	110	DONE3N	33	1	0.00400	0.24030	90	1.15000	0.85000	19
DONE1B	110	DONE3N	33	1	0.01190	0.36580	60	1.15000	0.85000	19
DONE1D	110	DONE3AS	33	1	0.01190	0.36070	60	1.15000	0.85000	19
DONE1A	110	DONE3AS	33	1	0.01190	0.36580	60	1.15000	0.85000	19
DRUM1-	110	DRUM3-	33	1	0.00610	0.24230	90	1.10000	0.80000	19
DRUM1-	110	DRUM3-	33	2	0.00610	0.24260	90	1.10000	0.80000	19
DUNG1-	110	DUNG3-	33	1	0.00870	0.25660	90	1.10000	0.80000	19
DUNG1-	110	DUNG3-	33	2	0.00870	0.25990	90	1.10000	0.80000	19
EDEN1A	110	EDEN3-	33	1	0.01250	0.27330	45	1.10000	0.80000	19
EDEN1B	110	EDEN3-	33	1	0.01230	0.27380	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	0.01260	0.27200	45	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	2	0.01260	0.27330	45	1.1500	0.850	19
ENNK1_	110	ENNK3-	33	3	0.00750	0.25120	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	0.25490	45	1.10000	0.80000	19
GLEN1A	110	GLEN3A	33	1	0.01190	0.26920	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	0.01110	0.27100	60	1.15000	0.85000	19
KNCK1B	110	KNCK3-	33	1	0.01110	0.27150	60	1.15000	0.85000	19
LARN1A	110	LARN3-	33	1	0.01160	0.27780	45	1.10000	0.90000	15
LARN1B	110	LARN3-	33	1	0.01160	0.27710	45	1.10000	0.90000	15
LIMA1-	110	LIMA3-	33	1	0.01250	0.28090	45	1.50000	0.51000	15
LIMA1-	110	LIMA3-	33	2	0.01220	0.27640	45	1.50000	0.51000	15
LISB1A	110	LISB3-	33	1	0.00870	0.25400	90	1.10000	0.80000	19
LISB1B	110	LISB3-	33	1	0.00860	0.25690	90	1.10000	0.80000	19
LSMR1A	110	LSMR3-	33	1	0.00760	0.25400	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	0.27380	45	1.10000	0.80000	19
LOGE1B	110	LOGE3-	33	1	0.01280	0.28000	45	1.10000	0.80000	19
NARD1A	110	NARD3-	33	1	0.00750	0.25050	60	1.10000	0.80000	19
NARD1B	110	NARD3-	33	1	0.00730	0.25000	60	1.10000	0.80000	19
NEWY1A	110	NEWY3-	33	1	0.00380	0.24270	90	1.10000	0.80000	19
NEWY1B	110	NEWY3-	33	1	0.00380	0.24190	90	1.10000	0.80000	19
OMAH1-	110	OMAH3-	33	1	0.00750	0.25220	60	1.10000	0.80000	19
OMAH1-	110	OMAH3-	33	2	0.00750	0.25150	60	1.10000	0.80000	19

TABLE A.4 TRANSFORMER DATA

TABLE A.4 TRANSFORMER DATA

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NO. OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
RATH1A	110	RATH3-	33	1	0.00870	0.25490	90	1.10000	0.80000	19
RATH1B	110	RATH3-	33	1	0.00460	0.24020	90	1.10000	0.80000	19
ROSE1A	110	ROSE3-	33	1	0.00870	0.25760	90	1.10000	0.80000	19
ROSE1B	110	ROSE3-	33	1	0.00870	0.25330	90	1.10000	0.80000	19
SPRN1A	110	SPRN3-	33	1	0.00390	0.24700	90	1.10000	0.80000	19
SPRN1B	110	SPRN3-	33	1	0.00390	0.24710	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	0.00760	0.25220	45	1.10000	0.80000	19
STRA1-	110	STRA3-	33	2	0.00760	0.25160	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	0.00390	0.24810	90	1.10000	0.80000	19
WARN1B	110	WARN3-	33	1	0.00390	0.24880	90	1.10000	0.80000	19
WEST1A	110	WEST3A	33	1	0.00630	0.16710	75	1.15000	0.85000	19
WEST1B	110	WEST3B	33	1	0.00630	0.16590	75	1.15000	0.85000	19

TABLE A.4 TRANSFORMER DATA

TABLE A.5 TRANSFORMER DATA CHANGES

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NO. OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
Winter 11/12 Transformer Add										
BAME1A	110	BAME3R	33	1	0.00390	0.24470	90	1.10000	0.80000	19
BAME1B	110	BAME3R	33	1	0.00390	0.24470	90	1.10000	0.80000	19
DONE1B	110	DONE3N	33	1	0.00390	0.24470	90	1.15000	0.80000	19
OMAH1-	110	OMAH3-	33	1	0.00390	0.24470	90	1.10000	0.80000	19
OMAH1-	110	OMAH3-	33	2	0.00390	0.24470	90	1.10000	0.80000	19
Winter 11/12 Transformer Delete										
BAME1A	110	BAME3R	33	1	0.01260	0.19400	45	1.10000	0.80000	16
BAME1B	110	BAME3R	33	1	0.01400	0.26490	45	1.10000	0.80000	16
DONE1B	110	DONE3N	33	1	0.01190	0.36580	60	1.15000	0.85000	19
OMAH1-	110	OMAH3-	33	1	0.00750	0.25220	60	1.10000	0.80000	19
OMAH1-	110	OMAH3-	33	2	0.00750	0.25150	60	1.10000	0.80000	19
Winter 12/13 Transformer Add										
MAKL1-CL	110	MAKL3-CL	33	1	0.00390	0.24470	90	1.10000	0.80000	19
MAKL1-CL	110	MAKL3-CL	33	2	0.00390	0.24470	90	1.10000	0.80000	19
KILL1-CL	110	KILL3-CL	33	1	0.00750	0.25000	60	1.10000	0.80000	19
CARN1A	110	CARN3-	33	1	0.00390	0.24470	90	1.15000	0.80000	19
CARN1B	110	CARN3-	33	1	0.00390	0.24470	90	1.15000	0.80000	19
KNCK1A	110	KNCK3-	33	1	0.00390	0.24470	90	1.15000	0.80000	19
KNCK1B	110	KNCK3-	33	1	0.00390	0.24470	90	1.15000	0.80000	19
Winter 12/13 Transformer Delete										
CARN1A	110	CARN3-	33	1	0.01190	0.22830	60	1.15000	0.85000	19
CARN1B	110	CARN3-	33	1	0.03070	0.44900	30	1.15000	0.85000	19
KNCK1A	110	KNCK3-	33	1	0.01110	0.27100	60	1.15000	0.85000	19
KNCK1B	110	KNCK3-	33	1	0.01110	0.27150	60	1.15000	0.85000	19
Winter 13/14 Transformer Add										
AIRP1A	110	AIRP3-	33	1	0.00390	0.24470	90	1.10000	0.80000	19
AIRP1B	110	AIRP3-	33	1	0.00390	0.24470	90	1.10000	0.80000	19
BELN1A	110	BELN3A	33	1	0.00390	0.24470	90	1.10000	0.80000	19
BELN1B	110	BELN3B	33	1	0.00390	0.24470	90	1.10000	0.80000	19
FALL1-CL	110	FALL3-CL	33	1	0.00740	0.25000	60	1.10000	0.80000	19
POME1-CL	110	POME3-CL	33	1	0.00750	0.25000	60	1.10000	0.80000	19
ENNK1_	110	ENNK3-	33	1	0.00390	0.24470	90	1.15000	0.80000	19
ENNK1_	110	ENNK3-	33	2	0.00390	0.24470	90	1.10000	0.80000	19

TABLE A.5 TRANSFORMER DATA CHANGES

TABLE A.5 TRANSFORMER DATA CHANGES

FROM BUS		TO BUS		ID	IMPEDANCE PU ON 100MVA BASE		RATING (MVA)	PU OFF NOMINAL RATIO		NO. OF TAP
NAME	kV	NAME	kV		R	X		UPPER	LOWER	
Winter 13/14 Transformer Delete										
WEST1A	110	WEST3A	33	1	0.00630	0.16710	75	1.15000	0.85000	19
WEST1B	110	WEST3B	33	1	0.00630	0.16590	75	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	1	0.01260	0.27200	45	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	2	0.01260	0.27330	45	1.15000	0.85000	19
ENNK1_	110	ENNK3-	33	3	0.00750	0.25120	60	1.10000	0.80000	19
Winter 14/15 Transformer Add										
MANT1-CL	110	MANT3-CL	33	1	0.00740	0.25000	60	1.10000	0.80000	19
ALTA1-CL	110	ALTA3-CL	33	1	0.00740	0.25000	60	1.10000	0.80000	19
CREG1A	110	CREG3A	33	1	0.00390	0.24470	90	1.15000	0.80000	19
CREG1B	110	CREG3A	33	1	0.00390	0.24470	90	1.15000	0.80000	19
BAME1A	110	BAME3T	33	1	0.00390	0.24470	90	1.15000	0.80000	19
BAME1B	110	BAME3T	33	1	0.00390	0.24470	90	1.15000	0.80000	19
Winter 14/15 Transformer Delete										
CREG1A	110	CREG3A	33	1	0.00910	0.19530	75	1.15000	0.85000	19
CREG1B	110	CREG3A	33	1	0.00910	0.19670	75	1.15000	0.85000	19
BAME1A	110	BAME3T	33	1	0.00650	0.28930	60	1.15000	0.85000	19
BAME1B	110	BAME3T	33	1	0.00390	0.24470	90	1.15000	0.80000	19
Winter 15/16 Transformer Add										
DONE1D	110	DONE3AS	33	1	0.00390	0.24470	90	1.15000	0.80000	19
DONE1A	110	DONE3AS	33	1	0.00390	0.24470	90	1.15000	0.80000	19
Winter 15/16 Transformer Delete										
DONE1D	110	DONE3AS	33	1	0.01190	0.36070	60	1.15000	0.85000	19
DONE1A	110	DONE3AS	33	1	0.01190	0.36580	60	1.15000	0.85000	19

TABLE A.5 TRANSFORMER DATA CHANGES

TABLE A.6 275/110 kV INTERBUS TRANSFORMER DATA

FROM BUS	TO BUS	LAST BUS	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-	BAFD6P	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
BAFD1-	BAFD2-	BAFD6Q	0.0018	0.0641	0.0018	0.2059	0.0000	0.1280	240	240	30	1.15	0.85	19
CAST1A	CAST2-	CAST6P	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
CAST1A	CAST2-	CAST6Q	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	30	1.15	0.85	19
CAST1B	CAST2-	CAST6R	0.0018	0.0656	0.0018	0.2375	0.0000	0.1593	240	240	30	1.15	0.85	19
COOL1-	COOL2-	COOL6P	0.0018	0.0609	0.0018	0.1273	0.0000	0.0570	240	240	30	1.15	0.85	19
COOL1-	COOL2-	COOL6Q	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	30	1.15	0.85	19
HANA1A	HANA2A	HANA6P	0.0018	0.0591	0.0018	0.1261	0.0000	0.0560	240	240	30	1.15	0.85	19
HANA1A	HANA2A	HANA6Q	0.0018	0.0591	0.0018	0.1261	0.0000	0.0560	240	240	30	1.15	0.85	19
KELS1-	KELS2-	KELS6P	0.0018	0.0609	0.0018	0.1273	0.0000	0.0570	240	240	30	1.15	0.85	19
KELS1-	KELS2-	KELS6Q	0.0018	0.0607	0.0018	0.1317	0.0000	0.0570	240	240	30	1.15	0.85	19
TAND1A	TAND2-	TAND6P	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	60	1.10	0.90	19
TAND1A	TAND2-	TAND6Q	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
TAND1B	TAND2-	TAND6R	0.0018	0.0656	0.0018	0.2375	0.0000	0.1575	240	240	30	1.15	0.85	19
TAMN1-	TAMN2-	TAMN6P	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19

TABLE A.6 275/110 kV INTERBUS TRANSFORMER DATA

TABLE A.7 275/11.5 kV GENERATOR TRANSFORMER DATA

FROM BUS	TO BUS	LAST 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	
KILR2-	KILRG3	KILRG4	1	0.0027	0.3040	0.0027	0.5740	0.0027	0.3040	110	55	55	1.15	0.94	18

TABLE A.7 275/11.5 kV GENERATOR TRANSFORMER DATA

TABLE A.8 275/110 kV INTERBUS TRANSFORMER DATA CHANGES

FROM BUS	TO BUS	LAST 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 2011/12 INTERBUS TRANSFORMERS ADDED															
HANA1A	HANA2A	HANA6R	1	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19
WINTER 2012/13 INTERBUS TRANSFORMERS ADDED															
CAST1B	CAST2-	CAST6S	1	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19
WINTER 2013/14 INTERBUS TRANSFORMERS ADDED															
TAMN1-	TAMN2-	TAMN6P	1	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19
CAST1A	CAST2-	CAST6P	1	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19
WINTER 2013/14 INTERBUS TRANSFORMERS DELETED															
CAST1A	CAST2-	CAST6P	1	0.0018	0.0641	0.0018	0.2092	0.0000	0.1325	240	240	30	1.15	0.85	19
WINTER 2016/17 INTERBUS TRANSFORMERS ADDED															
COOL1-	COOL2-	COOL6P	1	0.0014	0.0639	0.0018	0.2236	0.0000	0.1449	240	240	60	1.15	0.85	19
WINTER 2016/17 INTERBUS TRANSFORMERS DELETED															
COOL1-	COOL2-	COOL6P	1	0.0018	0.0609	0.0018	0.1273	0.0000	0.057	240	240	30	1.15	0.85	19

TABLE A.8 275/110 kV INTERBUS TRANSFORMER DATA CHANGES

TABLE A.9 400/275 kV INTERBUS TRANSFORMER DATA CHANGES

FROM BUS	TO BUS	LAST 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 2016/17 INTERBUS TRANSFORMERS ADDED															
TURL2-	TURL4-	TURL6P	1	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	600	600	60	1.1	0.9	23
TURL2-	TURL4-	TURL6Q	1	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	600	600	60	1.1	0.9	23
TURL2-	TURL4-	TURL6R	1	0.0008	0.0150	0.0000	0.0001	0.0000	0.0001	600	600	60	1.1	0.9	23

TABLE A.9 400/275 kV INTERBUS TRANSFORMER DATA CHANGES

TABLE A.10 CAPACITANCE DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	LOAD (MVAr)
70033	DYLN3C	DERRYLIN	33	5
74571	CAST6P	CASTLEREAGH	22	25
74572	CAST6Q	CASTLEREAGH	22	25
74573	CAST6R	CASTLEREAGH	22	25
75011	COLE1C	COLERAINE	110	48
75514	COOL1C	COOLKEERAGH	110	40
79030	ENNK3-	ENNISKILLEN	30	24
86220	MOYLE2-	MOYLE	275	236
90071	TAND6P	TANDRAGEE	22	25
90073	TAND6Q	TANDRAGEE	22	25

TABLE A.10 CAPACITANCE DATA

TABLE A.11 CAPACITANCE DATA CHANGES

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	LOAD (MVAr)
CAPACITANCE ADD WINTER 12/13				
74514	CAST1_FIX1	CASTLEREAGH	110	25
74515	CAST1_FIX2	HANNAHSTOWN	110	25
75512	COOL1_FIX1	HANNAHSTOWN	110	25
75513	COOL1_FIX2	KELLS	110	25
90014	TAND1_FIX1	KELLS	110	25
90015	TAND1_FIX2	TANDRAGEE	110	25

TABLE A.11 CAPACITANCE DATA CHANGES

TABLE A.12 REACTANCE DATA

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	LOAD (MVAr)
74572	CAST6P	CASTLEREAGH	22	-30
81071	HANA6P	HANNAHSTOWN	22	-30
81072	HANA6Q	HANNAHSTOWN	22	-30
81571	KELS6P	KELLS	22	-30
81572	KELS6Q	KELLS	22	-30
90071	TAND6P	TANDRAGEE	22	-30
90072	TAND6Q	TANDRAGEE	22	-30

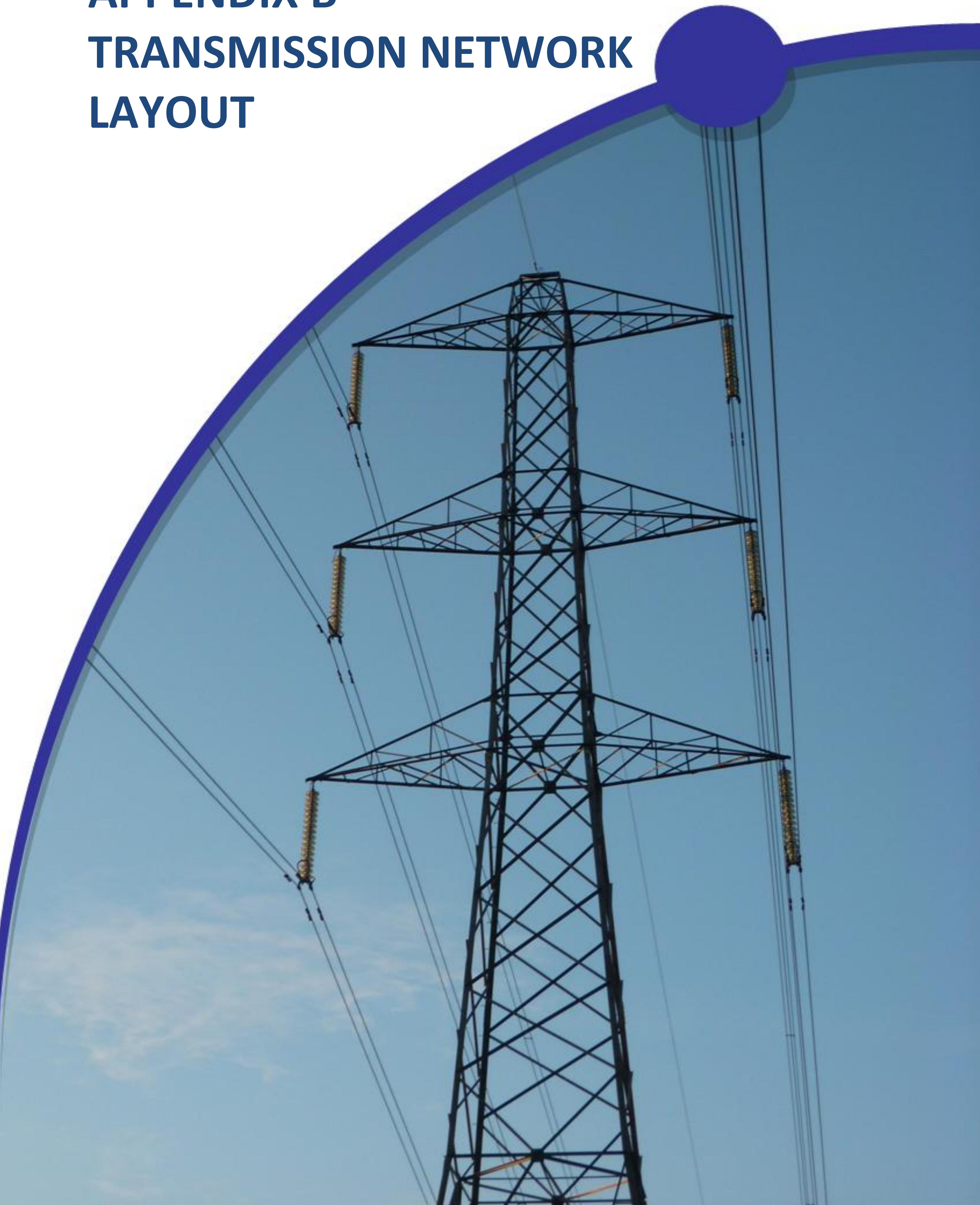
TABLE A.12 REACTANCE DATA

TABLE A.13 SVC DATA CHANGES

BUS NUMBER	BUS NAME	NAME	VOLTAGE (kV)	CONTROL BUS NUMBER	CONTROL BUS NAME	LOWER LIMIT (MVAr)	UPPER LIMIT (MVAr)
SVC ADD WINTER 12/13							
74513	CAST1_SVC	CASTLEREAGH	110	74512	CAST1B	-50	50
75511	COOL1_SVC	COOLKEERAGH	110	75510	COOL1-	-50	50
90013	TAND1_SVC	TANDRAGEE	110	90012	TAND1B	-50	50

TABLE A.13 SVC DATA CHANGES

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 2011/12

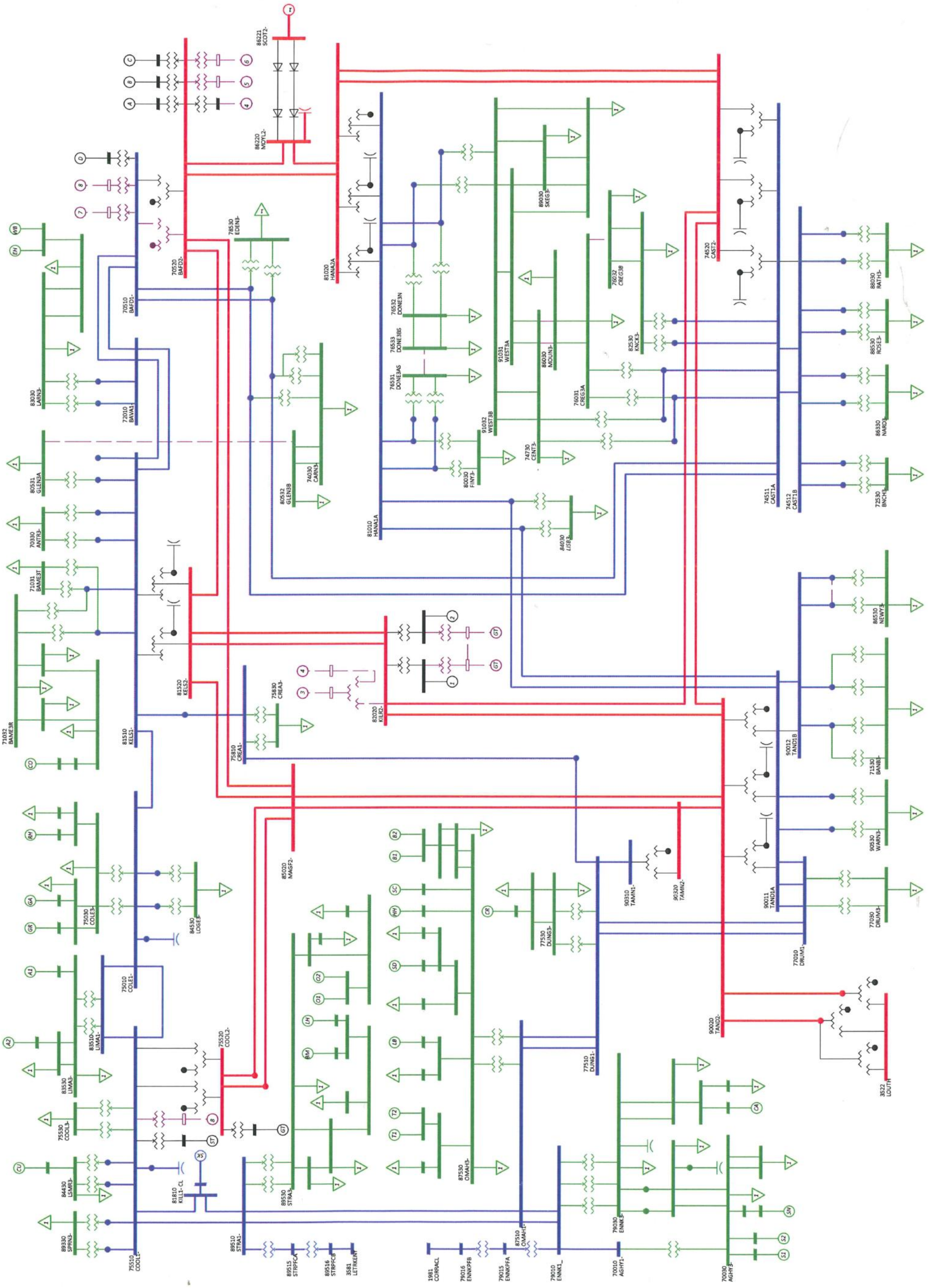
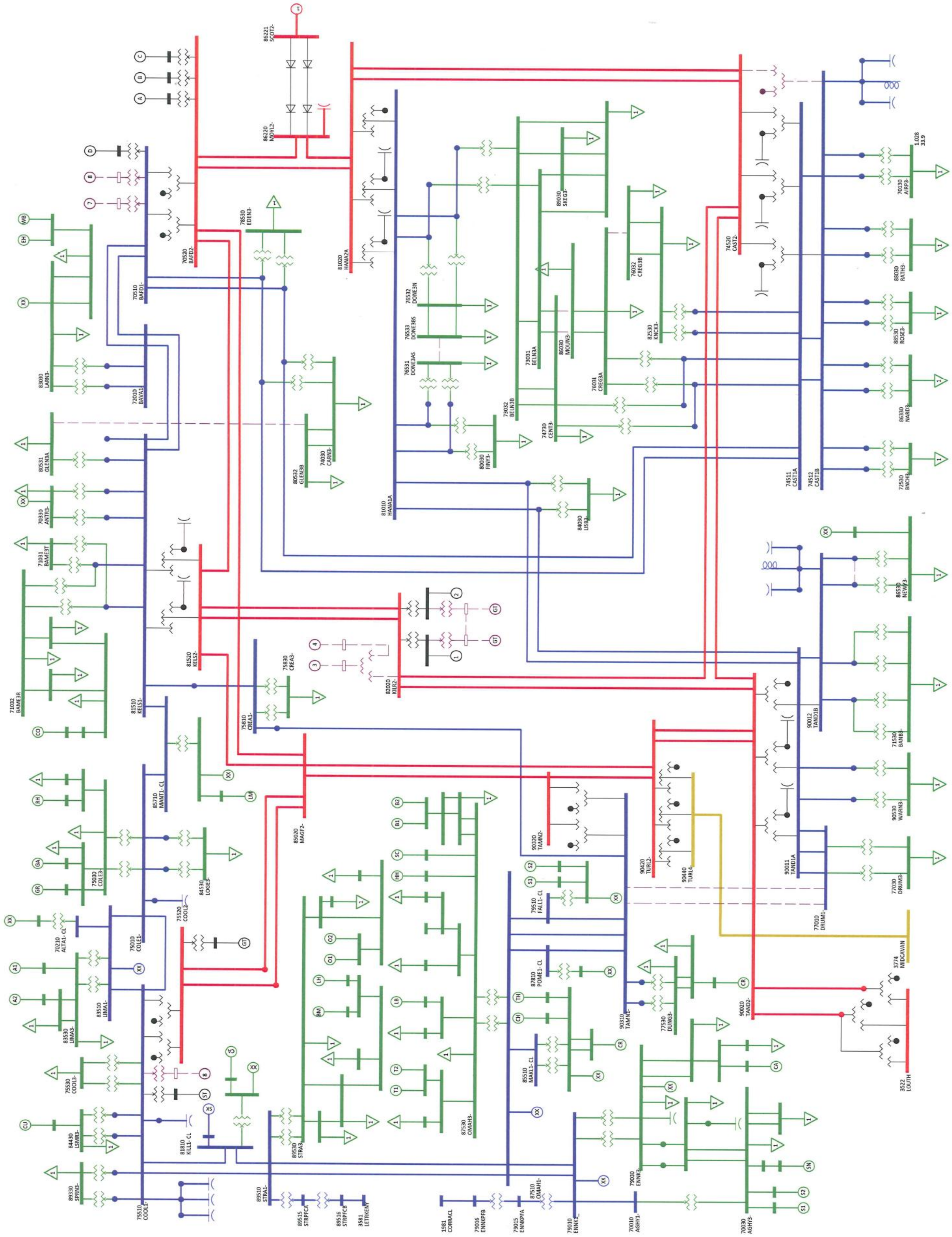
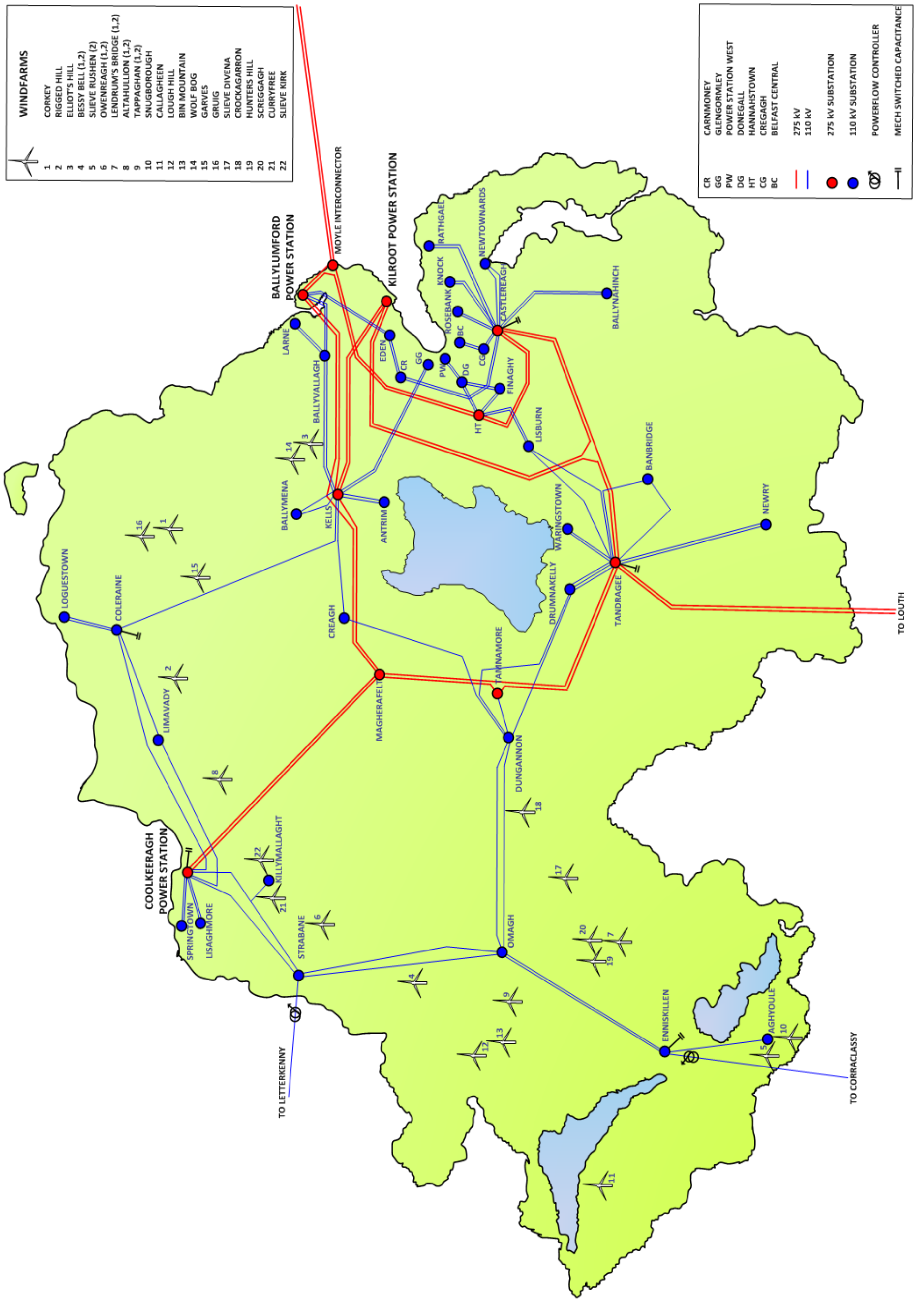
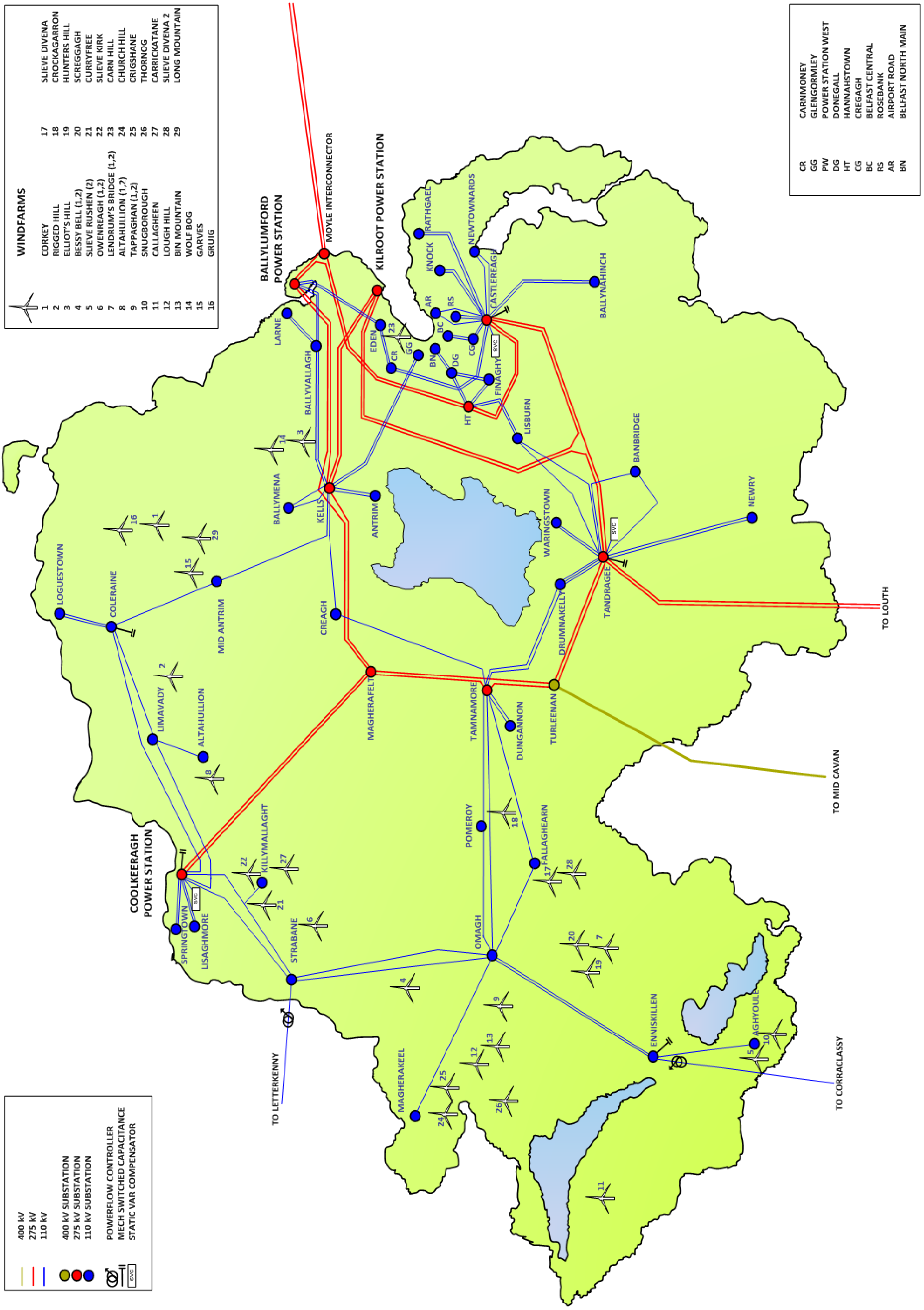


FIGURE B.2: BUSBAR LAYOUT WINTER 2017/18





MAP B1: APPROVED TRANSMISSION SYSTEM WINTER 2011/12



MAP B2: UNAPPROVED TRANSMISSION SYSTEM WINTER 2017/18

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						
		2011	2012	2013	2014	2015	2016	2017
BALLYLUMFORD ST 4	**GAS**/HFO	180	180	180	180	180		
BALLYLUMFORD ST 5	**GAS**/HFO	180	180	180	180	180		
BALLYLUMFORD ST 6	**GAS**/HFO	180	180	180	180	180		
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	STEAM	180	180	180	180	180	180	180
BALLYLUMFORD CCGT 10	**GAS**/GASOIL	100	100	100	100	100	100	100
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**	260	260	260	260	260	260	260
KILROOT ST 2	COAL/**OIL**	260	260	260	260	260	260	260
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	42	42	42	42	42	42	42
KILROOT GT 4	GASOIL	42	42	42	42	42	42	42
COOLKEERAGH GT8	GASOIL	53	53	53	53	53	53	53
COOLKEERAGH CCGT	**GAS**/GASOIL	430	430	430	430	430	430	430
MOYLE	DC LINK	450	450	450	450	450	450	450
TOTAL		2851	2851	2851	2851	2851	2311	2311

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

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	SEE NOTE 1
BALLYLUMFORD ST 5	GAS/HFO	IPP	SEE NOTE 2
BALLYLUMFORD ST 6	GAS/HFO	IPP	SEE NOTE 2
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	STEAM	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	IPP	IPP UNIT SINCE 01/11/2010
KILROOT ST 2	COAL/OIL	IPP	IPP UNIT SINCE 01/11/2010
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	COMMENCED OPERATION 01/03/2009
KILROOT GT 4	GASOIL	IPP	COMMENCED OPERATION 01/03/2009
COOLKEERAGH GT8	GASOIL	NIE	CONTRACTED UNTIL 31/03/2018
COOLKEERAGH CCGT	GAS/GASOIL	IPP	COMMENCED OPERATION 01/04/2005
MOYLE	DC LINK		SEE NOTE 3

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

NOTE 1: In a GUA with NIE PPB until 31st March 2012; Due to EU legislation on emissions it is assumed that this generation will be decommissioned beyond 2015.

NOTE 2: This is an Independent Power Producer (IPP); due to EU legislation on emissions it is assumed that this generation will be decommissioned beyond 2015.

NOTE 3: Capacity is auctioned regularly (monthly and annually) to the market participants.

TABLE C.3: NON FOSSIL FUELS OBLIGATIONS CAPACITY

SCHEME NAME	TECHNOLOGY	MAXIMUM CAPACITY (kW)	CONTRACT EXPIRY DATE
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.3: NON FOSSIL FUELS OBLIGATIONS CAPACITY

TABLE C.4: EXISTING AND COMMITTED WIND GENERATION

SCHEME NAME	MAXIMUM CAPACITY (MW)	110 kV NODE	COMMISSIONING DATE
RIGGED HILL	5	COLERAINE	
CORKEY	5	BALLYMENA	
ELLIOTT'S HILL	5	LARNE	
BESSEY BELL	5	OMAGH	
OWENREAGH	5.5	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	
CALAGHEEN	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	5.1	STRABANE	
GARVES	15	COLERAINE	
GRUIG	25	COLERAINE	
SLIEVE DIVENA	30	OMAGH	
TAPPAGHAN 2	9	OMAGH	
CROCKAGARRON	15	DUNGANNON	
HUNTER'S HILL	20	OMAGH	
SCREGGAGH	20	OMAGH	SUMMER 11
CURRYFREE	15	LISAGHMORE	SUMMER 11
SLIEVE KIRK	27.6	KILLYMALLAGHT	AUTUMN 11
CARN HILL	13.8	CARNMONEY	SUMMER 12
CHURCH HILL	18.4	MAGHERAKEEL	SUMMER 13
CRIGSHANE	32.2	MAGHERAKEEL	SUMMER 13
THORNOG	10	MAGHERAKEEL	SUMMER 13
CARRICKATANE	22.5	KILLYMALLAGHT	SUMMER 13
SLIEVE DIVENA 2	20	FALLAGHERN	SUMMER 14
LONG MOUNTAIN	24	MID-ANTRIM	SUMMER 15
TOTAL	**538.7**		

TABLE C.4: EXISTING AND COMMITTED WIND GENERATION

TABLE C.5: UNAPPROVED WIND GENERATION

ASSUMED TRANSMISSION CONNECTION NODE	ASSUMED MAXIMUM CAPACITY (MW)	ASSUMED CONNECTION DATE
MAGHERAKEEL 1	37.5	WINTER 2012
KILLYMALLAGHT 1	20	WINTER 2013
NEWRY	12.5	WINTER 2013
ENNISKILLEN 1	3	WINTER 2014
FALLAGHEARN 1	22.5	WINTER 2014
LARNE	10	WINTER 2014
MID ANTRIM	18	WINTER 2014
POMEROY 1	47	WINTER 2014
ALTAHULLION	27.6	WINTER 2015
ANTRIM	7	WINTER 2015
KILLYMALLAGHT 2	15	WINTER 2015
MAGHERAKEEL 2	39	WINTER 2015
FALLAGHEARN 2	9	WINTER 2016
LIMAVADY 1	63	WINTER 2016
OMAGH	71.7	WINTER 2016
POMEROY 2	6	WINTER 2016
ENNISKILLEN 2	20.7	WINTER 2017
LIMAVADY 2	60	WINTER 2017
MAGHERAKEEL 3	12	WINTER 2017
TOTAL	**501.5**	

TABLE C.5: UNAPPROVED WIND GENERATION

APPENDIX D
BULK SUPPLY POINT SUBSTATION CAPACITY

APPENDIX D BULK SUPPLY POINT SUBSTATION CAPACITY

This Appendix presents the available capacity at Bulk Supply Point (BSP) substations over the seven year period covered by this Transmission System Capacity Statement (TSCS). The demand forecasts for Winter Maximum, Summer Maximum and Autumn Maximum conditions are provided. **Table D2** will highlight the spare capacity at each Bulk Supply Point at winter maximum. All of the maximum demand forecasts have been calculated without wind generation supplying local load.

The highest demand will be seen at the BSP's under single circuit outage conditions. Under single circuit outage conditions the BSP load will be supplied through a single impedance path for example through a single 110 kV branch and a 110/33 kV transformer. The resulting power flow has higher MVAr flow and thus gives a true picture of when improvements are required on the NI Transmission System.

Table D.5 illustrates the Summer Minimum BSP loading, under single circuit outage conditions, with maximum wind. This scenario highlights the risk to the transmission system posed by high levels of distributed connected wind generation.

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.** These notes refer the factor that determines the firm capacity of the BSP substation:

1. The normal rating of the transformer, as it is greater than 40 years old.
2. The cyclic rating of the transformer.
3. The 110 kV line rating.
4. Substation components.
5. Voltage performance under outage conditions.
6. The 110 kV line rating in summer, substation components in winter.
7. The firm capacity of Belfast Central BSP is based upon support from Power Station West, via interconnected 33 kV cables.

8 The firm capacity of the Glengormley BSP is based upon the rating of the 33 kV 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 DRUMNAKELLY

Drumnakelly main is overloaded in winter 2011/12 this overload is alleviated when the 33/11 kV substation load at Carn Central is transferred from Drumnakelly to Warringstown in Winter 2012/13

D.2.2 WARINGSTOWN

The demand forecast is based on a 33/11 kV substation load at Carn Central being transferred to Waringstown in Winter 2012/13. Since the firm capacity of the substation is exceeded, the load transfer will not take place until capacity issues have been managed by replacing the 33 kV switchboard.

D.2.3 KNOCK

The overload is currently managed by a load transfer scheme. The Ballymacarrett load is scheduled to be transferred from Knock to Airport Road in Winter 2013/14 this resolves the overload issue at Knock.

D.2.4 STRABANE

NIE have confirmed that the overloads at Strabane will be addressed by up rating the cables that limit the substation capacity as part of the mesh refurbishment.

D.2.5 OTHER ISSUES

NIE have confirmed that the overloads that have been highlighted at Eden, Lisaghmore, and Donegall Main (North) will be resolved by asset replacement works that will increase substation capacity.

TABLE D.1: WINTER BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

BSP Location	TX (MVA)	SS (MVA)	WINTER BSP FORECAST LOADING- SINGLE OUTAGE CONDITIONS (MVA) 11/12	12/13	13/14	14/15	15/16	16/17	17/18	Notes
Aghyoule Main	90	29.0	13.23	13.31	13.44	13.61	13.75	13.90	14.04	5
Antrim Main	90	55.3	45.80	46.26	46.91	47.59	48.26	48.94	49.61	4
Ballymena Mesh (Rural)	90	55.3	52.16	52.70	53.46	54.27	39.07	39.84	40.60	4
Ballymena SWBD (Town)	120	72.8	47.76	48.28	48.98	49.73	50.46	51.21	51.94	4
Ballynahinch Main	180	71.4	64.97	65.64	66.57	67.61	68.59	69.58	70.55	4
Banbridge Main	120	71.4	45.51	45.99	46.65	47.38	48.07	48.78	49.47	4
Coleraine Main	120	71.4	46.81	47.30	47.98	48.73	49.44	50.16	50.88	4
Coolkeeragh Main	180	114.0	34.34	34.71	35.23	35.74	36.26	36.80	37.32	2
Creagh Main	120	78.0	26.58	26.82	27.16	27.53	43.58	43.98	44.36	4
Drumnakelly Main	180	111.0	112.38	100.93	102.56	104.23	105.90	107.61	109.29	4
Dungannon Main	180	114.0	89.94	90.96	92.35	93.79	95.21	96.68	98.11	4
Eden Main	90	37.4	34.91	35.27	35.77	36.35	36.88	37.42	37.95	4
Enniskillen Main	150	73.0	51.56	52.10	52.85	53.65	54.43	55.22	56.00	4
Larne Main	90	55.3	46.18	46.69	47.39	48.19	48.93	49.67	50.41	4
Limavady Main	90	40.3	25.64	25.91	26.28	26.69	27.08	27.47	27.86	4
Lisaghmore Main	90	58.5	54.17	54.73	55.52	56.38	57.20	58.03	58.85	2
Lisburn Main	180	90.0	73.27	74.04	75.12	76.24	77.35	78.48	79.60	1
Loguestown Main	90	58.5	41.03	41.45	42.03	42.70	43.32	43.94	44.56	2
Newry Main	180	103.0	86.98	87.90	89.18	90.53	91.85	93.20	94.52	3
Newtownards Main	120	78.0	48.20	48.70	49.39	50.18	50.91	51.65	52.38	2
Omagh Main	120	78.0	59.09	59.63	60.41	61.26	62.07	62.90	63.71	2
Rathgael Main	180	103.0	71.68	72.42	73.44	74.62	75.71	76.81	77.89	3
Rosebank Main	180	111.0	38.97	44.53	34.54	35.10	35.60	36.11	36.62	4
Springtown Main	180	87.9	34.02	34.39	34.90	35.42	35.95	36.48	37.01	4
Strabane Main	90	33.8	38.02	38.42	38.97	39.58	40.16	40.74	41.32	4
Waringstown Main	180	65.4	56.16	68.90	69.74	70.66	71.54	72.43	73.30	4
BELFAST - Belfast Central Main	180	110.0	68.81	69.60	70.67	71.61	72.67	73.76	74.84	7
BELFAST - Belfast North Main*	180	100.0	N/A	N/A	65.69	66.73	67.70	68.68	69.63	7
BELFAST - PSW	150	100.0	54.76	55.32	BSP will be decommissioned					7
BELFAST - Carnmoney Main	120	68.6	43.86	44.33	44.97	45.66	46.32	47.00	47.67	4
BELFAST - Glengormley Main	60	30.8	16.96	17.14	17.39	17.66	17.92	18.19	18.45	8
BELFAST - Cregagh Main	150	78.9	67.93	68.62	56.45	57.48	58.46	59.46	60.45	4
BELFAST - Knock Main	120	71.0	75.36	76.12	66.45	67.61	68.72	69.84	70.94	4
BELFAST - Finaghy Main	90	58.5	39.38	39.80	40.38	41.01	41.61	42.22	42.83	2
BELFAST - Donegall Main(North)	150	68.5	63.19	63.83	64.73	65.72	66.66	67.61	68.55	4
BELFAST - Donegall Main(South)	120	68.5	60.17	60.76	61.61	62.55	63.43	64.33	65.21	4
BELFAST - Airport Road Main*	180	103.0	N/A	N/A	33.93	34.44	34.94	35.45	35.95	3

TABLE D.1: WINTER BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

* New BSP to be established over the seven-year period

TABLE D.2: WINTER BSP SUBSTATION AVAILABILITY CAPACITY

BSP Location	TX (MVA)	SS (MVA)	WINTER BSP SUBSTATION AVAILABLE CAPACITY SINGLE OUTAGE CONDITIONS (MVA)							Notes
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	
Aghyoule Main	90	29.0	15.77	15.69	15.56	15.39	15.25	15.10	14.96	5
Antrim Main	90	55.3	9.50	9.04	8.39	7.71	7.04	6.36	5.69	4
Ballymena Mesh (Rural)	90	55.3	3.14	2.60	1.84	1.03	16.23	15.46	14.70	4
Ballymena SWBD (Town)	120	72.8	25.04	24.52	23.82	23.07	22.34	21.59	20.86	4
Ballynahinch Main	180	71.4	6.43	5.76	4.83	3.79	2.81	1.82	0.85	4
Banbridge Main	120	71.4	25.89	25.41	24.75	24.02	23.33	22.62	21.93	4
Coleraine Main	120	71.4	24.59	24.10	23.42	22.67	21.96	21.24	20.52	4
Coolkeeragh Main	180	114.0	79.66	79.29	78.77	78.26	77.74	77.20	76.68	2
Creagh Main	120	78.0	51.42	51.18	50.84	50.47	34.42	34.02	33.64	4
Drumnakelly Main	180	111.0	-1.38	10.07	8.44	6.77	5.10	3.39	1.71	4
Dungannon Main	180	114.0	24.06	23.04	21.65	20.21	18.79	17.32	15.89	4
Eden Main	90	37.4	2.49	2.13	1.63	1.05	0.52	-0.02	-0.55	4
Enniskillen Main	150	73.0	21.44	20.90	20.15	19.35	18.57	17.78	17.00	4
Larne Main	90	55.3	9.12	8.61	7.91	7.11	6.37	5.63	4.89	4
Limavady Main	90	40.3	14.66	14.39	14.02	13.61	13.22	12.83	12.44	4
Lisaghmore Main	90	58.5	4.33	3.77	2.98	2.12	1.30	0.47	-0.35	2
Lisburn Main	180	90.0	16.73	15.96	14.88	13.76	12.65	11.52	10.40	1
Loguestown Main	90	58.5	17.47	17.05	16.47	15.80	15.18	14.56	13.94	2
Newry Main	180	103.0	16.02	15.10	13.82	12.47	11.15	9.80	8.48	3
Newtownards Main	120	78.0	29.80	29.30	28.61	27.82	27.09	26.35	25.62	2
Omagh Main	120	78.0	18.91	18.37	17.59	16.74	15.93	15.10	14.29	2
Rathgael Main	180	103.0	31.32	30.58	29.56	28.38	27.29	26.19	25.11	3
Rosebank Main	180	111.0	72.03	66.47	76.46	75.90	75.40	74.89	74.38	4
Springtown Main	180	87.9	53.88	53.51	53.00	52.48	51.95	51.42	50.89	4
Strabane Main	90	33.8	-4.22	-4.62	-5.17	-5.78	-6.36	-6.94	-7.52	4
Waringstown Main	180	65.4	9.24	-3.50	-4.34	-5.26	-6.14	-7.03	-7.90	4
BELFAST - Belfast Central Main	180	110.0	41.19	40.40	39.33	38.39	37.33	36.24	35.16	7
BELFAST - Belfast North Main*	180	100.0	N/A	N/A	34.31	33.27	32.30	31.32	30.37	7
BELFAST - PSW	150	100.0	45.24	44.68	BSP will be decommissioned					7
BELFAST - Carnmoney Main	120	68.6	24.74	24.27	23.63	22.94	22.28	21.60	20.93	4
BELFAST - Glengormley Main	60	30.8	13.84	13.66	13.41	13.14	12.88	12.61	12.35	8
BELFAST - Cregagh Main	150	78.9	10.97	10.28	22.45	21.42	20.44	19.44	18.45	4
BELFAST - Knock Main	120	71.0	-4.36	-5.12	4.55	3.39	2.28	1.16	0.06	4
BELFAST - Finaghy Main	90	58.5	19.12	18.70	18.12	17.49	16.89	16.28	15.67	2
BELFAST - Donegall Main (North)	150	68.5	5.31	4.67	3.77	2.78	1.84	0.89	-0.05	4
BELFAST - Donegall Main (South)	120	68.5	8.33	7.74	6.89	5.95	5.07	4.17	3.29	4
BELFAST - Airport Road Main*	180	103.0	N/A	N/A	69.07	68.56	68.06	67.55	67.05	3

TABLE D.2: WINTER BSP SUBSTATION AVAILABILITY CAPACITY

*** New BSP to be established over the seven-year period**

TABLE D.3: AUTUMN BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

BSP Location	TX (MVA)	SS (MVA)	AUTUMN BSP FORECAST LOADING- SINGLE OUTAGE CONDITIONS (MVA)							Notes
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	
Aghyoule Main	90	29.0	11.33	11.40	11.51	11.66	11.78	11.90	12.01	5
Antrim Main	90	55.3	38.37	38.74	39.28	39.87	40.41	40.98	41.49	4
Ballymena Mesh (Rural)	90	55.3	44.87	45.32	45.96	46.68	33.59	34.25	34.87	4
Ballymena SWBD (Town)	120	72.8	41.18	41.60	42.21	42.87	43.48	44.12	44.71	4
Ballynahinch Main	180	71.4	56.03	56.58	57.38	58.30	59.11	59.96	60.74	4
Banbridge Main	120	71.4	39.14	39.53	40.10	40.75	41.32	41.93	42.48	4
Coleraine Main	120	71.4	40.12	40.52	41.11	41.77	42.35	42.97	43.53	4
Coolkeeragh Main	180	114.0	29.67	29.98	30.43	30.88	31.32	31.78	32.20	2
Creagh Main	120	78.0	22.88	23.08	23.37	23.71	37.50	37.84	38.12	4
Drumnakelly Main	180	111.0	96.62	86.73	88.13	89.62	91.00	92.46	93.81	4
Dungannon Main	180	114.0	77.81	78.66	79.86	81.14	82.33	83.59	84.74	4
Eden Main	90	37.4	29.42	29.71	30.13	30.63	31.06	31.51	31.92	4
Enniskillen Main	150	73.0	45.79	46.25	46.92	47.66	48.32	49.02	49.66	4
Larne Main	90	55.3	39.22	39.63	40.22	40.93	41.53	42.16	42.74	4
Limavady Main	90	40.3	22.01	22.23	22.55	22.91	23.23	23.57	23.88	4
Lisaghmore Main	90	58.5	46.67	47.13	47.81	48.57	49.25	49.97	50.62	2
Lisburn Main	180	90.0	63.13	63.77	64.70	65.70	66.62	67.59	68.47	1
Loguestown Main	90	58.5	35.36	35.70	36.20	36.80	37.31	37.84	38.33	2
Newry Main	180	95.0	75.63	76.40	77.51	78.72	79.82	80.99	82.06	3
Newtownards Main	120	78.0	41.40	41.81	42.40	43.10	43.71	44.34	44.92	2
Omagh Main	120	78.0	50.73	51.17	51.84	52.59	53.26	53.97	54.61	2
Rathgael Main	180	95.0	61.90	62.50	63.39	64.44	65.34	66.29	67.15	3
Rosebank Main	180	111.0	32.92	37.60	29.17	29.65	30.06	30.49	30.88	4
Springtown Main	180	87.9	29.22	29.53	29.96	30.43	30.86	31.32	31.74	4
Strabane Main	90	33.8	32.62	32.94	33.42	**33.96**	**34.43**	**34.94**	**35.39**	4
Waringstown Main	180	65.4	48.44	59.41	60.13	60.96	61.68	62.44	63.12	4
BELFAST - Belfast Central Main	180	110.0	58.98	59.63	60.55	61.38	62.25	63.19	64.04	7
BELFAST - Belfast North Main*	180	100.0	N/A	N/A	46.97	47.74	48.40	49.09	49.73	7
BELFAST - PSW	150	100.0	46.30	46.75	BSP will be decommissioned					7
BELFAST - Carnmoney Main	120	68.6	37.70	38.08	38.63	39.24	39.79	40.37	40.90	4
BELFAST - Glengormley Main	60	30.8	14.47	14.61	14.83	15.07	15.28	15.51	15.71	8
BELFAST - Cregagh Main	150	78.9	58.50	59.07	48.59	49.50	50.31	51.17	51.97	4
BELFAST - Knock Main	120	71.0	64.28	64.91	56.66	57.68	58.59	59.54	60.42	4
BELFAST - Finaghy Main	90	58.5	33.27	33.61	34.09	34.64	35.13	35.65	36.12	2
BELFAST - Donegall Main(North)	150	68.5	55.52	56.06	56.85	57.75	58.54	59.38	60.14	4
BELFAST - Donegall Main(South)	120	68.5	51.56	52.05	52.77	53.61	54.34	55.10	55.80	4
BELFAST - Airport Road Main*	180	95.0	N/A	N/A	29.18	29.64	30.06	30.49	30.89	3

TABLE D.3: AUTUMN BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

* New BSP to be established over the seven-year period

TABLE D.4: SUMMER BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

BSP Location	TX (MVA)	SS (MVA)	SUMMER MAXIMUM BSP FORECAST LOADING- SINGLE OUTAGE CONDITIONS (MVA)							Notes
			11/12	12/13	13/14	14/15	15/16	16/17	17/18	
Aghyoule Main	90	29	10.37	10.42	10.52	10.67	10.77	10.88	10.97	5
Antrim Main	90	55	36.07	36.40	36.91	37.49	37.97	38.50	38.95	4
Ballymena Mesh (Rural)	90	55	41.00	41.39	41.98	42.67	30.68	31.28	31.81	4
Ballymena SWBD (Town)	120	73	37.66	38.03	38.58	39.22	39.75	40.33	40.83	4
Ballynahinch Main	180	71	50.94	51.41	52.14	53.02	53.72	54.49	55.14	4
Banbridge Main	120	71	35.67	36.01	36.53	37.14	37.64	38.19	38.65	4
Coleraine Main	120	71	36.63	36.97	37.50	38.14	38.64	39.21	39.68	4
Coolkeeragh Main	180	114	27.14	27.41	27.81	28.25	28.63	29.05	29.41	2
Creagh Main	120	78	20.92	21.09	21.36	21.68	34.27	34.58	34.80	4
Drumnakelly Main	180	111	88.47	79.37	80.65	82.07	83.28	84.62	85.76	4
Dungannon Main	180	114	71.14	71.88	72.97	74.20	75.23	76.39	77.36	4
Eden Main	90	37	27.42	27.67	28.06	28.55	28.93	29.35	29.71	4
Enniskillen Main	150	73	40.20	40.58	41.16	41.84	42.39	43.01	43.52	4
Larne Main	90	55	35.75	36.11	36.64	37.31	37.83	38.41	38.89	4
Limavady Main	90	40	20.12	20.31	20.60	20.94	21.22	21.53	21.79	4
Lisaghmore Main	90	59	42.52	42.93	43.54	44.27	44.86	45.51	46.06	2
Lisburn Main	180	90	57.65	58.20	59.05	60.00	60.80	61.69	62.43	1
Loguestown Main	90	59	32.38	32.67	33.13	33.70	34.15	34.64	35.05	2
Newry Main	180	95	68.95	69.61	70.62	71.78	72.73	73.80	74.69	3
Newtownards Main	120	78	37.78	38.13	38.67	39.34	39.86	40.44	40.92	2
Omagh Main	120	78	46.23	46.61	47.22	47.94	48.51	49.16	49.69	2
Rathgael Main	180	95	56.19	56.71	57.51	58.51	59.28	60.14	60.86	3
Rosebank Main	180	111	30.63	34.96	27.12	27.59	27.95	28.35	28.69	4
Springtown Main	180	88	26.72	26.98	27.38	27.83	28.20	28.62	28.98	4
Strabane Main	90	34	29.80	30.08	30.51	31.03	31.44	31.90	32.28	4
Waringstown Main	180	65	44.24	54.22	54.88	55.68	56.30	57.00	57.56	4
BELFAST - Belfast Central Main	180	110	52.01	52.56	53.37	54.14	54.87	55.70	56.39	7
BELFAST - Belfast North Main*	180	100	N/A	N/A	42.09	42.81	43.38	44.00	44.52	7
BELFAST - PSW	150	100	42.22	42.60	BSP will be decommissioned					7
BELFAST - Carnmoney Main	120	69	34.42	34.75	35.26	35.83	36.31	36.84	37.29	4
BELFAST - Glengormley Main	60	31	13.20	13.33	13.52	13.75	13.94	14.14	14.31	8
BELFAST - Cregagh Main	150	79	52.76	53.24	43.80	44.65	45.35	46.13	46.80	4
BELFAST - Knock Main	120	71	56.76	57.28	50.00	50.94	51.70	52.55	53.26	4
BELFAST - Finaghy Main	90	59	30.35	30.64	31.09	31.61	32.03	32.51	32.90	2
BELFAST - Donegall Main (North)	150	69	50.34	50.81	51.52	52.37	53.05	53.81	54.44	4
BELFAST - Donegall Main (South)	120	69	47.11	47.53	48.19	48.99	49.62	50.32	50.90	4
BELFAST - Airport Road Main*	180	95	N/A	N/A	26.67	27.11	27.46	27.86	28.19	3

TABLE D.4: SUMMER BSP PEAK DEMAND: SINGLE CIRCUIT OUTAGE CONDITIONS

*** New BSP to be established over the seven-year period**

TABLE D.5: SUMMER MINIMUM, MAXIMUM WIND, SINGLE CIRCUIT OUTAGE BSP LOADING

BSP Location	BSP Installed Wind Capacity (MW)			TX (MVA)	SS (MVA)	BSP LOADING (MVA)			Notes
	2011	2014	2017			2011	2014	2017	
Aghyoule Main	67.5	67.5	67.5	90	29.0	-62	-62.2	-64.2	5
Antrim Main	N/A	N/A	7	90	55.3	N/A	N/A	12.2	4
Ballymena Mesh (Rural)	5	5	5	90	55.3	8.5	9	5.8	4
BELFAST - Carnmoney Main	N/A	13.8	13.8	120	68.6		-6.4	-6.1	4
Coleraine Main	45	45	45	120	71.4	-37.3	-37.1	-36.8	4
Dungannon Main	15	15	15	180	114.0	15.2	16.1	17.3	4
Enniskillen Main	16.9	19.9	19.9	150	73.0	-25.3	-26.6	-28.2	4
Larne Main	15	25	25	90	55.3	-8.5	-8.6	-15.3	4
Limavady Main	37.7	37.7	37.7	90	40.3	-33.5	-33.3	-33.1	4
Lisaghmore Main	15	15	15	90	58.5	-7.8	-7.7	-7.6	2
Newry Main	N/A	12.5	12.5	180	95.0	N/A	13.9	14.9	3
Omagh Main	125.7	95.7	95.7	120	78.0	-127.2	-90.7	-82.9	2
Strabane Main	27.4	27.4	27.4	90	33.8	-18.8	-18.6	-17.8	4
Note that a negative loading indicates that power is exported from BSP onto the Transmission System									

TABLE D.5: SUMMER MINIMUM, MAXIMUM WIND, SINGLE CIRCUIT OUTAGE - BSP LOADING

TABLE D.6: SUMMER MINIMUM, MAXIMUM WIND, SINGLE CIRCUIT OUTAGE BSP AVAILABILITY

BSP Location	BSP Installed Wind Capacity (MW)			TX (MVA)	SS (MVA)	BSP AVAILABLE CAPACITY (MVA)			Notes
	2011	2014	2017			2011	2014	2017	
Aghyoule Main	67.5	67.5	67.5	90	29	-33	-33.2	-35.2	5
Antrim Main			7	90	55.3			43.1	4
Ballymena Mesh (Rural)	5	5	5	90	55.3	46.8	46.3	49.5	4
BELFAST - Carnmoney Main		13.8	13.8	120	68.6		62.2	62.5	4
Coleraine Main	45	45	45	120	71.4	34.1	34.3	34.6	4
Dungannon Main	15	15	15	180	114	98.8	97.9	96.7	4
Enniskillen Main	16.9	19.9	19.9	150	73	47.7	46.4	44.8	4
Larne Main	15	25	25	90	55.3	46.8	46.7	40	4
Limavady Main	37.7	37.7	37.7	90	40.3	6.8	7	7.2	4
Lisaghmore Main	15	15	15	90	58.5	50.7	50.8	50.9	2
Newry Main		12.5	12.5	180	95		81.1	80.1	3
Omagh Main	125.7	95.7	95.7	120	78	-49.2	-12.7	-4.9	2
Strabane Main	27.4	27.4	27.4	90	33.8	15	15.2	16	4

TABLE D.6: SUMMER MINIMUM, MAXIMUM WIND, SINGLE CIRCUIT OUTAGE - BSP AVAILABILITY

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

In line with the 2009 Transmission System Capacity Statement (TSCS) the G74 calculation techniques have been adopted and 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:

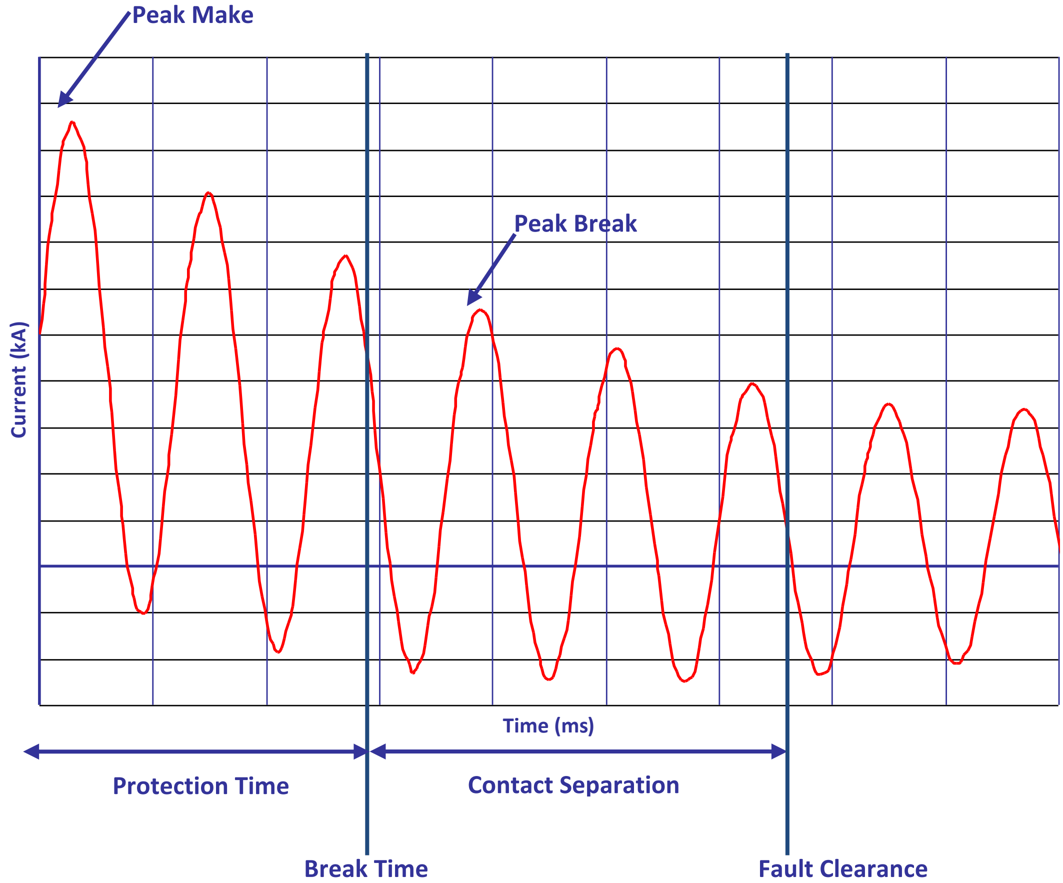


Figure E.1: Short Circuit Current

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 275 kV and 110 kV 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.

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 0 MW 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.

CENTRALLY DISPATCHED GENERATING UNIT	2011/12		2017/18	
	SUMMER MIN	WINTER MAX	SUMMER MIN	WINTER MAX
BALLYLUMFORD ST 4	-	0	Decommissioned	Decommissioned
BALLYLUMFORD ST 5	-	0	Decommissioned	Decommissioned
BALLYLUMFORD ST 6	-	0	Decommissioned	Decommissioned
BALLYLUMFORD CCGT 21	-	140	-	140
BALLYLUMFORD CCGT 22	-	140	-	140
BALLYLUMFORD CCGT 20	-	140	-	150
BALLYLUMFORD CCGT 10	60	80	65	80
BALLYLUMFORD GT 7	-	0	-	58
BALLYLUMFORD GT 8	-	0	-	58
KILROOT ST 1	110	175	110	195
KILROOT ST 2	-	175	-	195
KILROOT GT 1	-	0	-	0
KILROOT GT 2	-	0	-	0
KILROOT GT 3	-	42	-	42
KILROOT GT 4	-	42	-	42
COOLKEERAGH GT8	0	0	-	50
COOLKEERAGH CCGT	260	410	260	400
MOYLE	235	325	235	325
NORTH-SOUTH	-246*	127	-379*	19
WIND	30%	10%	30%	10%

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

*A negative value for the North-South flow indicates a net export to EirGrid.

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 50 ms has been assumed for the circuit breakers at all nodes, both 275 kV and 110 kV.

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 System Capacity Statements (TSCS), 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. This TSCS like the previous statement shows that 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 110 kV 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 2011/12

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275 kV											
BALLYLUMFORD	26.5	66.3	35.65	21.13	54.63	18.35	24.78	24.95	64.85	22.93	30.76
CASTLEREAGH	31.5	79	35.65	16.52	40.89	14.42	16.40	17.23	42.67	15.93	18.18
COOLKEERAGH	31.5	79	35.3	12.1	29	10.84	12.05	12.48	30.64	11.75	13.52
HANNAHSTOWN	31.5	79	35.65	16.6	41.27	14.51	16.72	17.4	43.26	16.1	18.76
KELLS	31.5	79	35.65	18.56	46.89	16.22	19.43	19.25	48	17.9	20.57
KILROOT	31.5	79	45.3	18.11	46.19	15.89	19.82	21.75	56.03	20.12	25.58
MAGHERAFELT	31.5	79	35.65	18.02	45.16	15.78	18.20	15.73	37.91	14.76	15.51
MOYLE	31.5	79	35.65	20.59	53.11	17.92	23.84	24.02	62.18	22.14	28.97
TANDRAGEE	26.5	66.3	35.65	18.53	45.81	16.2	18.18	18.23	44.8	16.93	18.98
TAMNAMORE	31.5	79	57.3	14.46	35.82	12.93	14.28	12.58	30.49	11.92	12.69

Table E.2: 275 kV Winter 2011/12 Fault Level Results

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
AGHYOULE	25.0	62.5		3.91	8.20	3.24	3.46	3.97	8.83	3.49	3.89
ANTRIM	18.4	46.8		9.73	20.62	9.20	9.32	9.70	20.92	9.39	9.74
BALLYLUMFORD*	21.9	55	25.88	23.76	59.26	21.61	28.58				
	26.2	65.0	29.7					27.99	70.74	26.44	35.26
BALLYMENA	18.4	46.8		9.43	20.17	8.85	9.00	10.00	22.18	9.61	10.09
BANBRIDGE	18.4	46.8		6.76	14.01	6.46	6.50	6.63	14.54	6.46	6.69
BALLYVALLAGH	18.4	46.8	23	16.30	35.24	15.02	15.07	14.78	31.73	14.17	14.24
BALLYNAHINCH	18.4	46.8		5.94	12.37	5.64	5.69	5.89	12.88	5.71	5.94
CARNMONEY	26.2	65	44.9	9.00	18.36	8.54	8.56	8.84	18.88	8.59	8.75
CASTLEREAGH	26.2	65	33.5	20.66	50.78	18.22	22.20	26.17	64.93	23.77	29.01
BELFAST CENTRAL	31.5	79		16.13	38.02	14.56	15.61	18.99	41.19	17.65	18.93
COLERAINE	31.5	79	42.5	8.10	16.46	6.99	6.99	9.27	19.65	8.33	8.37
COOLKEERAGH	31.5	80	33.5	21.81	53.16	18.48	22.56	27.17	66.96	24.12	29.62
CREAGH	31.5	80	33.5	8.00	15.93	7.58	7.58	8.37	17.67	8.10	8.14
CREGAGH	26.2	65		18.33	43.89	16.35	18.20	22.27	51.3	20.46	22.41
DONEGALL NORTH	31.5	79	33.5	18.39	43.67	16.69	18.04	22.23	48.79	20.72	21.54
DONEGALL SOUTH	31.5	79	33.5	13.68	30.54	12.68	12.88	14.41	31.07	13.74	14.11
DRUMNAKELLY	31.5	79	42.5	21.14	48.98	18.87	20.01	22.34	52.16	20.77	22.45
DUNGANNON	18.4	46.8	23	16.97	37.39	15.08	15.56	16.26	36.93	15.16	16.26
EDEN	25.0	62.5	45	10.09	20.72	9.58	9.61	9.75	20.76	9.48	9.66

Table E.3: 110 kV Winter 2011/12 Fault Level Results

E.4.1 WINTER MAX 2011/12

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
ENNISKILLEN	25.0	62.5	33.5	8.08	16.62	6.67	6.69	9.63	20.78	8.30	8.37
FINAGHY	31.5	79		19.08	46.2	17.27	19.39	23.85	54.35	22.15	23.60
GLENGORMLEY	18.4	46.8		5.55	10.98	5.34	5.34	5.40	11.3	5.28	5.32
HANNAHSTOWN	31.5	80	33.5	21.48	53.1	19.26	23.34	27.53	68.41	25.35	30.94
KELLS*	21.9	55.9	27.4	20.67	49.58	18.64	22.42				
	26.2	65.0	29.7					25.59	62.06	23.78	28.81
KILLYMALLAGHT	40.0	100		12.14	27.36	10.61	10.89	10.37	23.52	9.43	9.67
KNOCK	18.4	46.8		16.99	35.85	15.25	15.37	16.85	32.41	15.78	16.71
LARNE	18.4	46.8	42.5	9.72	20.44	9.17	9.19	9.13	20.01	8.85	9.02
LIMAVADY	18.4	46.8	23	7.41	15.10	6.45	6.46	7.85	16.78	7.15	7.23
LISBURN	18.4	46.8	23	13.07	28.29	12.16	12.26	12.62	27.13	12.11	12.50
LISAGHMORE	18.4	46.8		10.03	21.31	9.13	9.23	9.70	21.03	9.20	9.55
LOGUESTOWN	18.4	46.8		5.74	11.46	5.13	5.13	6.25	13.05	5.78	5.81
NEWTOWNARDS	40.0	100		8.30	17.59	7.81	7.87	7.75	17.32	7.49	7.77
NEWRY	18.4	46.8	23	5.74	11.86	5.47	5.51	5.68	12.39	5.51	5.71
OMAGH	40.0	100	42.5	13.01	27.23	10.75	10.79	12.96	28.22	11.44	11.76
RATHGAEL	18.4	46.8		6.37	13.26	6.03	6.08	6.24	13.61	6.04	6.26
ROSEBANK	40.0	100		19.32	46.21	17.15	19.15	23.96	57.33	21.91	24.32
SLIEVE KIRK	40.0	100		9.16	20.38	8.07	8.27	7.02	15.93	6.26	6.49
SPRINGTOWN	31.5	79	33.6	10.18	21.69	9.33	9.44	10.04	21.78	9.55	9.88
STRABANE	18.4	46.8	23	14.73	31.84	12.67	12.78	15.93	35.8	14.41	14.89
TANDRAGEE	31.5	79	33.6	23.63	56.82	20.96	24.65	27.74	67.75	25.50	30.59
TAMNAMORE	40.0	100	45	14.51	33.57	13.28	15.20	12.79	30.6	12.20	14.39
WARINGSTOWN	18.4	46.8		8.68	18.78	8.22	8.33	8.22	18.41	7.97	8.33
PSW	18.4	46.8		15.13	31.80	13.92	14.09	14.44	29.16	13.77	14.94

Table E.3: 110 kV Winter 2011/12 Fault Level Results (continued)

E.4.2 SUMMER MIN 2011

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275 kV											
BALLYLUMFORD	26.5	66.3	35.65	8.43	20.85	7.16	8.27	10.22	25.42	9.18	10.75
CASTLEREAGH	31.5	79	35.65	8.56	21	7.25	8.23	10.44	25.71	9.34	10.62
COOLKEERAGH	31.5	79	35.3	8.61	21.26	7.31	8.80	9.79	24.47	8.87	10.81
HANNAHSTOWN	31.5	79	35.65	8.33	20.44	7.07	8.02	10.07	24.8	9.04	10.30
KELLS	31.5	79	35.65	9.26	22.99	7.78	9.16	10.99	27.29	9.83	11.44
KILROOT	31.5	79	45.3	9.09	22.7	7.69	9.23	10.09	25.08	9.14	10.73
MAGHERAFELT	31.5	79	35.65	9.93	24.69	8.3	9.74	10.63	25.85	9.57	10.35
MOYLE	31.5	79	35.65	8.36	20.66	7.11	8.20	10.16	25.28	9.13	10.71
TANDRAGEE	26.5	66.3	35.65	10.41	25.68	8.72	10.05	12.13	29.87	10.84	12.37
TAMNAMORE	31.5	79	57.3	8.92	22.05	7.58	8.62	9.29	22.63	8.46	9.20

Table E.4: 275 kV Summer 2011 Fault Level Results

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
AGHYOULE	25.0	62.5		3.81	8.00	3.13	3.34	3.91	8.69	3.42	3.80
ANTRIM	18.4	46.8		8.01	17.32	7.37	7.49	8.47	18.46	8.07	8.37
BALLYLUMFORD*	21.9	55	25.88	12.57	30.08	11.20	13.55				
	26.2	65.0	29.7					15.08	36.61	14.00	17.18
BALLYMENA	18.4	46.8		7.78	16.98	7.14	7.27	8.60	19.23	8.16	8.56
BANBRIDGE	18.4	46.8		6.00	12.66	5.66	5.71	6.14	13.58	5.95	6.18
BALLYVALLAGH	18.4	46.8	23	11.19	24.99	9.99	10.14	11.53	25.39	10.80	10.93
BALLYNAHINCH	18.4	46.8		5.16	10.93	4.88	4.94	5.35	11.77	5.18	5.39
CARNMONEY	26.2	65	44.9	7.22	15.18	6.72	6.76	7.63	16.54	7.32	7.49
CASTLEREAGH	26.2	65	33.5	13.70	33.88	12.01	14.28	18.41	45.86	16.69	19.89
BELFAST CENTRAL	31.5	79		11.56	27.69	10.32	11.19	14.64	32.63	13.52	14.55
COLERAINE	31.5	79	42.5	7.33	15.18	6.26	6.27	8.58	18.4	7.66	7.70
COOLKEERAGH	31.5	80	33.5	17.37	42.97	14.32	18.27	22.57	56.21	19.69	24.95
CREAGH	31.5	80	33.5	6.95	14.2	6.44	6.44	7.60	16.24	7.26	7.31
CREGAGH	26.2	65		12.64	30.65	11.18	12.50	16.44	38.6	15.04	16.52
DONEGALL NORTH	31.5	79	33.5	11.68	27.84	10.43	11.45	15.17	34.29	13.98	14.76
DONEGALL SOUTH				9.59	21.86	8.73	9.00	11.10	24.5	10.44	10.80
DRUMNAKELLY	31.5	79	42.5	15.17	35.92	13.20	14.34	17.61	41.69	16.07	17.58
DUNGANNON	18.4	46.8	23	13.42	30.28	11.49	12.03	13.98	32.1	12.72	13.76
EDEN	25.0	62.5	45	7.68	16.26	7.12	7.18	8.08	17.51	7.74	7.94
ENNISKILLEN	25.0	62.5	33.5	7.34	15.2	5.96	5.98	8.97	19.42	7.64	7.71

Table E.5: 110 kV Summer 2011 Fault Level Results

E.4.2 SUMMER MIN 2011

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
FINAGHY	**31.5**	**79**		11.93	28.77	10.64	11.95	15.83	36.72	14.55	15.70
GLENGORMLEY	**18.4**	**46.8**		4.94	9.97	4.69	4.69	5.01	10.58	4.87	4.92
HANNAHSTOWN	**31.5**	**80**	**33.5**	12.83	31.28	11.35	13.27	17.33	42.48	15.81	18.57
KELLS*	**21.9**	**55.9**	**27.4**	14.18	34.25	12.36	14.67				
	26.2	**65.0**	**29.7**					18.55	45.15	16.80	20.03
KNOCK	**18.4**	**46.8**		12.04	26.54	10.71	10.89	13.49	26.89	12.54	13.30
LARNE	**18.4**	**46.8**	**42.5**	7.67	16.56	7.04	7.08	7.81	17.35	7.44	7.64
LIMAVADY	**18.4**	**46.8**	**23**	6.90	14.33	5.90	5.91	7.54	16.3	6.79	6.88
LISBURN	**18.4**	**46.8**	**23**	9.60	21.37	8.74	8.90	10.26	22.51	9.71	10.08
LISAGHMORE	**18.4**	**46.8**		9.01	19.51	8.03	8.16	9.06	19.84	8.50	8.86
LOGUESTOWN	**18.4**	**46.8**		5.36	10.86	4.75	4.75	5.94	12.51	5.47	5.50
NEWTOWNARDS	**40.0**	**100**		6.91	15.01	6.44	6.52	6.92	15.62	6.65	6.92
NEWRY	**18.4**	**46.8**	**23**	5.13	10.73	4.86	4.91	5.25	11.52	5.10	5.29
OMAGH	**40.0**	**100**	**42.5**	11.38	24.27	9.11	9.16	11.84	25.98	10.24	10.56
RATHGAEL	**18.4**	**46.8**		5.49	11.67	5.18	5.23	5.65	12.43	5.47	5.68
ROSEBANK	**40.0**	**100**		13.10	31.79	11.55	12.96	17.33	41.92	15.79	17.56
SPRINGTOWN	**31.5**	**79**	**33.6**	9.15	19.86	8.18	8.31	9.39	20.6	8.83	9.18
STRABANE	**18.4**	**46.8**	**23**	12.41	27.28	10.45	10.55	14.20	32.19	12.71	13.14
TANDRAGEE	**31.5**	**79**	**33.6**	16.36	39.88	14.15	16.81	20.75	51.06	18.72	22.48
TAMNAMORE	**40.0**	**100**	**45**	11.82	27.68	10.40	12.01	11.37	27.32	10.60	12.53
WARINGSTOWN	**18.4**	**46.8**		7.47	16.47	6.94	7.07	7.48	16.91	7.19	7.55
PSW	**18.4**	**46.8**		10.34	22.65	9.34	9.59	11.28	23.51	10.61	11.60

Table E.5: 110 kV Summer 2011 Fault Level Results (continued)

E.4.3 WINTER MAX 2017/18

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275 kV											
BALLYLUMFORD	26.5	66.3	35.65	18.54	47.2	15.8	19.97	20.94	53.65	18.94	24.21
CASTLEREAGH	31.5	79	35.65	16.32	40.36	13.9	15.81	17	42.07	15.41	17.59
COOLKEERAGH	31.5	79	35.3	13.23	33.64	11.46	13.76	13.07	33.4	12.04	14.81
HANNAHSTOWN	31.5	79	35.65	16.03	39.72	13.7	15.69	16.52	40.91	15.03	17.20
KELLS	31.5	79	35.65	18.64	47.05	15.84	19.14	19.28	48.09	17.54	20.30
KILROOT	31.5	79	45.3	18.3	46.68	15.69	19.76	21.96	56.56	19.9	25.53
MAGHERAFELT	31.5	79	35.65	19.57	49.4	16.51	19.78	16.92	40.95	15.5	16.47
MOYLE	31.5	79	35.65	18.15	46.14	15.51	19.42	20.4	52.18	18.5	23.36
TANDRAGEE	26.5	66.3	35.65	20.15	50.11	17.07	19.64	19.74	48.66	17.92	20.40
TAMNAMORE	31.5	79	57.3	18.77	46.91	15.93	18.41	16.63	40.63	15.24	16.90
TURLEENAN	31.5	79	35.65	20.31	50.87	17.18	20.09	18.16	44.3	16.59	18.46

Table E.6: 275 kV Winter 2017/18 Fault Level Results

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
AGHYOULE	25.0	62.5		4.16	8.74	3.35	3.60	4.13	9.23	3.56	4.00
AIRPORT ROAD	40.0	100		11.35	24.65	10.40	10.53	11.44	25.20	10.83	11.25
ALTAHULLION CLUSTER	40.0	100		6.59	14.75	4.90	5.37	6.18	14.46	5.03	5.78
ANTRIM	18.4	46.8		9.90	20.99	9.18	9.31	9.82	21.19	9.38	9.76
BALLYLUMFORD*	21.9	55	25.88	23.77	59.27	21.14	27.45				
	26.2	65.0	29.7					27.86	70.4	25.85	33.92
BALLYMENA	18.4	46.8		9.56	20.46	8.84	9.00	9.89	21.91	9.41	9.93
BANBRIDGE	18.4	46.8		6.64	13.9	6.30	6.34	6.56	14.48	6.36	6.60
BALLYVALLAGH	18.4	46.8	23	16.55	35.83	14.87	14.95	14.93	32.09	14.09	14.17
BALLYNAHINCH	18.4	46.8		6.03	12.54	5.68	5.73	5.97	13.02	5.75	5.98
BELFAST NORTH MAIN	18.4	46.8		15.50	33.25	14.06	14.29	14.94	29.2	14.08	15.29
CARNMONEY	26.2	65	44.9	9.45	20.94	8.81	9.03	9.01	20.3	8.66	9.23
CASTLEREAGH	26.2	65	33.5	21.26	52.51	18.34	22.42	27.02	67.32	24.06	29.43
BELFAST CENTRAL	31.5	79		16.54	39.09	14.68	15.74	19.46	42.03	17.80	19.13
COLERAINE	31.5	79	42.5	9.48	20.02	7.23	7.28	10.57	23.11	8.58	8.76
COOLKEERAGH	31.5	80	33.5	24.71	61.07	19.36	25.34	29.42	73.3	24.54	31.88
CREAGH	31.5	80	33.5	8.43	16.86	7.82	7.82	8.72	18.49	8.31	8.36
CREGAGH	26.2	65		18.83	45.22	16.46	18.31	22.87	52.48	20.65	22.42

Table E.7: 110 kV Winter 2017/18 Fault Level Results

E.4.3 WINTER MAX 2017/18

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
DONEGALL SOUTH				13.61	30.55	12.47	12.73	14.47	31.7	13.67	14.22
DRUMNAKELLY	31.5	79	42.5	18.21	43.49	16.26	17.53	19.58	46.93	18.14	19.95
DUNGANNON	18.4	46.8	23	12.89	29.72	11.31	11.79	11.04	26.17	10.26	11.12
EDEN	25.0	62.5	45	10.75	24.69	10.03	10.37	10.11	23.16	9.73	10.44
ENNISKILLEN	25.0	62.5	33.5	9.54	20.2	7.27	7.45	10.70	23.82	8.65	9.08
FALLAGHEARN CLUSTER	40.0	100		9.11	21.61	7.35	7.85	8.07	18.91	7.05	8.13
FINAGHY	31.5	79		18.81	45.75	16.80	18.99	22.88	52.74	21.02	22.66
GLENGORMLEY	18.4	46.8		5.63	11.11	5.35	5.35	5.46	11.42	5.30	5.34
HANNAHSTOWN	31.5	80	33.5	21.12	52.45	18.66	22.85	26.14	65.23	23.81	29.04
KELLS*	21.9	55.9	27.4	21.02	50.36	18.38	22.30				
	26.2	65.0	29.7					25.96	62.89	23.49	28.67
KILLYMALLAGHT	10	100		13.82	31.55	11.21	11.76	12.54	29.22	10.89	11.79
KNOCK	18.4	46.8		17.41	36.64	15.33	15.46	17.25	33.22	15.93	16.95
LARNE	18.4	46.8	42.5	9.89	20.85	9.15	9.18	9.24	20.3	8.84	9.06
LIMAVADY	18.4	46.8	23	11.19	25.98	7.51	10.14	11.91	28.28	8.49	11.79
LISBURN	18.4	46.8	23	13.19	30.09	12.13	12.44	12.33	28.11	11.75	12.35
LISAGHMORE	18.4	46.8		10.63	22.51	9.33	9.43	10.05	21.79	9.31	9.67
LOGUESTOWN	18.4	46.8		6.41	13.08	5.23	5.24	6.79	14.44	5.87	5.94
MAGHERAKEEL CLUSTER	40.0	100		5.71	13.25	3.99	5.08	5.93	14.37	4.53	6.02
MID-ANTRIM CLUSTER	40.0	100		6.66	14.02	5.60	5.67	6.37	13.94	5.69	5.98
NEWTOWNARDS	40.0	100		8.44	17.87	7.87	7.93	7.87	17.56	7.55	7.83
NEWRY	18.4	46.8	23	5.75	12.07	5.38	5.48	5.68	12.52	5.45	5.76
OMAGH	40.0	100	42.5	18.31	41.57	12.80	14.12	18.06	41.71	13.79	16.02
POMEROY CLUSTER	40.0	100		9.63	20.53	7.95	8.09	8.64	18.94	7.66	8.16
RATHGAEL	18.4	46.8		6.47	13.47	6.08	6.12	6.33	13.79	6.10	6.32
ROSEBANK	40.0	100		19.46	47.35	16.97	19.48	24.25	59.92	21.81	25.65
SLIEVE KIRK	40.0	100		10.06	22.52	8.40	8.68	7.86	18.06	6.86	7.25
SPRINGTOWN	31.5	79	33.6	10.82	22.99	9.54	9.65	10.44	22.66	9.69	10.04
STRABANE	18.4	46.8	23	16.86	36.63	13.54	13.68	17.71	39.99	15.25	15.87
TANDRAGEE	31.5	79	33.6	21.55	53.77	18.99	23.45	25.81	65.1	23.50	29.46
TAMNAMORE	40.0	100	45	19.91	48.87	16.65	20.92	19.69	48.76	17.53	21.99
WARINGSTOWN	18.4	46.8		8.48	18.62	7.97	8.09	8.13	18.39	7.83	8.22

Table E.7: 110 kV Winter 2017/18 Fault Level Results (continued)

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
380 kV											
TURLEENAN	31.5	79	35.65	11.47	29.03	10.15	11.83	11.92	29.60	11.06	12.47

Table E.8: 380 kV Winter 2017/18 Fault Level Results

E.4.4 SUMMER MIN 2017

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
275 kV											
BALLYLUMFORD	26.5	66.3	35.65	10.23	25.54	8.3	9.87	12.13	30.45	10.49	12.66
CASTLEREAGH	31.5	79	35.65	10.23	25.35	8.32	9.65	12.01	29.82	10.41	12.03
COOLKEERAGH	31.5	79	35.3	10.29	26.24	8.28	10.48	10.91	27.91	9.52	12.07
HANNAHSTOWN	31.5	79	35.65	9.94	24.63	8.11	9.39	11.61	28.8	10.09	11.64
KELLS	31.5	79	35.65	11.27	28.29	9.03	11.01	12.79	32.02	11.03	13.14
KILROOT	31.5	79	45.3	10.83	27.28	8.8	10.82	11.4	28.49	10.05	11.95
MAGHERAFELT	31.5	79	35.65	12.73	32.2	10.01	12.58	12.83	31.42	11.07	12.19
MOYLE	31.5	79	35.65	10.12	25.26	8.23	9.76	12.02	30.18	10.41	12.56
TANDRAGEE	26.5	66.3	35.65	13.05	32.7	10.39	12.60	14.6	36.31	12.54	14.77
TAMNAMORE	31.5	79	57.3	12.69	31.92	10.02	12.26	12.98	32.02	11.21	12.86
TURLEENAN	31.5	79	35.65	13.34	33.62	10.53	13.03	13.87	34.22	11.95	13.78

Table E.9: 275 kV Summer 2017 Fault Level Results

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
AGHYOULE	25.0	62.5		4.05	8.50	3.23	3.45	4.07	9.08	3.50	3.91
AIRPORT ROAD				9.48	21.12	8.56	8.72	10.14	22.69	9.51	9.93
ALTAHULLION CLUSTER				5.92	13.16	4.50	4.86	5.73	13.32	4.75	5.35
ANTRIM	18.4	46.8		8.66	18.65	7.78	7.91	8.94	19.42	8.37	8.70
BALLYLUMFORD*	21.9	55	25.88	16.26	40.09	13.89	17.24				
	26.2	65.0	29.7					19.71	49.18	17.65	22.24
BALLYMENA	18.4	46.8		8.35	18.15	7.52	7.70	8.97	20.02	8.39	8.90
BANBRIDGE	18.4	46.8		6.06	12.9	5.69	5.74	6.18	13.75	5.96	6.20
BALLYVALLAGH	18.4	46.8	23	13.07	29.06	11.25	11.39	12.85	28.14	11.76	11.88
BALLYNAHINCH	18.4	46.8		5.40	11.4	5.07	5.13	5.52	12.13	5.32	5.54
BELFAST NORTH MAIN	18.4	46.8		12.34	27.33	10.92	11.22	13.02	26.25	12.07	13.21
CARNMONEY	26.2	65	44.9	8.11	18.23	7.38	7.62	8.17	18.56	7.73	8.28
CASTLEREAGH	26.2	65	33.5	15.42	38.53	13.17	16.08	20.48	51.47	18.11	22.07
BELFAST CENTRAL	31.5	79		12.78	30.75	11.18	12.17	15.92	35.28	14.43	15.54
COLERAINE	31.5	79	42.5	8.40	17.91	6.43	6.49	9.61	21.11	7.82	8.01
COOLKEERAGH	31.5	80	33.5	20.18	50.13	15.12	20.26	24.71	61.73	19.86	26.21
CREAGH	31.5	80	33.5	7.59	15.44	6.87	6.87	8.08	17.28	7.59	7.64
CREGAGH	26.2	65		14.09	34.42	12.18	13.76	18.06	42.33	16.17	17.73

Table E.10: 110 kV Summer 2017 Fault Level Results

E.4.4 SUMMER MIN 2017

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
110 kV											
DONEGALL NORTH	31.5	79	33.5	13.88	33.54	12.13	13.41	17.29	39.21	15.66	16.63
DONEGALL SOUTH				11.07	25.35	9.91	10.21	12.49	27.84	11.62	12.16
DRUMNAKELLY	31.5	79	42.5	14.49	35.31	12.64	14.00	16.53	40.19	15.08	16.84
DUNGANNON	18.4	46.8	23	11.52	26.81	9.63	10.16	10.28	24.43	9.28	10.11
EDEN	25.0	62.5	45	8.98	20.83	8.14	8.50	9.00	20.78	8.51	9.18
ENNISKILLEN	25.0	62.5	33.5	8.49	17.79	6.47	6.51	9.73	21.41	7.91	8.07
FALLAGHEARN CLUSTER	40.0	100		8.75	20.9	6.76	7.32	7.91	18.61	6.72	7.84
FINAGHY	31.5	79		14.24	34.93	12.41	14.15	18.21	42.71	16.43	17.89
GLENGORMLEY	18.4	46.8		5.16	10.34	4.84	4.84	5.14	10.82	4.96	5.01
HANNAHSTOWN	31.5	80	33.5	15.53	38.71	13.40	16.23	20.17	50.43	18.03	21.74
KELLS*	21.9	55.9	27.4	16.23	39.3	13.57	16.61				
	26.2	65.0	29.7					20.84	50.85	18.16	22.27
KILLYMALLAGHT	40.0	100.0		12.62	29.18	9.75	10.42	11.88	27.88	10.00	10.98
KNOCK	18.4	46.8		13.37	29.35	11.62	11.81	14.60	29.05	13.34	14.26
LARNE	18.4	46.8	42.5	8.54	18.39	7.65	7.69	8.41	18.67	7.88	8.12
LIMAVADY	18.4	46.8	23	9.21	20.93	6.51	7.67	10.05	23.37	7.59	9.27
LISBURN	18.4	46.8	23	10.88	25.25	9.77	10.12	10.92	25.16	10.25	10.82
LISAGHMORE	18.4	46.8		9.63	20.68	8.17	8.29	9.41	20.58	8.53	8.91
LOGUESTOWN	18.4	46.8		5.90	12.14	4.81	4.83	6.37	13.62	5.51	5.58
MAGHERAKEEL CLUSTER	40.0	100		5.55	12.88	3.84	4.83	5.80	14.05	4.40	5.78
MID-ANTRIM CLUSTER	40.0	100		6.29	13.36	5.17	5.25	6.13	13.49	5.40	5.70
NEWTOWNARDS	40.0	100		7.35	15.89	6.77	6.84	7.20	16.24	6.88	7.15
NEWRY	18.4	46.8	23	5.27	11.21	4.91	5.01	5.34	11.85	5.12	5.42
OMAGH	40.0	100	42.5	16.65	38.40	11.11	12.56	17.00	39.58	12.51	14.79
POMEROY CLUSTER	40.0	100		9.19	19.84	7.25	7.42	8.44	18.63	7.27	7.81
RATHGAEL	18.4	46.8		5.77	12.21	5.39	5.44	5.84	12.83	5.62	5.83
ROSEBANK	40.0	100		14.46	35.69	12.46	14.48	18.86	47.03	16.83	19.86
SLIEVE KIRK	40.0	100		9.43	21.35	7.56	7.89	7.60	17.56	6.50	6.92
SPRINGTOWN	31.5	79	33.6	9.80	21.13	8.34	8.47	9.78	21.42	8.87	9.25
STRABANE	18.4	46.8	23	15.06	33.32	11.48	11.68	16.41	37.45	13.59	14.30
TANDRAGEE	31.5	79	33.6	16.60	41.97	14.25	18.00	20.84	53.06	18.62	23.64
TAMNAMORE	40.0	100.0	45.0	16.88	41.63	13.29	17.05	17.58	43.62	14.97	19.02
WARINGSTOWN	18.4	46.8		7.55	16.86	6.99	7.12	7.53	17.17	7.20	7.58

Table E.10: 110 kV Summer 2017 Fault Level Results (continued)

E.4.4 SUMMER MIN 2017

NODE	RATING			THREE PHASE				SINGLE PHASE			
	RMS	PEAK	ASYM	I''	ip	IB	asym B	I''	ip	IB	asym B
380 kV											
TURLEENAN	**31.5**	**79.0**	**35.65**	8.23	20.87	6.77	8.28	9.39	23.46	8.24	9.59

Table E.11: 380 kV Summer 2017 Fault Level Results

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 2017/18 - the final year of this TSCS. For this year, four seasons have been studies. They are listed below:

1. Winter maximum 2017/18,
2. Autumn maximum 2017,
3. Summer maximum 2017,
4. Summer minimum 2017,

F.1.2 GENERATION

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

CONVENTIONAL GENERATION

It has been assumed that Units 4, 5 and 6 at Ballylumford are no longer available due to EU emissions targets.

CENTRALLY DISPATCHED GENERATING UNIT	2017/18			
	WINTER MAX	AUTUMN MAX	SUMMER MAX	SUMMER MIN
BALLYLUMFORD CCGT 21	120	100	150	-
BALLYLUMFORD CCGT 22	120	100	-	-
BALLYLUMFORD CCGT 20	100	140	70	-
BALLYLUMFORD CCGT 10	80	-	-	65
BALLYLUMFORD GT 7	-	-	-	-
BALLYLUMFORD GT 8	-	-	-	-

Table F.1: Generation Dispatches used in Capability Analysis

CENTRALLY DISPATCHED GENERATING UNIT	2017/18			
	WINTER MAX	AUTUMN MAX	SUMMER MAX	SUMMER MIN
KILROOT ST 1	170	120	170	110
KILROOT ST 2	170	120	170	-
KILROOT GT 1	-	-	-	-
KILROOT GT 2	-	-	-	-
KILROOT GT 3	-	-	-	-
KILROOT GT 4	-	-	-	-
COOLKEERAGH GT8	0	0	0	-
COOLKEERAGH CCGT	400	400	290	260
MOYLE*	325	293	317	150
NORTH-SOUTH*	297	248	246	36
WIND	100%	100%	100%	100%

Table F.1: Generation Dispatches used in Capability Analysis (continued)

WIND

Table F.1 shows wind is dispatched at full output in all seasons. **Table F.2** below details the total amount of wind dispatched in the studies at 110 kV nodes. **Tables C.4** and **C.5** in **Appendix C** provides a full list of WFPSs which contribute to these totals.

110 kV TRANSMISSION NODE	Wind Totals (MW) Summer/Autumn 2017	Wind Totals (MW) Winter 2017/18
AGHYOULE	67.5	67.5
ALTAHULLION	27.6	27.6
ANTRIM	7	7
BALLYMENA	5	5
CARNMONEY	13.8	13.8
COLERAINE	45	45
DUNGANNON	15	15
ENNISKILLEN	19.9	40.6
FALLAGHEARN	81.5	81.5
KILLYMALLAGHT	85.1	85.1
LARNE	25	25
LIMAVADY	100.7	160.7
LISAGHMORE	15	15
MAGHERAKEEL	137.1	149.1
MID-ANTRIM	42	42

Table F.2: Wind Totals used in Capability Analysis

110 kV TRANSMISSION NODE	Wind Totals (MW) Summer/Autumn 2017	Wind Totals (MW) Winter 2017/18
NEWRY	12.5	12.5
OMAGH	167.4	167.4
POMEROY	53	53
STRABANE	27.4	27.4
TOTAL	**947.5**	**1040.2**

Table F.2: Wind Totals used in Capability Analysis (continued)

It has been assumed that this wind generation is operating at a power factor of 0.98 leading.

F.1.3 NEW TRANSMISSION PROJECTS INCLUDED IN THE ANALYSIS

The following transmission projects have been included in the 2017/18 analysis:

1. Tamnamore Phase 2
2. Coleraine to Kells 110 kV Phase 3
3. Omagh to Tamnamore 110 kV circuit 3
4. Turleenan – Mid-Cavan 400 kV circuit
5. Coolkeeragh to Magherafelt 275 kV double circuit uprating
6. Hannahstown to Lisburn 110 kV circuits uprating
7. Ballylumford-Eden-Carnmoney 110 kV circuits uprating

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 275/110 kV Interbus Transformer (IBTX). It has been assumed that the completion of Tamnamore Phase 2 will result in the two 110 kV 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

Network reactive compensation schemes are in place at Castlereagh, Coolkeeragh, and Tandragee. Each scheme consists of two fixed 25 MVAr capacitors working in conjunction with a Static Var Compensator (SVC) with a range of ± 50MVAr. These schemes contribute a total of 300 MVAr of additional reactive support to the NI Transmission System

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 TSCS is 2017/18, 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 275 kV and 110 kV networks. Generation is also connected at 33 kV nodes at 110/33 kV Bulk Supply Points (BSP) and analysed. This is necessary because of the increasing amounts of renewable generation connecting at 33 kV 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

Maintenance Trip analysis is carried out in summer and autumn therefore when a capacity figure is quoted for a Transmission Node in this TSCS; the reader can be sure that this is a firm capacity, as the TSO can carryout system maintenance as required by the Transmission Owner (NIE) without the constraint of generation. There may however be times when it is necessary to curtail NI generation for system security reasons.

F.2.4 VOLTAGE SUPPORT

The previous statement found that the amount of generation that can be added to a node may be limited by voltage issues, i.e. after contingency analysis, the voltage is outside limits imposed by the Security and Planning standards.

The study files were preconditioned so that Network Reactive Compensation Schemes (detailed in **F.1.5**) can provide maximum instantaneous reactive support under outage conditions to ensure that 'under voltage' does not limit the capacity of the network.
It is essential that NIE's WFPS cluster proposals and Transmission Investment Plan provide adequate reactive power support to maintain stable operation and voltage control on the NI Transmission System.

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

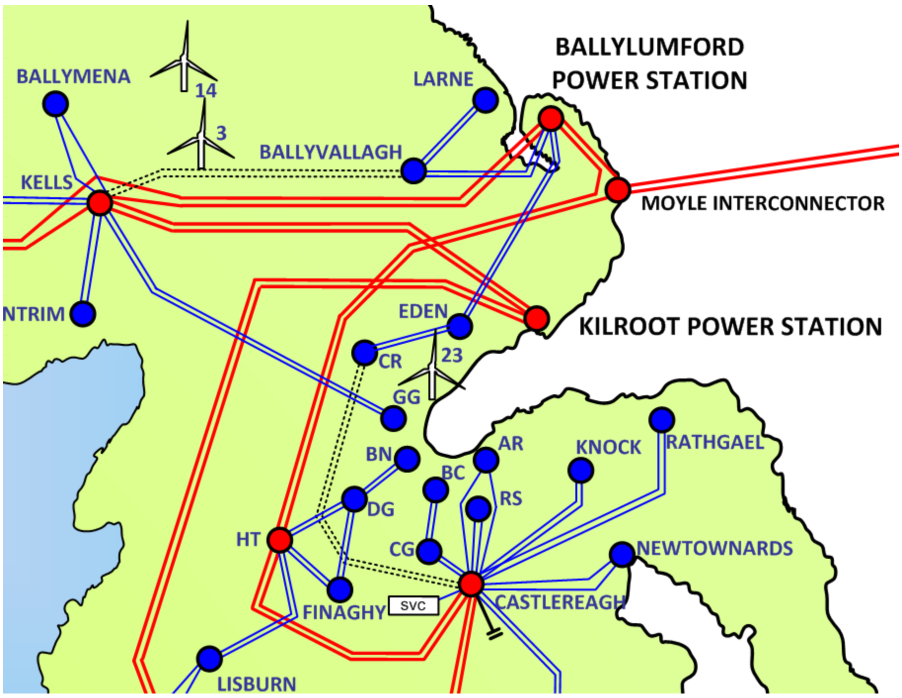


Figure F.1: Circuits Opened in Ballylumford Protection Scheme

COOLKEERAGH

Under high generation scenarios in the North-West, the loss of the 275 kV double circuit between Coolkeeragh and Magherafelt can lead to large overloads on the 110 kV circuits in the area. As discussed in **Section 3.6.3**, following the loss of the 275 kV double circuit, the CCGT at Coolkeeragh is automatically curtailed to 160 MW. As SONI has not received detailed SPS operating schemes for the year 2017/18 it has been assumed that the loss of this 275 kV double circuit will not cause any wind generation to trip via SPS.

F.3 RESULTS

TRANSMISSION SYSTEM CAPABILITY RESULTS

The results of the 275/110/33 kV capability studies are presented in the following sections. The NI system is tested for three scenarios; the new generation is absorbed by increasing either:

- The existing NI load
- The RoI load or
- The load in Great Britain (GB)

The results are displayed in the tables below. The maximum generation that can be accepted at each node is the minimum transfer capability of the 3 scenarios; this maximum capability value is listed in the **Tables F.1, F.3** and **F.5**, in the right hand column. These tables tie up with the geographic maps presented in **Section 8.** The tables contains notes which cross reference with a corresponding table for each voltage level, which lists the network constraint limiting the maximum power transfer, and the contingency that caused the constraint.

A number of circuits are overloaded under system normal conditions, these are:

- Omagh-Magherakeel 110 kV Circuit
- Fallaghearn 110/33 kV Transformer
- Killymallaght 110/33 kV Transformer

Nodes affected by these overloaded circuits are marked as overloaded in the base case in the results tables.

F.3.1 RESULTS AT 275 kV

Table F.4 corresponds with the Map in **Figure 8.1** and details the results of the transmission system capability analysis at 275 kV nodes.

275 kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
BALLYLUMFORD	0	A1	0	A1	0	A1	**0**
CASTLEREAGH	>400	-	>400	-	>400	-	**>400**
COOLKEERAGH	0	NW	0	NW	0	NW	**0**
HANNAHSTOWN	>400	-	>400	-	>400	-	**>400**
KELLS	>400	-	360	A2	>400	-	**360**
KILROOT	>400	-	>400	-	>400	-	**>400**
MAGHERAFELT	360	A2	240	A2	340	A2	**240**
MOYLE	0	A1	0	A1	0	A1	**0**
TAMNAMORE	0	A3	0	A3	0	A3	**0**
TANDRAGEE	>400	-	>400	-	>400	-	**>400**
TURLEENAN	>400	-	>400	-	>400	-	**>400**

Table F.4 Capability Results for 275 kV

F.3.2 CONSTRAINTS AT 275 kV

Table F.5 below cross references both the contingency and the resulting constraint for the 275 kV nodes.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 275 kV		
ID	OUTAGE	CONSTRAINT
A1	275 kV double circuit from Ballylumford to Kells/Magherafelt.	Overload on 110kV Ballylumford to Ballyvallagh circuits 1 and 2.
A2	275 kV Magherafelt - Turleenan.	Overload on 275 kV Tamnamore - Turleenan
A3	275 kV circuits from Tamnamore to Magherafelt & Turleenan	Overload on 110kV Drumnakelly - Tamnamore Circuit
NW	Coolkeeragh-Magherafelt 275 kV Circuits 1 & 2	Overload on the 110 kV Pomeroy - Tamnamore Circuit & Tamnamore IBTXs

Table F.5: Contingencies and Constraints Limiting 275 kV Capability

F.3.3 RESULTS AT 110 kV

Table F.6 corresponds with the Map in **Figure 8.2** and details the results of the transmission system capability analysis at 110 kV nodes.

110kV STATION	MAXIMUM TRANSFER (IN MW) TO						MINIMUM
	NI LOAD		ROI		SCOTLAND		
Aghyoule 110 kV	0	NW	0	NW	0	NW	**0**
Altahullion Cluster 110 kV	0	NW	0	NW	0	NW	**0**
Airport Road 110 kV	80	R	80	R	80	R	**80**
Antrim 110 kV	80	R	80	R	80	R	**80**
Ballylumford 110 kV	0	B1	0	B1	0	B1	**0**
Ballymena 110 kV	100	R	100	R	100	R	**100**
Banbridge 110 kV	80	R	80	R	80	R	**80**
Ballyvallagh 110 kV	80	B12	100	B12	100	B12	**80**
Ballynahinch 110 kV	80	R	80	R	80	R	**80**
Belfast Central 110 kV	140	B2	140	B2	140	B2	**140**
Belfast North Main 110 kV	80	B3	80	B4	80	B4	**80**
Carnmoney 110 kV	20	B5	20	B5	20	B5	**20**
Castlereagh 110 kV	>400	-	>400	-	>400	-	**>400**
Coleraine 110 kV	0	NW	0	NW	0	NW	**0**
Coolkeeragh 110 kV	0	NW	0	NW	0	NW	**0**
Creagh 110 kV	20	B6	20	B6	20	B6	**20**
Cregagh 110 kV	140	R	140	R	140	R	**140**
Donegall A&D 110 kV	60	R	60	R	60	R	**60**
Donegall B&C 110 kV	160	R	160	R	160	R	**160**
Drumnakelly 110 kV	100	B7	100	B7	100	B7	**100**
Dungannon 110 kV	40	B8	40	B8	40	B8	**40**
Eden 110 kV	40	B7	40	B7	40	B7	**40**
Enniskillen 110 kV	0	NW	0	NW	0	NW	**0**
Fallaghearn Cluster 110 kV	0	NW	0	NW	0	NW	**0**
Finaghy 110 kV	140	B9	140	B9	140	B9	**140**
Glengormley 110 kV	60	R	60	R	60	R	**60**
Hannahstown 110 kV	>400	-	320	B6	>400	-	**320**
Kells 110 kV	100	B1	120	B1	100	B1	**100**
Killymallaght Cluster 110 kV	0	NW	0	NW	0	NW	**0**

Table F.6 Capability Results for 110 kV

110 kV STATION	MAXIMUM TRANSFER (IN MW) TO						MINIMUM
	NI LOAD		ROI		SCOTLAND		
Knock 110 kV	60	R	60	R	60	R	60
Larne 110 kV	60	R	60	R	60	R	60
Limavady 110 kV	0	NW	0	NW	0	NW	0
Lisaghmore 110 kV	0	NW	0	NW	0	NW	0
Lisburn 110 kV	80	B10	80	B10	80	B10	80
Loguestown 110 kV	0	NW	0	NW	0	NW	0
Magherakeel Cluster 110 kV	Overloaded in Base Case						0
Mid-Antrim Cluster 110 kV	0	NW	0	NW	0	NW	0
Newtownards 110 kV	100	R	100	R	100	R	100
Newry 110 kV	80	R	80	R	80	R	80
Omagh 110 kV	0	NW	0	NW	0	NW	0
Pomeroy Cluster 110 kV	0	NW	0	NW	0	NW	0
Rathgael 110 kV	80	R	80	R	80	R	80
Rosebank 110 kV	140	R	140	R	140	R	140
Springtown 110 kV	0	NW	0	NW	0	NW	0
Strabane 110 kV	0	NW	0	NW	0	NW	0
Tandragee 110 kV	>400	-	>400	-	360	B11	360
Tamnamore 110 kV	0	NW	0	NW	0	NW	0
Waringstown 110 kV	80	R	80	R	80	R	80

Table F.6 Capability Results for 110 kV (Continued)

F.3.4 CONSTRAINTS AT 110 kV

Table F.7 below cross references both the contingency and the resulting constraint for the 110 kV nodes.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 110kV		
ID	OUTAGE	CONSTRAINT
B1	275 kV double circuit from Ballylumford to Kells/Magherafelt.	Overload on 110 kV Ballylumford to Ballyvallagh circuits 1 and 2.
B2	Ballylumford – Eden 110 kV Circuits 1 & 2	Overload on the 110 kV Belfast Central to Cregagh Circuit
B3	Intact System	Overload on the 110 kV Belfast North Main to Donegal Circuit

Table F.7: Contingencies and Constraints Limiting 110 kV Capability

NETWORK CONSTRAINTS FOR NEW GENERATION AT 110 kV		
ID	OUTAGE	CONSTRAINT
B4	275 kV double circuit from Tandragee to Kilroot/Castlereagh 275 kV	Overload on the 110 kV Belfast North Main to Donegal Circuit
B5	Castlereagh Double IBTX Outage	Overload on 110 kV circuits from Castlereagh to Carnmoney 1 and 2
B6	275 kV double circuit from Turleenan to Magherafelt/Tamnamore	Overload on the 110 kV Creagh – Kells Circuit
B7	110 kV circuits from Drumnakelly to Tandragee circuits 1 & 2	Overload on the 110 kV Drumnakelly to Tandragee circuit 3
B8	275 kV double circuit from Turleenan to Magherafelt/Tamnamore	Overload on the 110 kV Creagh – Tamnamore Circuit
B9	Intact System	Overload on the 110 kV Finaghy to Hannahstown circuit
B10	110 kV double circuit from Lisburn to Hannahstown	Overload on the 110 kV Lisburn – Tandragee circuit
B11	Tandragee Double IBTX Outage	Overload on the remaining Tandragee IBTXs
B12	110 kV circuit from Ballylumford – Ballyvallagh Circuit 1	Overload on the remaining 110 kV circuit from Ballylumford – Ballyvallagh
NW	Coolkeeragh-Magherafelt 275 kV Circuits 1 & 2	Overload on the 110 kV Pomeroy - Tamnamore Circuit & Tamnamore IBTXs
R	110 kV station is fed radially; loss of one 110 kV circuit.	Overload on second 110 kV circuit feeding the station.

Table F.7: Contingencies and Constraints Limiting 110 kV Capability (Continued)

F.3.5 RESULTS AT 33 kV

Table F.8 corresponds with the Map in **Figure 8.3** and details the results of the transmission system capability analysis at 110 kV nodes.

33 kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
Aghyoule 33 kV	0	NW	0	NW	0	NW	**0**
Altahullion Cluster 33 kV	0	NW	0	NW	0	NW	**0**
Airport Road 33 kV	80	C1	80	C1	80	C1	**80**
Antrim 33 kV	80	T	80	T	80	T	**80**
Ballymena Town 33 kV	120	C2	120	C2	120	C2	**120**
Ballymena Rural 33 kV	120	C2	120	C2	120	C2	**120**
Banbridge 33 kV	80	T	80	T	80	T	**80**
Ballynahinch 33 kV	80	T	80	T	80	T	**80**
Belfast Central 33 kV	160	T	160	T	160	T	**160**
Belfast North Main 33 kV	120	C3	120	C3	120	C3	**120**
Carnmoney 33 kV	60	C4	60	C4	60	C4	**60**
Coleraine 33 kV	0	NW	0	NW	0	NW	**0**
Coolkeeragh 33 kV	0	NW	0	NW	0	NW	**0**
Creagh 33 kV	20	C5	20	C5	20	C5	**20**
Cregagh 33 kV	120	T	120	T	120	T	**120**
Donegall AS 33 kV	80	T	80	T	80	T	**80**
Donegall 3N 33 kV	120	T	120	T	120	T	**120**
Drumnakelly 33 kV	120	C6	120	C6	120	C6	**120**
Dungannon 33 kV	40	C7	40	C7	40	C7	**40**
Eden 33 kV	60	T	60	T	60	T	**60**
Enniskillen 33 kV	0	NW	0	NW	0	NW	**0**
Fallaghearn Cluster 33 kV	**Overloaded in Base Case**						**0**
Finaghy 33 kV	60	T	60	T	60	T	**60**
Glengormley 33 kV	60	C8	60	C8	60	C8	**60**
Killymallaght Cluster 33 kV	**Overloaded in Base Case**						**0**
Knock 33 kV	80	C9	80	C9	80	C9	**80**
Larne 33 kV	40	T	40	T	40	T	**40**
Limavady 33 kV	0	NW	0	NW	0	NW	**0**
Lisaghmore 33 kV	0	NW	0	NW	0	NW	**0**
Lisburn 33 kV	120	T	120	T	120	T	**120**
Loguestown 33 kV	0	NW	0	NW	0	NW	**0**

Table F.8 Capability Results for 33 kV

33 kV STATION	MAXIMUM TRANSFER (IN MW) TO						MAXIMUM
	NI LOAD		ROI		SCOTLAND		
M'keel Cluster 33 kV	**Overloaded in Base Case**						**0**
Mid-Antrim Cluster 33 kV	0	NW	0	NW	0	NW	**0**
Newtownards 33 kV	80	T	80	T	80	T	**80**
Newry 33 kV	80	T	80	T	80	T	**80**
Omagh 33 kV	0	NW	0	NW	0	NW	**0**
Pomeroy Cluster 33 kV	**Overloaded in Base Case**						**0**
Rathgael 33 kV	100	C10	100	C10	100	C10	**100**
Rosebank 33 kV	100	T	100	T	100	T	**100**
Springtown 33 kV	0	NW	0	NW	0	NW	**0**
Strabane 33 kV	0	NW	0	NW	0	NW	**0**
Waringstown 33 kV	100	C11	100	C11	100	C11	**100**

Table F.8 Capability Results for 33 kV (Continued)

F.3.6 CONSTRAINTS AT 33 kV

Table F.9 below cross references both the contingency and the resulting constraint for the 33 kV nodes.

NETWORK CONSTRAINTS FOR NEW GENERATION AT 33 kV		
ID	**OUTAGE**	**CONSTRAINT**
C1	110 kV Airport Road to Castlereagh circuit 1	Overload on 110 kV Airport Road to Castlereagh circuit 2
C2	Kells Double IBTX Outage	Overloads on 110 kV Ballylumford to Ballyvallagh circuits 1 and 2.
C3	Castlereagh Double IBTX Outage	Overloads on 110 kV Belfast North Main - Belfast Central circuit
C4	Castlereagh Double IBTX Outage	Overloads on the 110 kV Carnmoney to Castlereagh Circuits 1 & 2
C5	275 kV double circuit from Turleenan to Magherafelt/Tamnamore	Overload on the 110 kV Creagh - Kells Circuit
C6	110 kV Drumnakelly to Tandragee circuits 1 & 2	Overload on the 110 kV Drumnakelly to Tandragee circuit 3
C7	275 kV double circuit from Turleenan to Magherafelt/Tamnamore	Overload on the 110 kV Creagh - Tamnamore Circuit

Table F.9: Contingencies and Constraints Limiting 33 kV Capability

NETWORK CONSTRAINTS FOR NEW GENERATION AT 33kV		
ID	OUTAGE	CONSTRAINT
C8	Intact System	Overload on the 110/33 kV Glengomley Transformer
C9	110 kV Castlereagh to Knock circuit 1	Overload on the 110 kV Castlereagh to Knock circuit 2
C10	110 kV Castlereagh to Rathgael circuit 1	Overload on the 110 kV Castlereagh to Rathgael circuit 2
C11	110 kV Tandragee to Waringstown circuit 1	Overload on the 110 kV Tandragee to Waringstown circuit 2
NW	Coolkeeragh-Magherafelt 275 kV Circuits 1 & 2	Overload on the 110 kV Pomeroy - Tamnamore Circuit & Tamnamore IBTXs
T	33 kV station supplied through 2 TXs; Loss of Transformer 1.	Overload on second Transformer.

Table F.9: Contingencies and Constraints Limiting 33 kV (Capability Continued)

APPENDIX G
GLOSSARY

APPENDIX G GLOSSARY

AC	Alternating Current
ACS	Average Cold Spell
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
DC	Direct Current
EU	European Union
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
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
SVC	Static Var Compensator
TSCS	Transmission Seven Year Capacity Statement
TSO	Transmission System Operator
UREGNI	Utility Regulator

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 400 kV and 275 kV 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

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 2011
- H.2 Summer Min 2011
- H.3 Winter Max 2011/12
- H.4 Summer Max 2014
- H.5 Summer Min 2014
- H.6 Winter Max 2014/15
- H.7 Summer Max 2017
- H.8 Summer Min 2017
- H.9 Winter Max 2017/18
- H.10 Summer Max 2017 with maximum wind
- H.11 Summer Min 2017 with maximum wind
- H.12 Winter Max 2017/18 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.

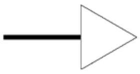
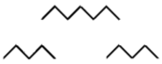
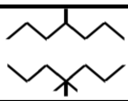
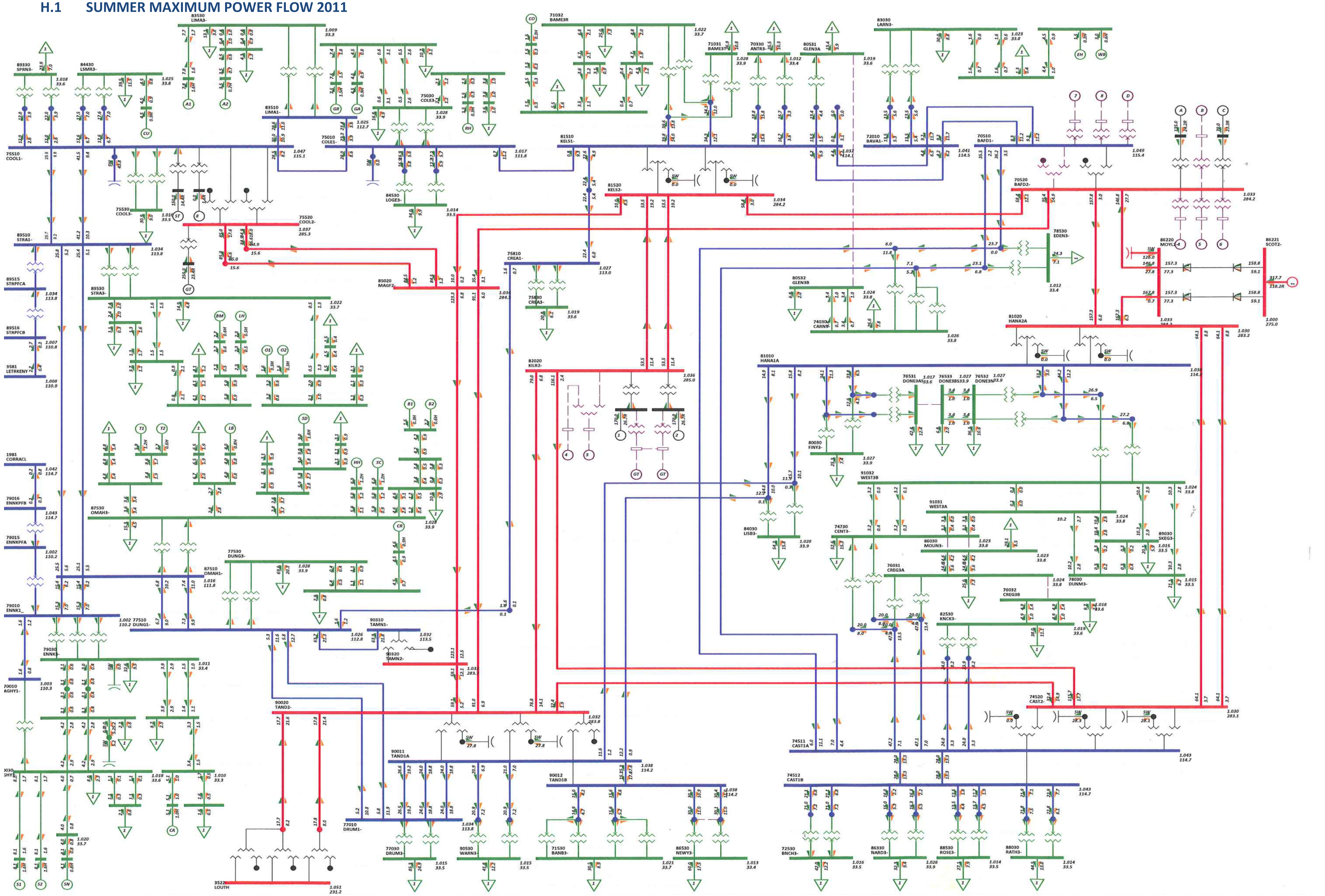
SYMBOL	DESCRIPTION
	400 kV
	275 kV
	110 kV
	33 kV
	< 33 kV
	**GENERATOR**
	**LOAD**
	**INTERBUS TRANSFORMER**
	**2 WINDING TRANSFORMER**
	**REACTANCE**
	**CAPACITANCE**
	**MW FLOW**
	**MVAR FLOW**

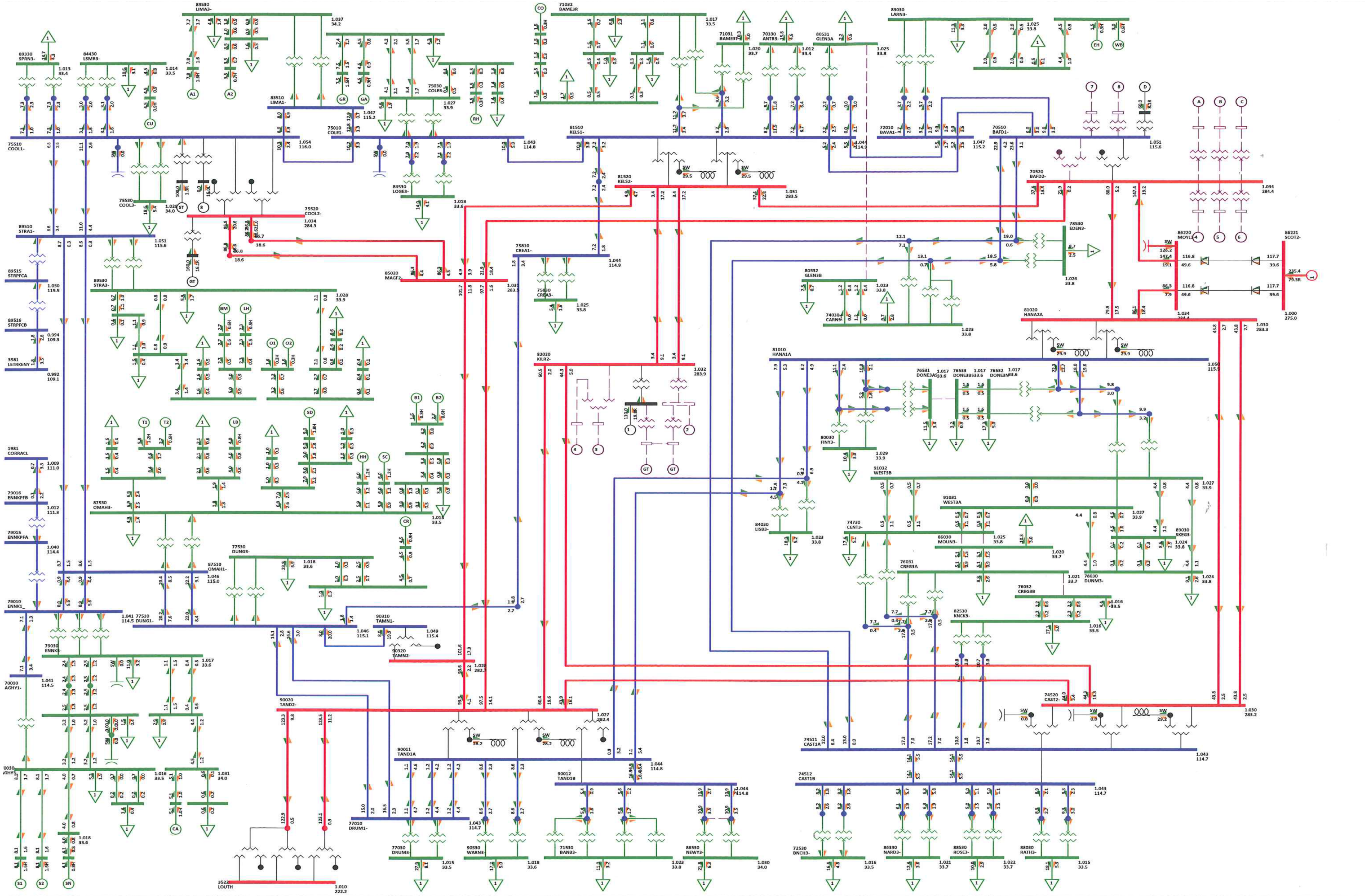
Figure H.1: Symbols used in the Power Flow Diagrams

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

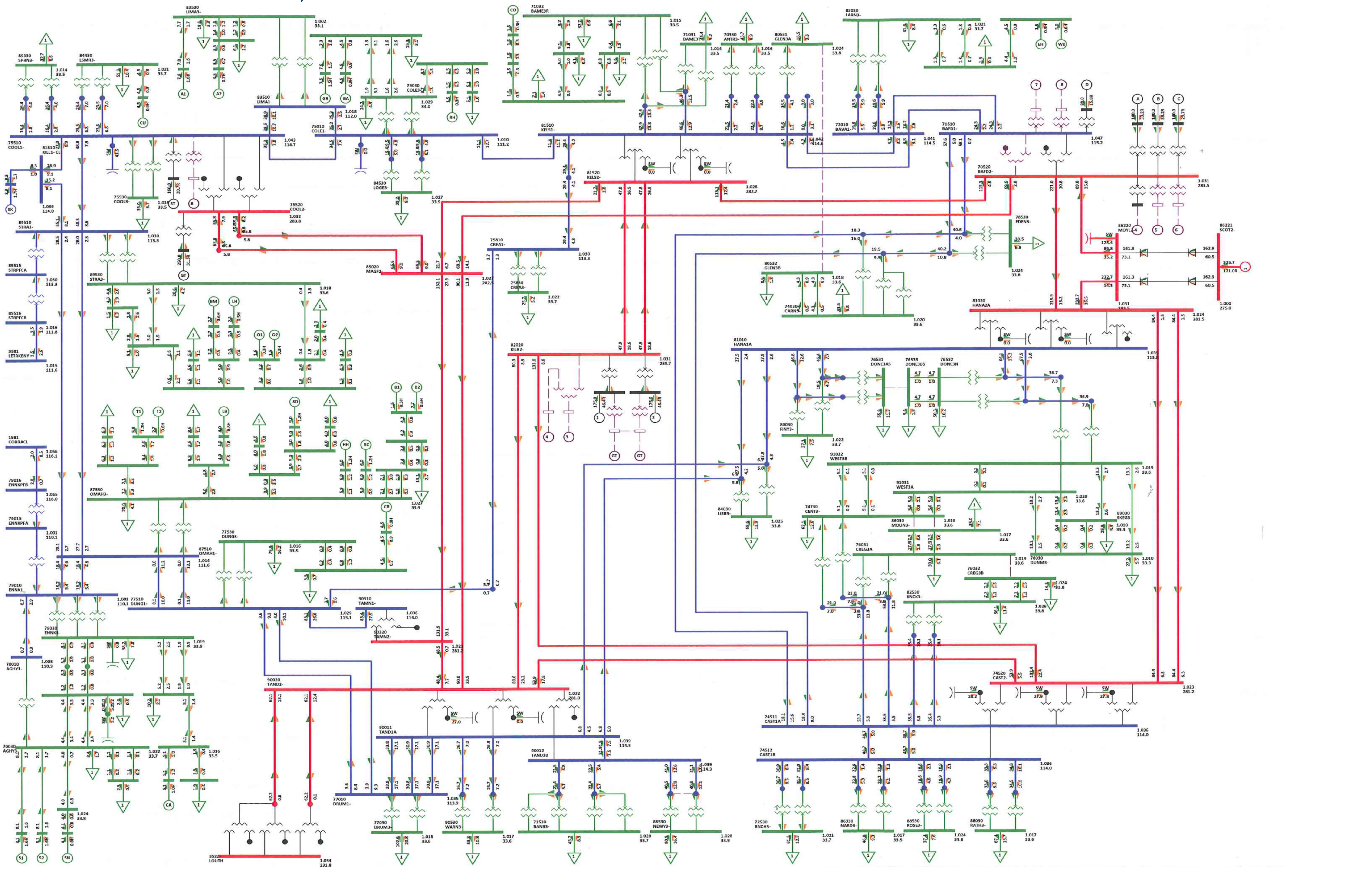
H.1 SUMMER MAXIMUM POWER FLOW 2011



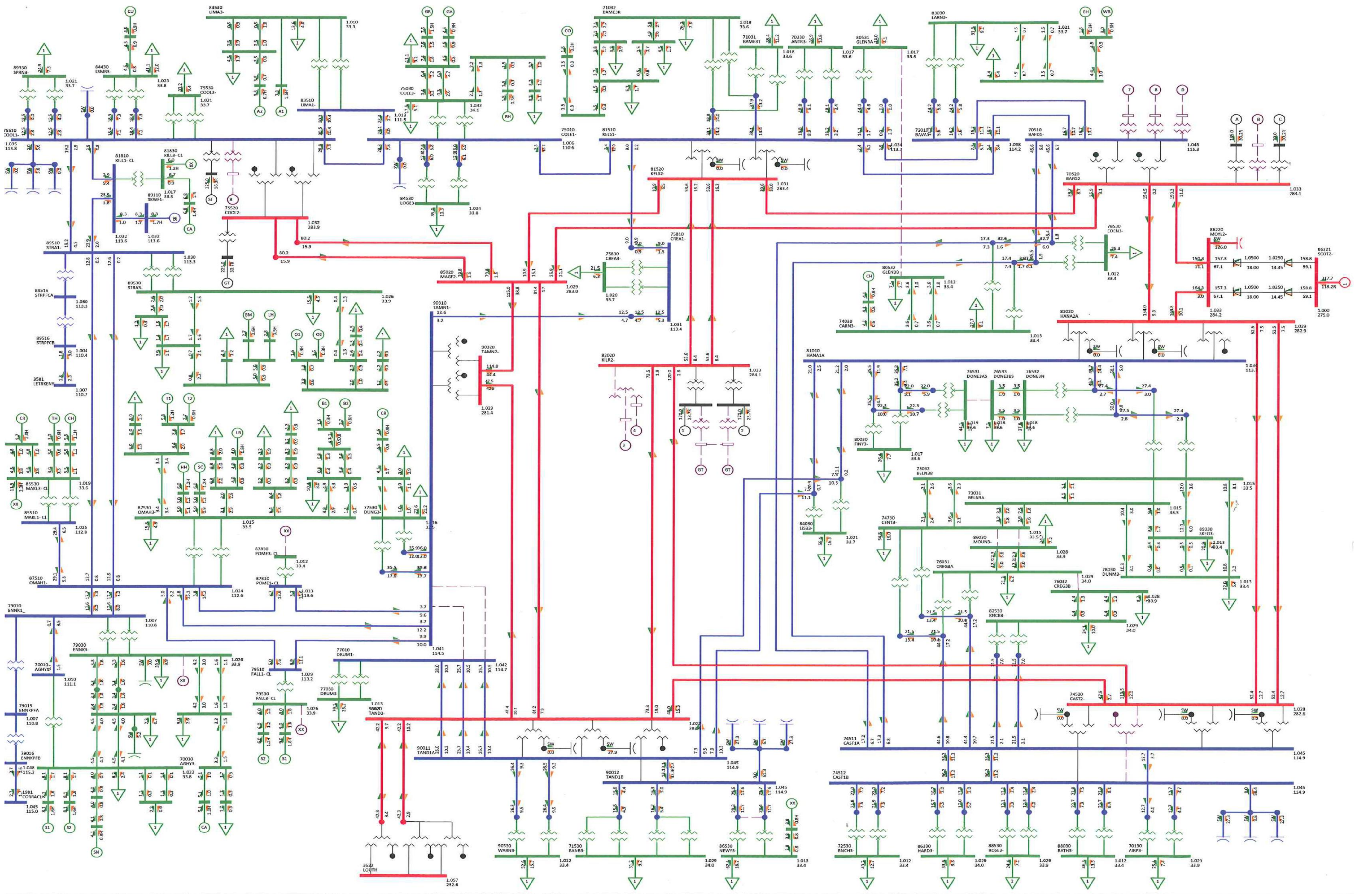
H.2 SUMMER MINIMUM POWER FLOW 2011



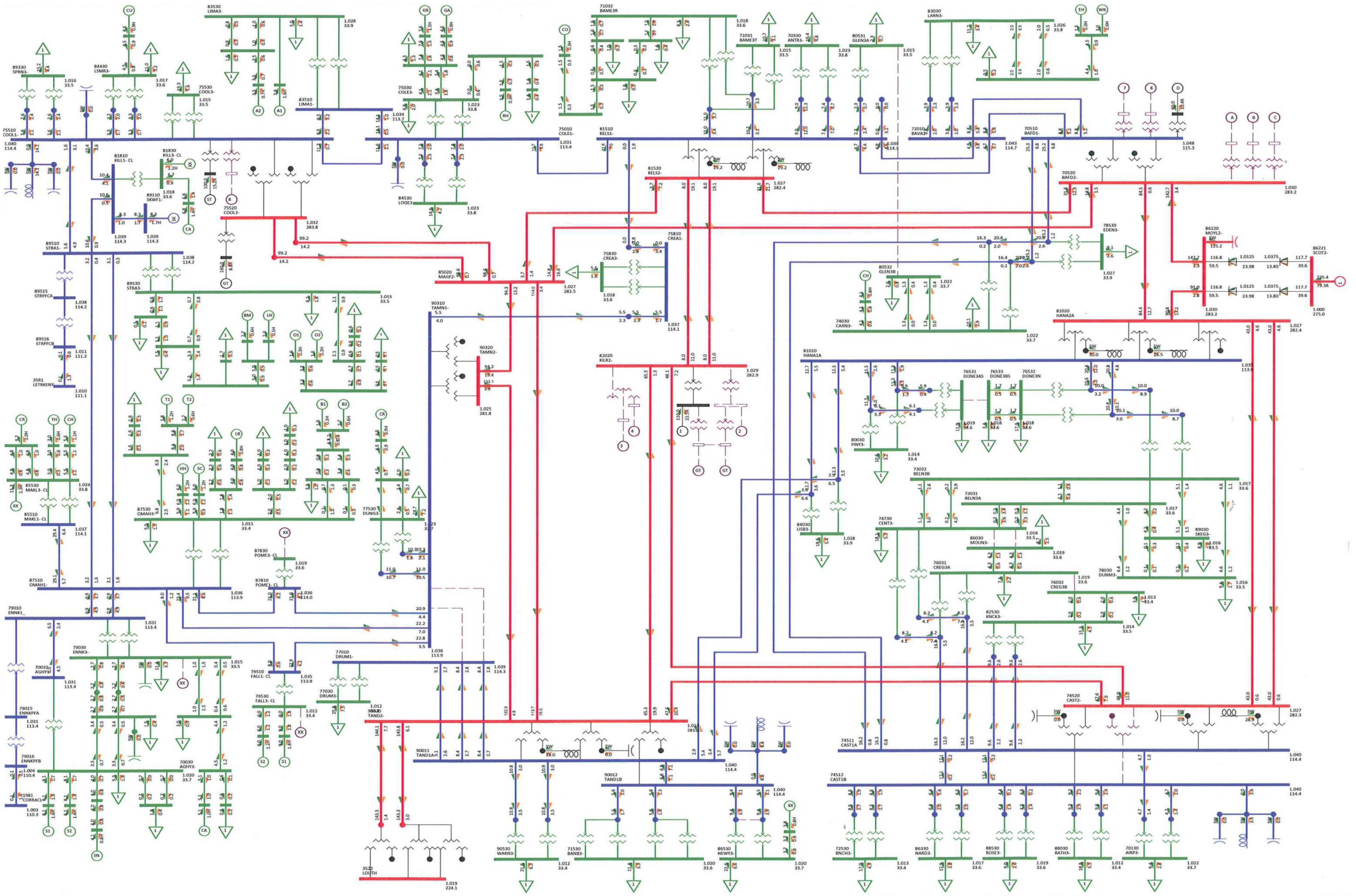
H.3 WINTER MAXIMUM POWER FLOW 2011/12



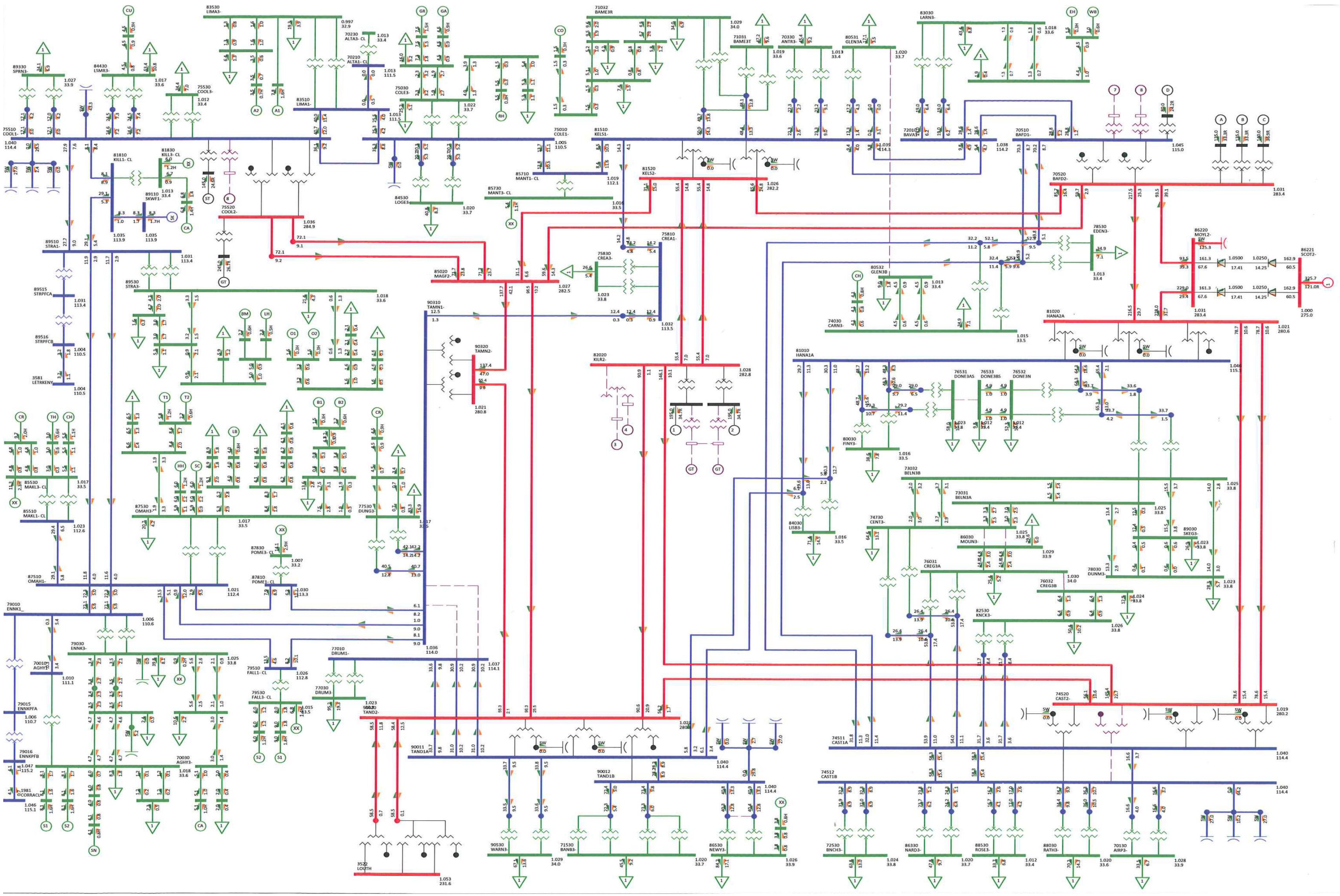
H.4 SUMMER MAXIMUM POWER FLOW 2014



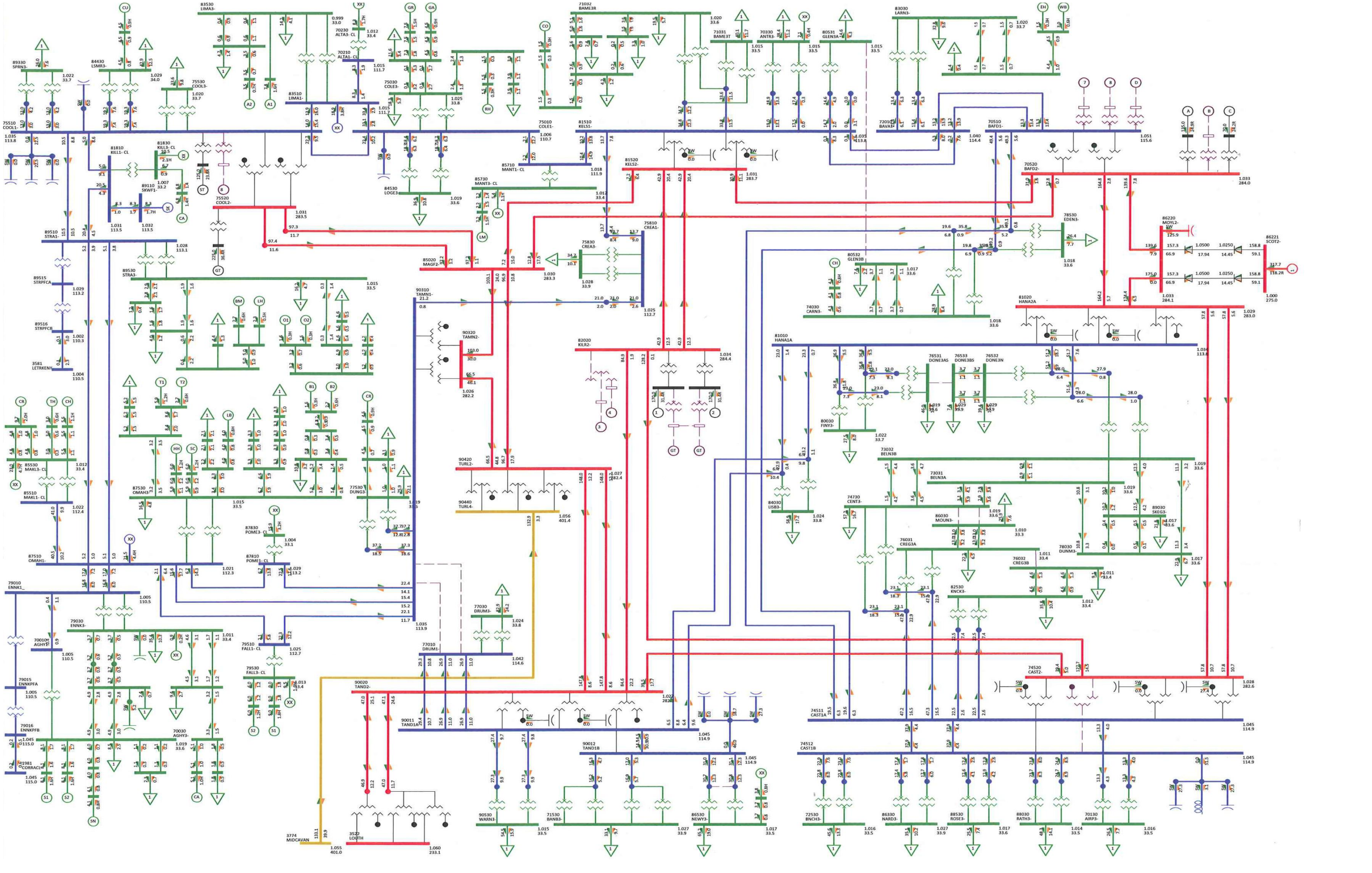
H.5 SUMMER MINIMUM POWER FLOW 2014



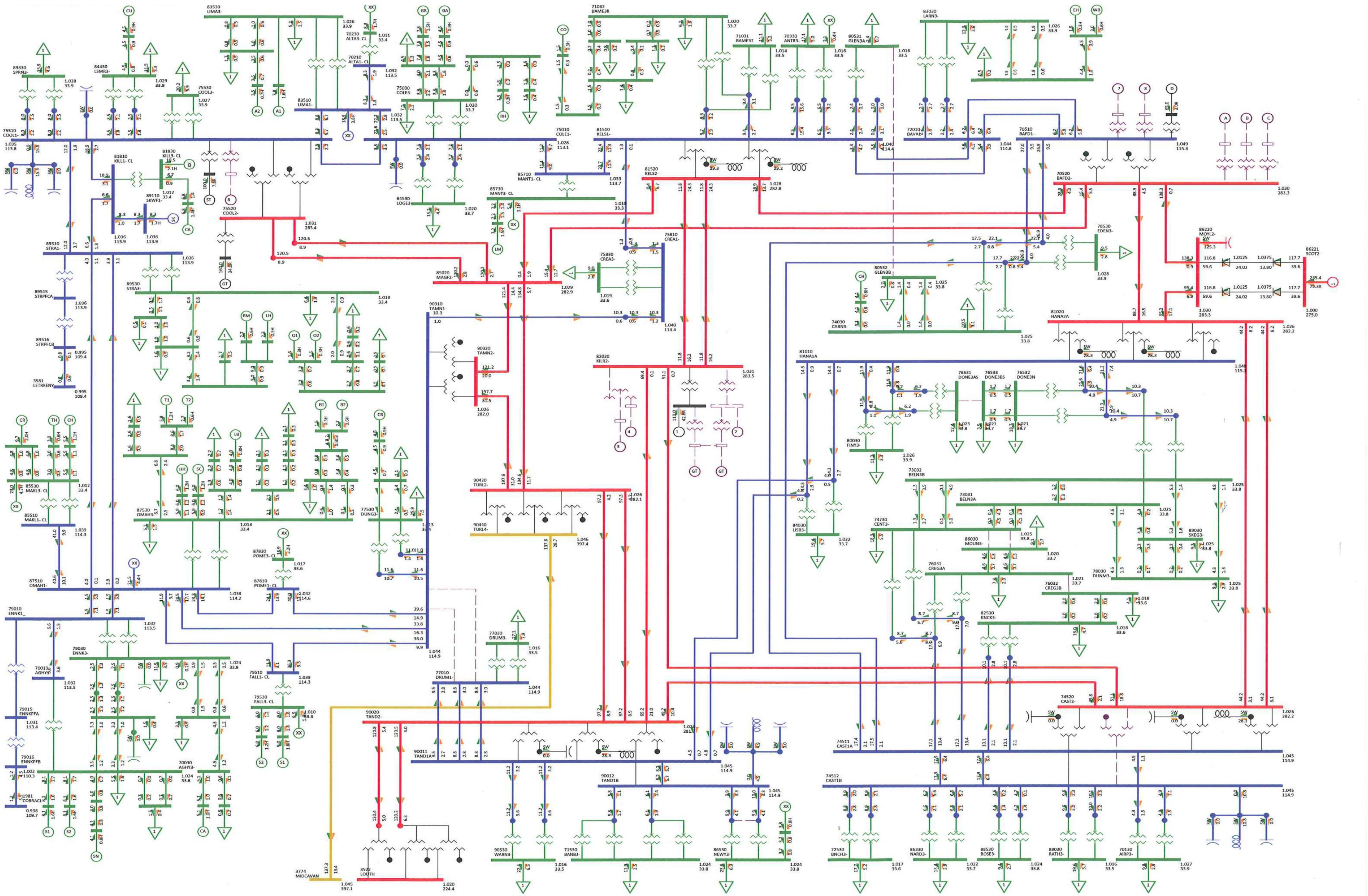
H.6 WINTER MAXIMUM POWER FLOW 2014/15



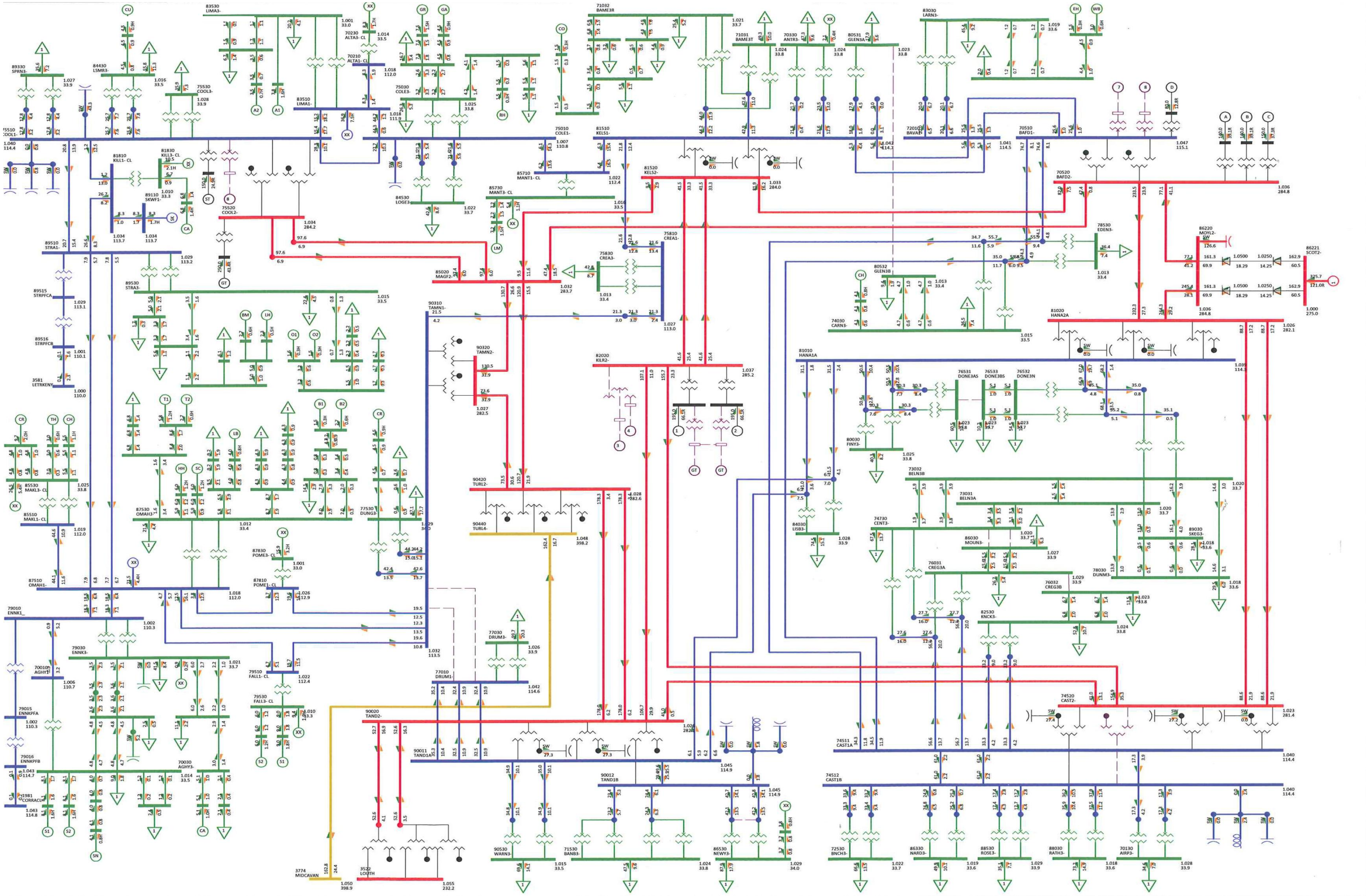
H.7 SUMMER MAXIMUM POWER FLOW 2017



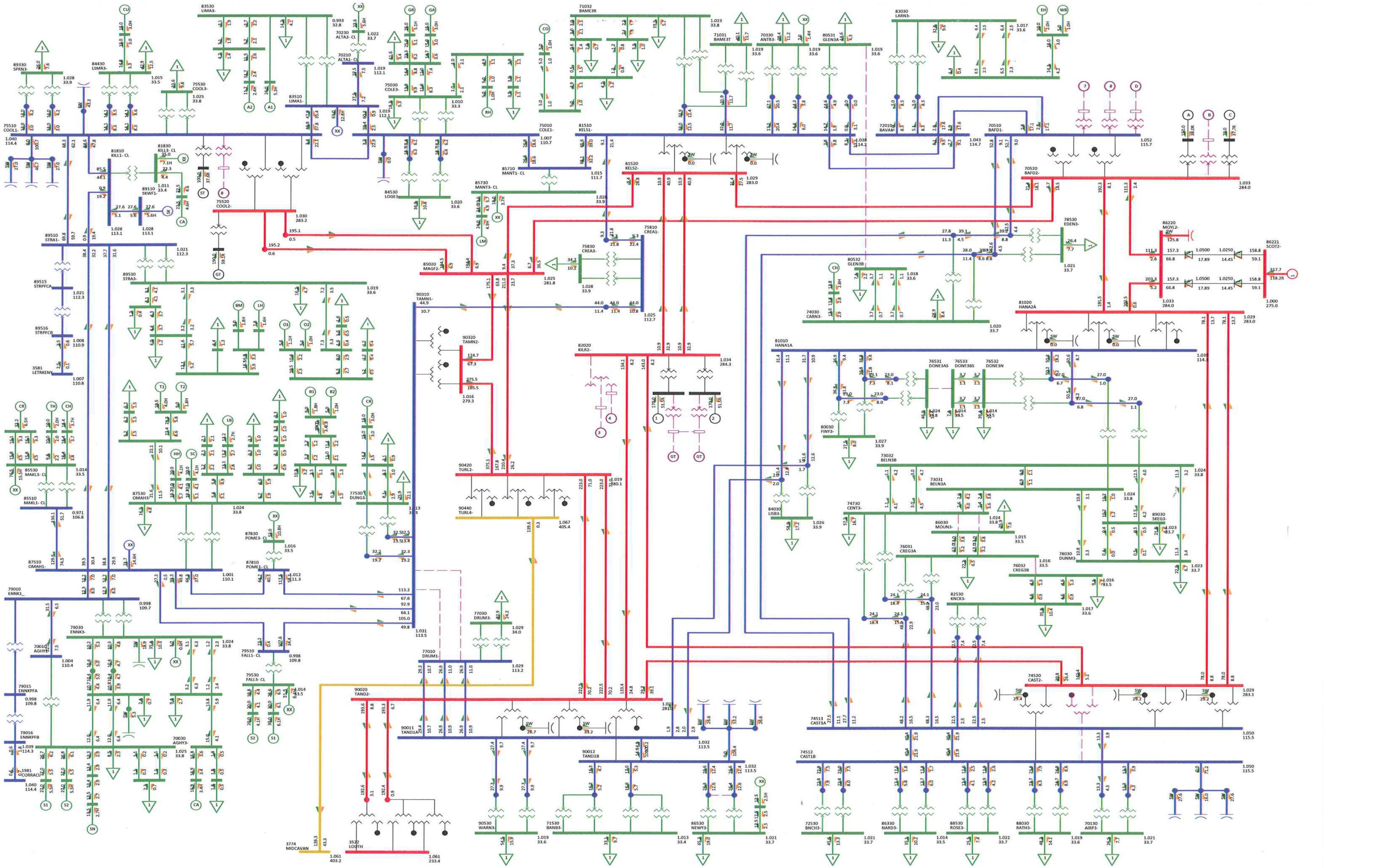
H.8 SUMMER MINIMUM POWER FLOW 2017



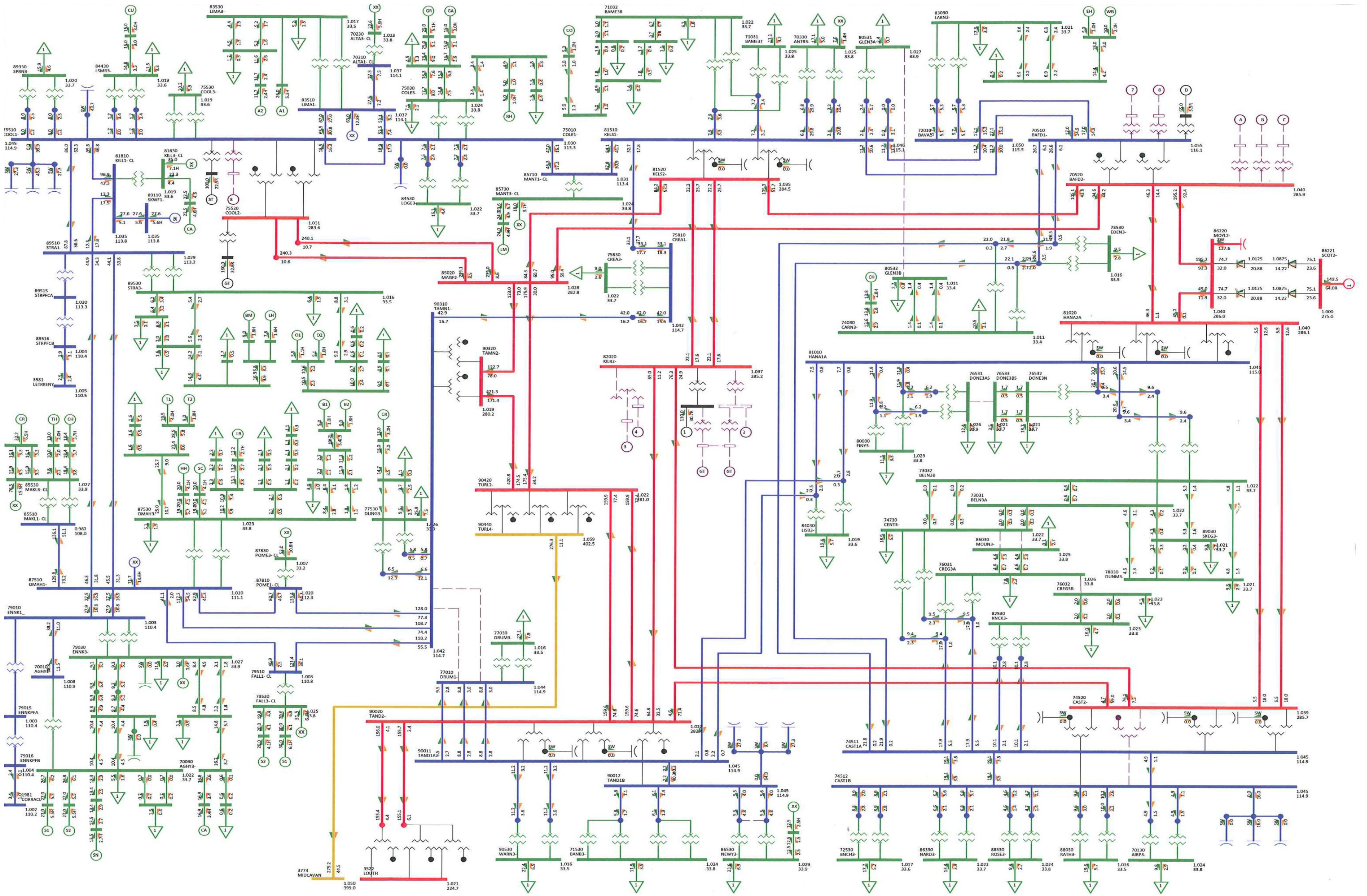
H.9 WINTER MAXIMUM POWER FLOW 2017/18



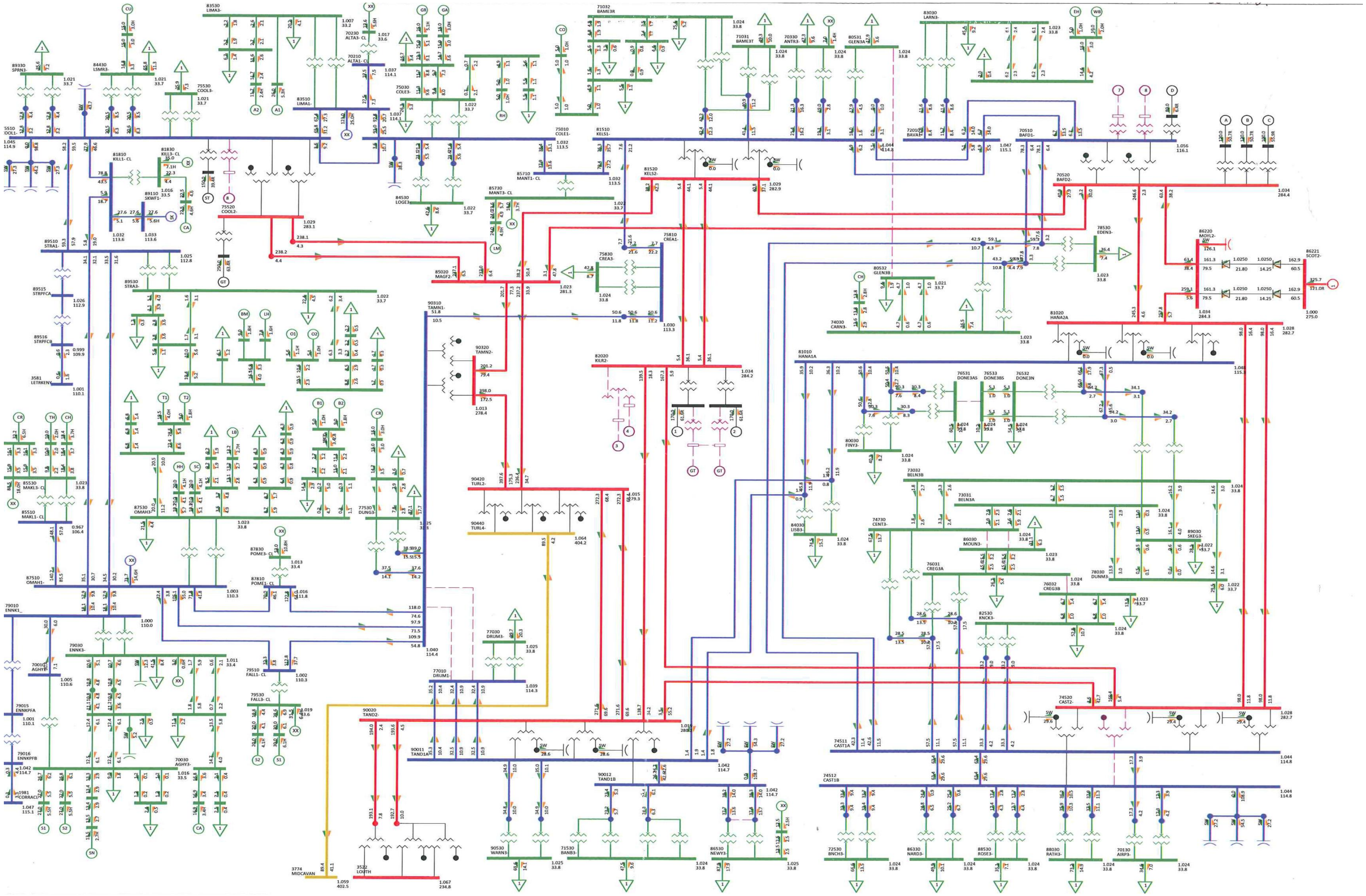
H.10 SUMMER MAXIMUM POWER FLOW 2017 WITH MAXIMUM WIND

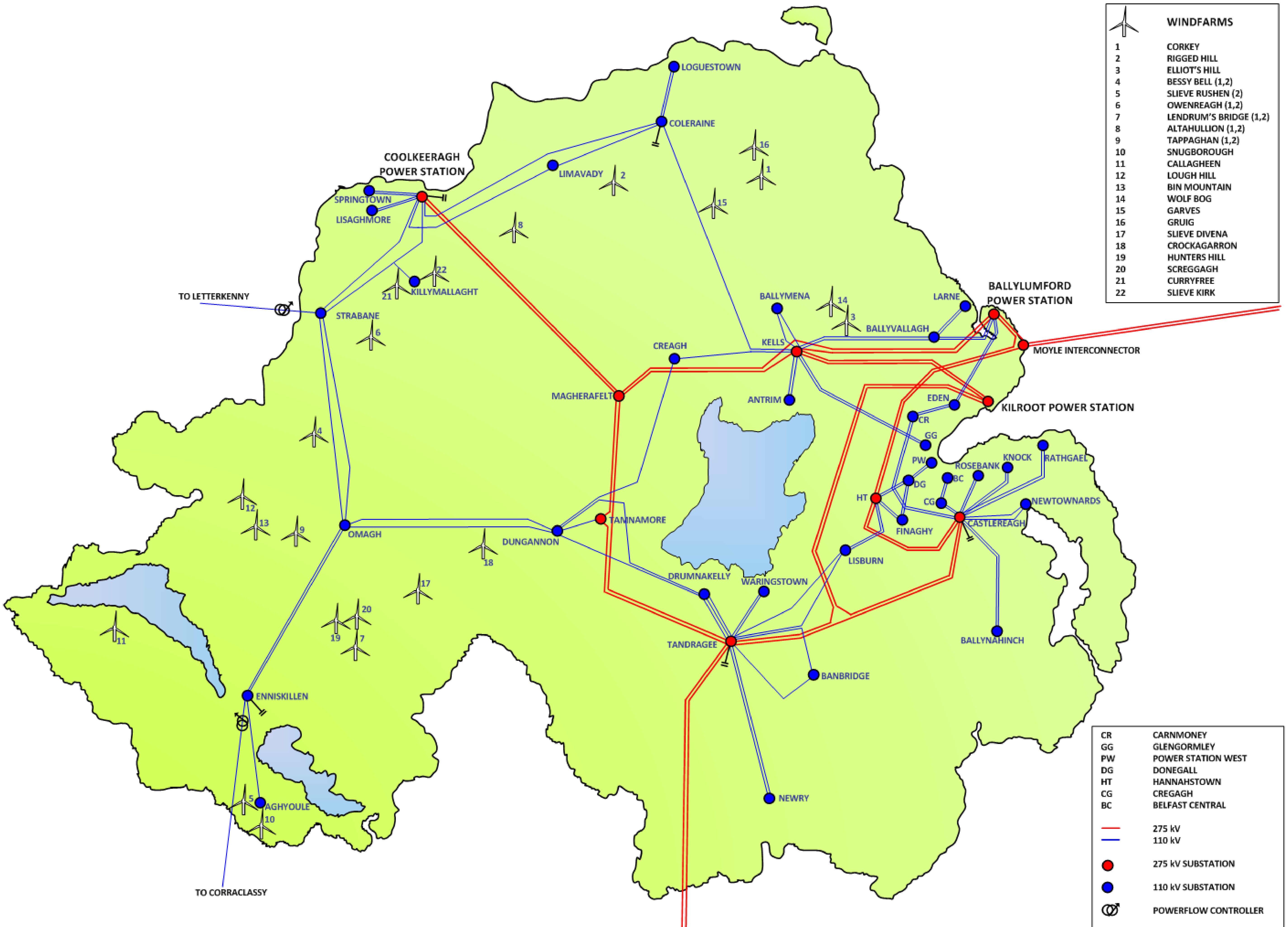


H.11 SUMMER MINIMUM POWER FLOW 2017 WITH MAXIMUM WIND

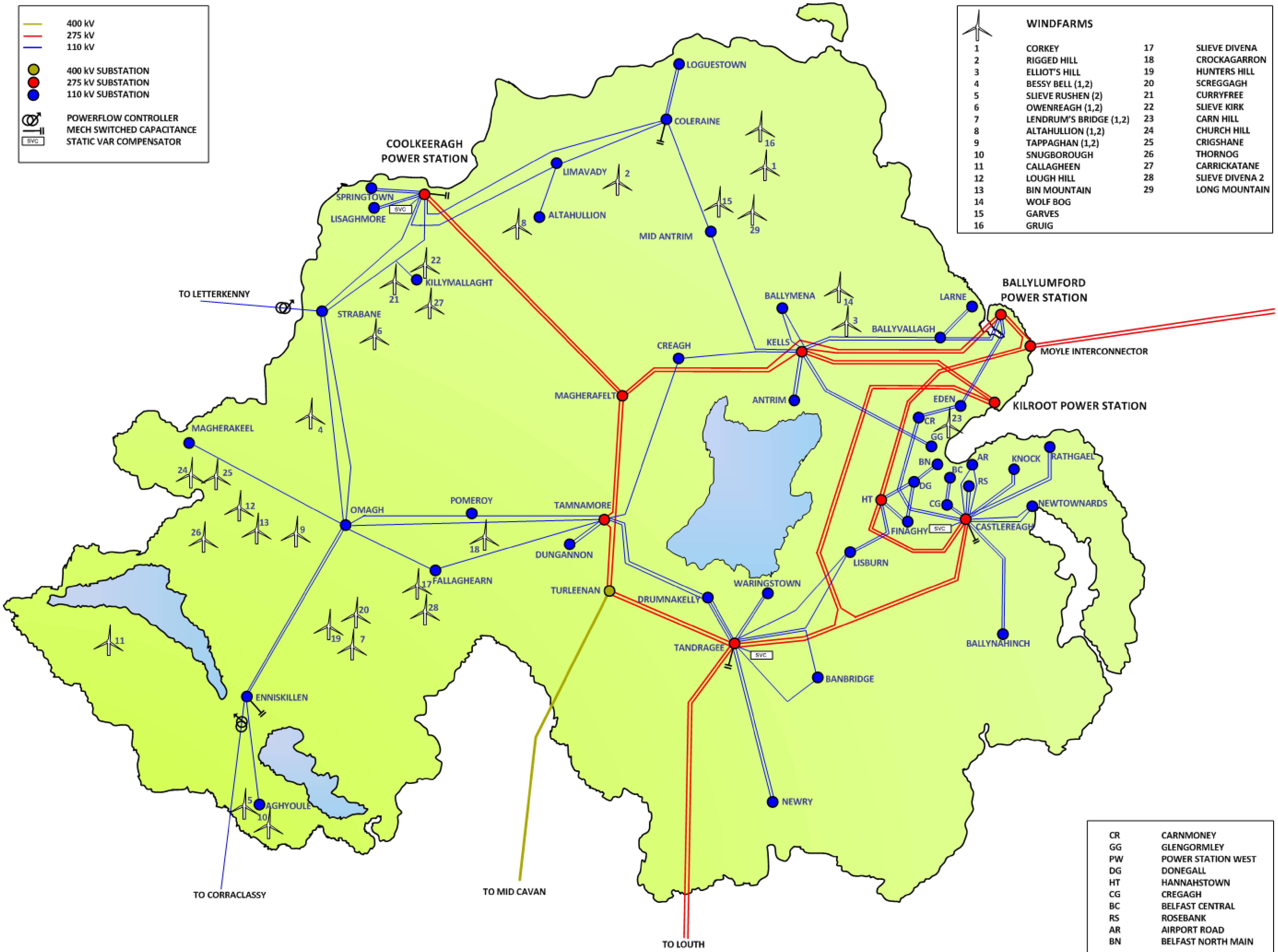


H.12 WINTER MAXIMUM POWER FLOW 2017/18 WITH MAXIMUM WIND





MAP 1: APPROVED TRANSMISSION SYSTEM WINTER 2011/12



MAP 2: UNAPPROVED TRANSMISSION SYSTEM WINTER 2017/18

SONI Ltd.
Castlereagh House
12 Manse Road
Belfast
BT6 9RT
Phone +44 (0)28 9079 4336
www.soni.ltd.uk