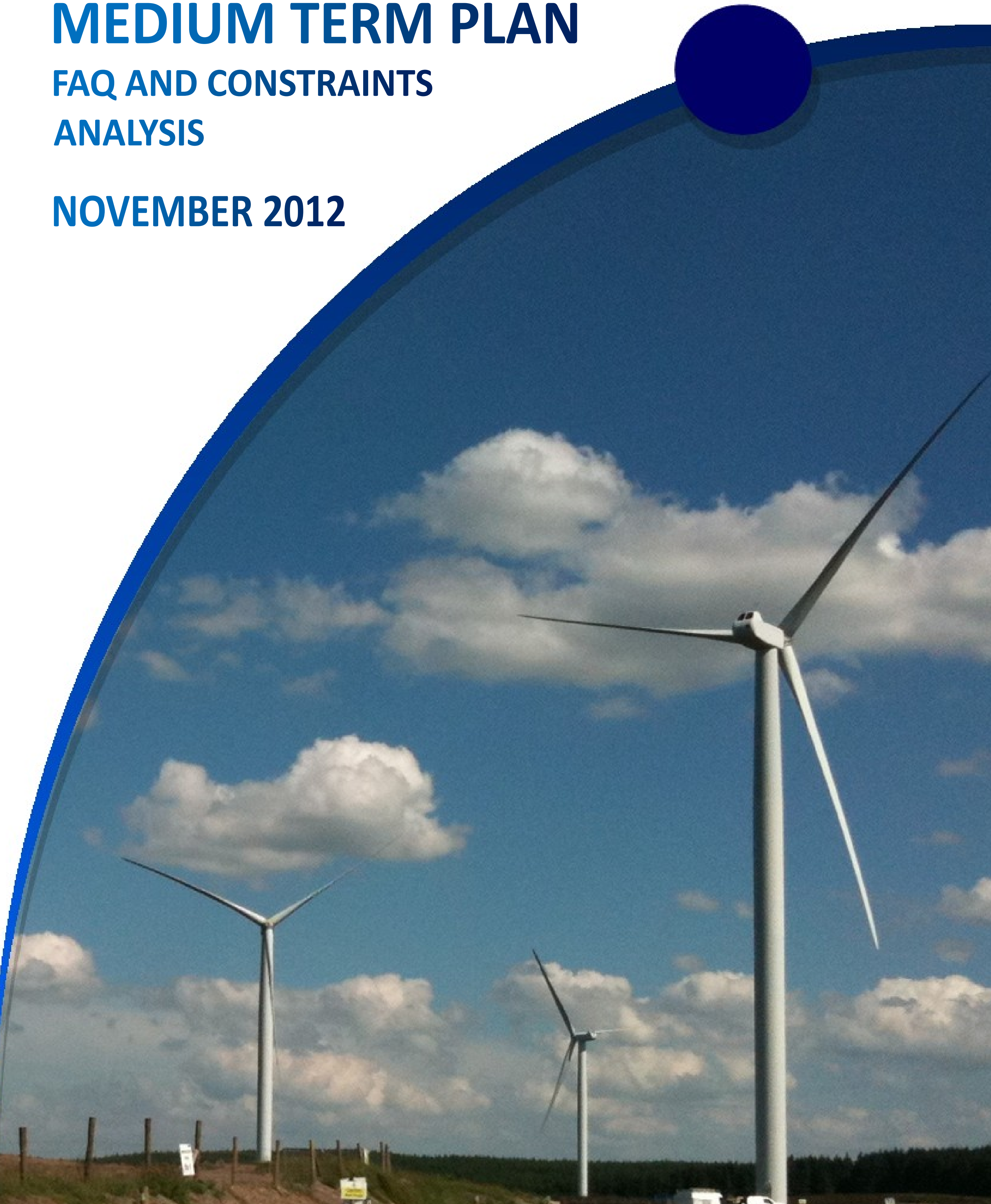
System Operator for Northern Ireland

MEDIUM TERM PLAN

FAQ AND CONSTRAINTS ANALYSIS

NOVEMBER 2012



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TAMNAMORE FAQ AND CONSTRAINTS ANALYSIS

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TAMNAMORE FAQ AND CONSTRAINTS ANALYSIS

DOCUMENT HISTORY

VERSION	DETAILS
1.0	Initial Version
1.1	Executive Summary, Introduction, Methodology sections modified
1.2	Assumptions sections modified
1.3	Final Version

DISCLAIMER

CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

BACKGROUND

Presently 450.9 MW of wind generation is connected in Northern Ireland (NI). A further 550 MW of renewable generation has received planning permission to connect in NI. The vast majority of this renewable generation in located in the North-West area of NI, where the transmission network is at its weakest. Northern Ireland Electricity (NIE) has proposed a series of developments to reinforce the transmission network in this area to accommodate a large proportion of this extra generation- collectively referred to as the Medium Term Plan (MTP).

SONI was requested on the 23rd August, by the Utility Regulator (UREGNI), to investigate the impact of the MTP on Firm Access Quantities (FAQ) and constraints costs for generation connecting in the North-West area. It was agreed that the studies were to include the 1000 MW of connected/proposed renewable generation, be carried out for the year 2016, and focus on the impacts of three specific projects:

- Tamnamore 275/110kV substation Phase 2
- Coleraine - Kells 110k V circuit uprate
- Omagh - Tamnamore 110kV third circuit

FAQ

Analysis was carried out to determine the impact on FAQ in the North-West area of the three projects described above. The methodology was based on the ITC study methodology described in the recent SONI Generator Connection Process consultation[1]. Analysis considered:

- The impact on FAQ with no reinforcements included,
- The impact on FAQ with any one reinforcement included,
- The impact on FAQ with any two reinforcements included,
- The impact on FAQ with all three reinforcements included.

This led to eight different studies being performed, and the subsequent analysis highlighted the inter-dependence of the three reinforcement options. The results are shown in table S.1 below. The coloured cells in table S.1 indicate which projects were included in each set of FAQ analyses.

[1] http://www.soni.ltd.uk/upload/Generator%20Connection%20Process%20Consultation%20Paper%20-%20October%202011.pdf

REINFORCEMENT	1	2	3	4	5	6	7	8
KELLS - COLERAINE								
OMAGH - TAMNAMORE 3								
TAMNAMORE PHASE 2								
NORTH WEST FAQ (MW)	383	443	424	403	530	458	477	701
INCREASE IN FAQ (MW)	0	60	41	20	147	75	94	318

Table S.1: North-West FAQ Associated With MTP Projects

The results indicate that the level of FAQ in the North-West area increases modestly with the inclusion of one or two of the three MTP projects; however, there is a significant increase if all three are included.

CONSTRAINTS

Following the FAQ analysis, it was decided to study the impact on constraints costs of the following network reinforcement options:

- No reinforcements included (Option A)
- The single reinforcement that provides the greatest increase in FAQ (Option B)
- The two reinforcements that provide the greatest increase in FAQ (option C)
- All three reinforcements (option D)

The studies were carried out on an hourly basis for the entire year of 2016, using a process based on the Generator Output Reduction methodology detailed in the SONI Generator Connection Process consultation. This study made use of three different yearly wind profiles, and then averaged the resulting yearly constraints costs. The final average annual costs are detailed in table S.2 below.

OPTION	ANNUAL CONSTRAINTS COSTS			
	2008 WIND PROFILE	2009 WIND PROFILE	2010 WIND PROFILE	AVERAGE
A	£13,431,651	£7,157,509	£9,999,896	**£10,196,352**
B	£11,343,614	£6,498,771	£6,601,798	**£8,148,061**
C	£7,704,581	£3,805,337	£4,582,725	**£5,346,214**
D	£730,441	£96,442	£206,129	**£344,337**

Table S.2: Constraints Costs Associated With MTP Projects

CONCLUSIONS

The graph in figure S.1 below compares the changes in FAQ and constraints costs of the four options studied. Option D, the inclusion of all three MTP projects, as expected provides the largest increase in FAQ in the North-West area, while also having the lowest associated constraints costs. The largest step increase in FAQ occurs when the third project is completed, providing an increase of at least 170 MW of FAQ.

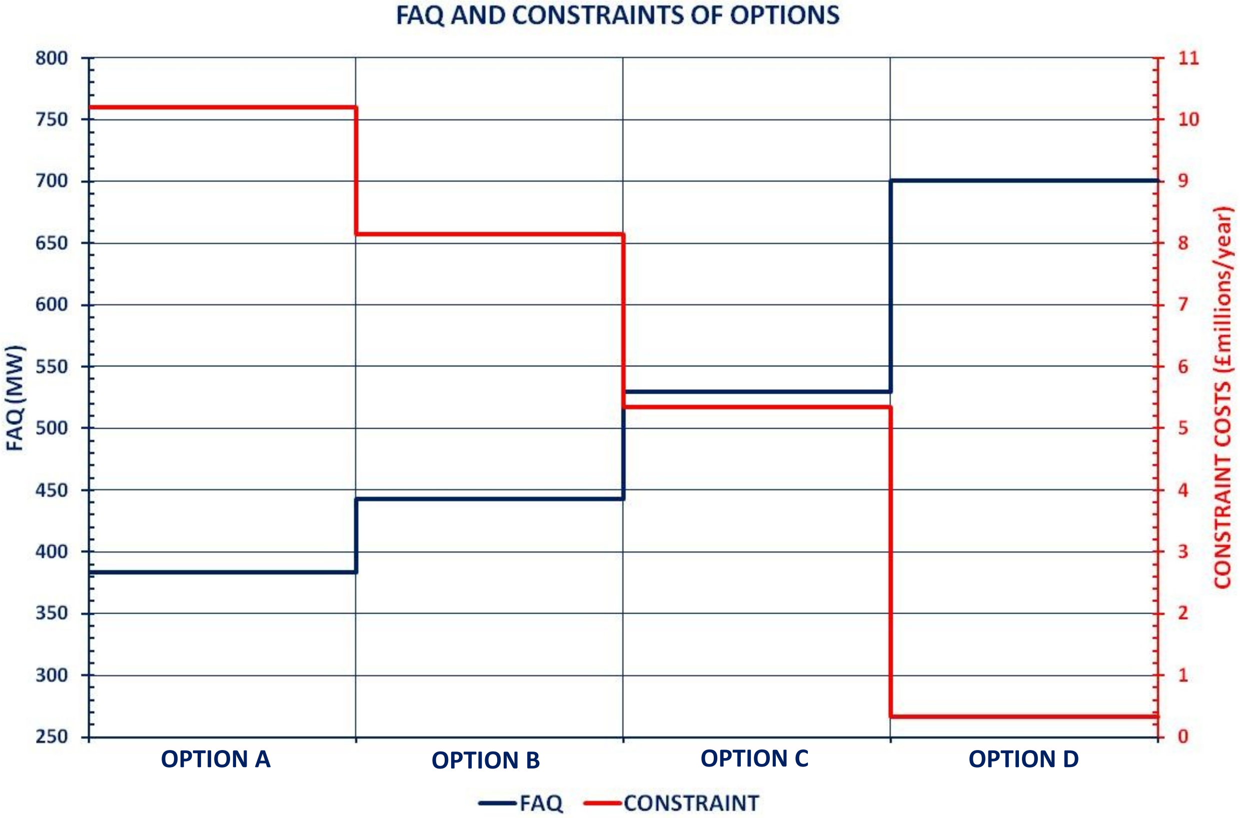


Figure S.1: Comparison of FAQ and Constraints Costs

The results, both from the FAQ analysis and the constraints analysis, demonstrate that while individual projects on their own may deliver some benefit, all three projects need to occur if the proposed levels of renewable generation are to be accommodated, and constraints costs minimised.

The impact of the recent announcement by Crown Estates on the 10th October into the awarding of development rights for two 100 MW tidal generation sites off the North Antrim coast has not been factored into these studies. If this extra proposed generation was to be included, the constraints costs would likely increase.

The run-back scheme on Coolkeeragh CCGT has been assumed to operate correctly in the event of the loss of the 275 k V double circuit from Coolkeeragh to Magherafelt. This scheme, in effect, allows 100 MW of extra renewable generation to remain connected in the North West area under contingency situations. If this scheme was not operational at all times, the constraints costs would increase.

1 INTRODUCTION

The increasing penetration of renewable generation in Northern Ireland (NI) results in a greater potential for thermal overloads on key transmission circuits in the North-West (NW) region. This generally occurs when system loads are low, and renewable generation output is high, meaning that there is insufficient local load to absorb the renewable generation, and exports onto the transmission system are high as a result.

In the short term, the TSO has dealt with this problem by using Special Protection Schemes (SPS), or by constraining wind off. Given that there is 450.9 MW of renewable generation connected in NI, and a further 550 MW of renewable generation with planning permission and looking to connect in the short to medium term, the existing transmission network is likely to come under severe pressure over the next few years. Northern Ireland Electricity (NIE) has drawn up a Medium Term Plan (MTP), which involves both the upgrading of 110 kV circuits in the NW area, and the construction of additional circuits and substations, to ensure the transmission network is capable of accepting much of this proposed generation.

SONI has been asked by the Utility Regulator (UREGNI) assess the impact of three of these MTP projects on the FAQ and constraints costs of renewable generation, for the year 2016. The three specific projects are:

- The completion of Phase 2 of Tamnamore 275/110 kV substation
- The uprating of the Coleraine-Kells 110 kV circuit
- The construction of a third 110 kV circuit between Omagh and Tamnamore

This report analyses the FAQ delivered by these projects, and then assesses the potential constraints costs associated with 1000 MW of renewable generation on the system.

1.1 OUTLINE OF REPORT

Section 2 contains details of the assumptions used in the FAQ and constraints analysis.

Section 3 provides details of both the FAQ and constraints calculations methodologies.

To assess the FAQ, it has been decided to test the transmission network with various combinations of the three MTP projects, ranging from none completed to all included. This results in eight different combinations of new infrastructure to be tested. **Sections 4-11** present the results of the FAQ calculations for these eight different combinations.

Section 12 takes the results of the FAQ analysis, and reduces them to four different options to bring forward to the constraints analysis.

Section 13 presents the results of the constraints analysis.

Section 14 summarises the main findings of the report.

2 ASSUMPTIONS

2.1 DEMAND FORECAST

The demand forecast for the year 2016 was based on the realistic demand forecast used in the most recent All-Island Generation Capacity Statement (2012 - 2021). The forecast is displayed in table 2.1 below. The demand forecast is based on sent out terms, i.e., net of generator house load.

YEAR	WINTER MAX	AUTUMN MAX	SUMMER MAX	SUMMER MIN
2016	1833	1576	1444	527

Table 2.1: NI Demand Forecast 2016

2.2 GENERATION

2.2.1 CONVENTIONAL GENERATION

The total conventional plant available in NI in the year 2016 is detailed in table 2.2 below

GENERATION PLANT	UNIT ID	2016
BALLYLUMFORD	GT7	58
	GT8	58
	CCGT 21	161
	CCGT 22	161
	CCGT 20	178
	CCGT 10	100
COOLKEERAGH	CCGT	430
	GT8	53
KILROOT	ST1	260
	ST2	260
	GT1	29
	GT2	29
	GT3	42
	GT4	42

Table 2.2: NI Conventional Generation 2016

2.2.2 RENEWABLE GENERATION

	GENERATOR	MEC (MW)	LOCATION
1	RIGGED HILL	5	COLERAINE
2	CORKEY	5	BALLYMENA
3	ELLIOT'S HILL	5	LARNE
4	BESSEY BELL	5	OMAGH
5	OWENREAGH	5.5	STRABANE
6	LENDRUM'S BRIDGE	13.2	OMAGH
7	ALTAHULLION	26	LIMAVADY
8	TAPPAGHAN	19.5	OMAGH
9	SNUGBOROUGH	13.5	AGHYOULE
10	CALLAGHEEN	16.9	ENNISKILLEN
11	LOUGH HILL	7.8	STRABANE
12	BIN MOUNTAIN	9	STRABANE
13	WOLF BOG	10	LARNE
14	SLIEVE RUSHEN	54	AGHYOULE
15	ALTAHULLION 2	11.7	LIMAVADY
16	BESSEY BELL 2	9	OMAGH
17	OWENREAGH 2	5.1	STRABANE
18	GARVES	15	COLERAINE
19	GRUIG	25	COLERAINE
20	SLIEVE DIVENA	30	OMAGH
21	TAPPAGHAN 2	9	OMAGH
22	CROCKAGARRAN	17.5	DUNGANNON
23	HUNTER'S HILL	20	OMAGH
24	SCREGGAGH	20	OMAGH
25	CURRYFREE	15	LISAGHMORE
26	SLIEVE KIRK	27.6	SLIEVE KIRK
18	CRIGHSHANE	32.2	MAGHERAKEEL
19	CHURCH HILL	18.4	MAGHERAKEEL
20	SLIEVE DIVENA 2	20	GORT
21	THORNOG	10	MAGHERAKEEL
22	LONG MOUNTAIN	24	MID ANTRIM
23	CARRICKATANE	22.5	KILLYMALLAGHT
24	CARN HILL	13.8	CARNMONEY
25	ALTAMOOSKIN	7.5	GORT
26	GORTFINBAR	12.5	TREMOGE
27	TIEVENAMEENTA	37.5	MAGHERAKEEL
28	CREGGANCONROE	20.7	TREMOGE
29	CROCKDUN	12.5	TREMOGE
30	ALTAHULLION 3	30	LIMAVADY CLUSTER
31	DUNMORE	21	CAM
32	INISHATIVE	13.8	TREMOGE
33	PIGEON TOP	20.7	DRUMQUIN
34	CORNAVARROW	36	DRUMQUIN
35	SEEGRONAN	18	MAGHERAKEEL
36	MAYDOWN BIOMASS	15	COOLKEERAGH
37	DUNBEG	42	CAM
38	ORA MORE	15	ENNISKILLEN
39	CASTLECRAIG	25	DRUMQUIN
40	GLENCONWAY	20	SLIEVE KIRK
41	ESHMORE	9	GORT
42	BROCKAGHBOY	45	BROCKAGHBOY
43	CREAGH CONCRETE	6	BALLYMENA
44	BALLYREAGH, TEMPO	2.5	ENNISKILLEN
45	MULLYNAVEAGH	2.6	DRUMNAKELLY
46	GLENBUCK 1	3	MID ANTRIM
47	GLENBUCK 2	6.9	MID ANTRIM
48	SHANTAVNY SCOTCH	14	GORT
49	CROCKABARAVALLY	6.9	GORT
50	CROCKBRACK	2.3	TREMOGE
51	TULLYNAGEER	12.5	NEWRY
	TOTAL	999.1	

Table 2.3: NI Renewable Generation 2016

2.3 INTERCONNECTION

2.3.1 A.C. INTERCONNECTION

The NI and RoI transmission systems are connected by a 275 kV double circuit tie line, between Tandragee in NI and Louth in RoI. It is planned that there will also be a 400 kV single circuit connection in place over the winter period of 2016/17, between Turleenan in NI and Woodland in RoI.

There are also two 110 kV single circuit connections, between Letterkenny and Strabane, and Corraclassy and Enniskillen. These provide support in the event of certain conditions, or an unexpected circuit outage. Phase Shifting Transformers (PSTs) are used on these circuits to control the power flow.

Table 2.4 below lists the capacities on all North-South tie-lines in 2016, in MVA.

IMPORT /EXPORT CAPACITY	kV	2016
TANDRAGEE-LOUTH	275	1420
ENNISKILLEN-CORRACLASSY	110	125
STRABANE-LETTERKENNY	110	125

Table 2.4: North South Tie-Line Capacities

2.3.2 TRANSFER CAPACITY BETWEEN NI AND ROI

Table 2.5 below lists the total transfer capacity, in MW, on all tie-lines between NI and RoI.

TOTAL TRANSFER CAPACITY	2016
NORTH-SOUTH	330
SOUTH - NORTH	260

Table 2.5: North South Total Transfer Capacity

The tie lines are normally operated in such a way that there is no exchange of reactive power between NI and RoI. This has been reflected in all studies carried out.

2.3.3 D.C. INTERCONNECTION

Currently, the only HVDC interconnection between NI and Great Britain (GB) is the Moyle interconnector, with a capacity of 500MW. Table 2.6 below lists the import and export limits on the Moyle interconnector used for the year 2016.

IMPORT/EXPORT CAPACITY	2016
IMPORT (WINTER)	450
IMPORT (AUTUMN AND SUMMER)	410
EXPORT	300

Table 2.6: Import and Export Capacities on the Moyle Interconnector

2.4 NETWORK REINFORCEMENTS

Table 2.7 below describes the network reinforcements assumed for all years up to 2016.

NETWORK REINFORCEMENTS	YEAR
MAGHERAKEEL WIND FARM CLUSTER AND 110kV CIRCUIT	2012
OMAGH - DUNGANNON 110kV CIRCUITS 1 &2 UPRATE TO 186/191/193MVA	2012
KILLYMALLAGHT WIND FARM CLUSTER	2012
KELLS - COLERAINE 110kV CIRCUIT UPRATE TO 186/191/193MVA – PHASE 1	2013
ENNISKILLEN – OMAGH 110kV DOUBLE CIRCUIT UPRATE TO 109/119/124 MVA	2013
KELLS - COLERAINE 110kV CIRCUIT UPRATE TO 186/191/193MVA – PHASES 2 & 3	2014
REACTIVE COMPENSATION AT CASTLEREAGH, COOLKEERAGH AND TANDRAGEE	2014
TAMNAMORE 275/110kV SUBSTATION PHASE 2	2015
OMAGH - TAMNAMORE 110kV CIRCUIT 3	2015
GORT WIND FARM CLUSTER	2015
LIMAVADY WIND FARM CLUSTER	2015
MID ANTRIM WIND FARM CLUSTER	2015
TREMOGE WIND FARM CLUSTER	2015
CAM WIND FARM CLUSTER	2016

Table 2.7: Network Reinforcements in Northern Ireland

3 METHODOLOGY

3.1 FAQ CALCULATION

The FAQ is calculated using the ITC study methodology described in the recent SONI Generator Connection Process consultation. The full methodology can be found in that document; a brief description is included in this report and demonstrated in the simplified diagram in figure 3.1 below.

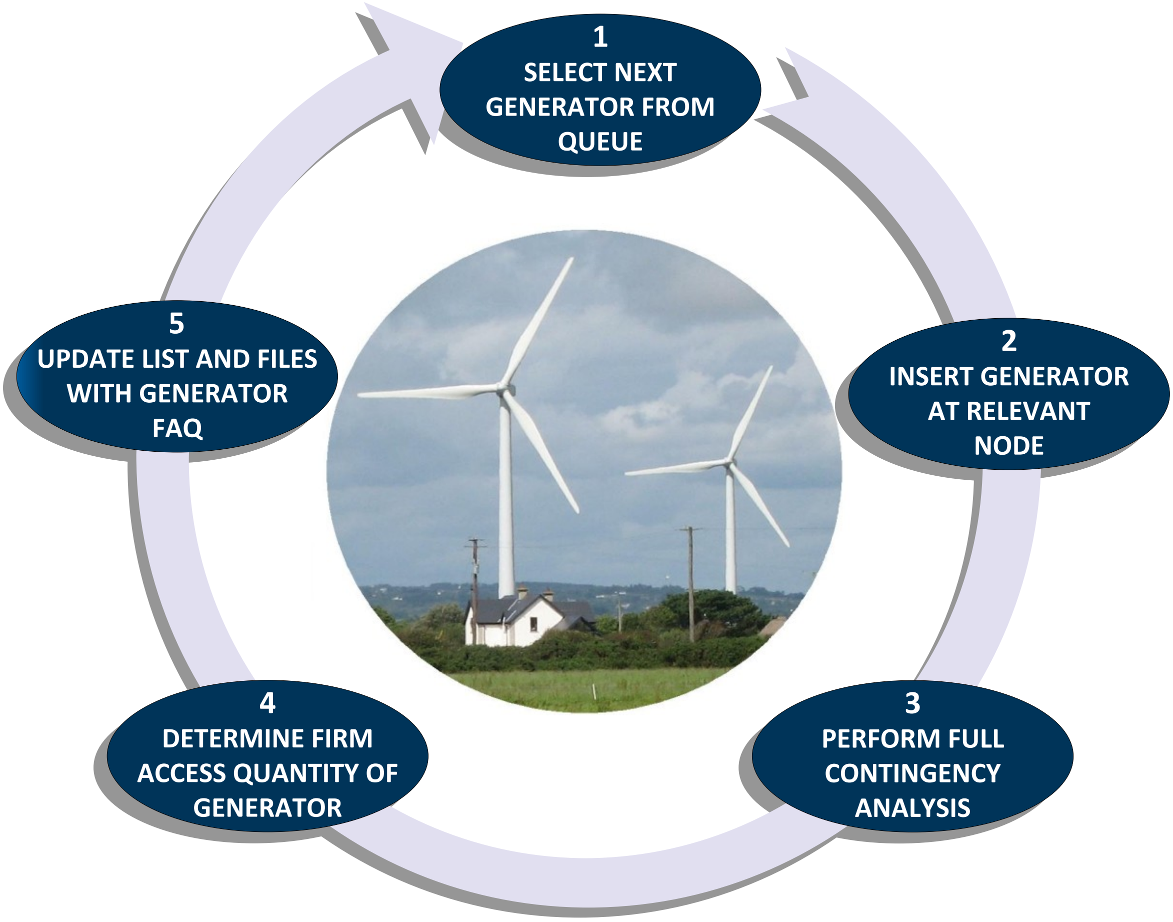


Figure 3.1: Simplified ITC Methodology

At a very simplistic level, the ITC process looks at each generator in turn, based on a list of generators to be tested. The list is comprised by assessing the status of generators in the connection application process, and also their date of planning permission.

For each generator, the FAQ at the node of connection is assessed using rigorous contingency analysis, through use of PSS/E software. The process itself is run via an automation program already tested and used for transmission capability analysis in recent Transmission System Capacity Statements.

Table 3.1 below illustrates the contingency analysis performed for each scenario. The more probable contingencies are comprised of single contingency events (N-1), which covers the loss of any single item of generation or transmission equipment at any time. N-1 contingency analysis is carried out in each season. In winter, N-DC events are also analysed. This event examines the simultaneous loss of both 275kV circuits on a 275kV double circuit tower, effectively treating the loss of both circuits as an N-1 event.

SEASON	CONTINGENCY ANALYSIS
WINTER	N-1 AND N-DC
AUTUMN	N-1
SUMMER	N-1

Table 3.1: Contingency Analysis Performed

The loss of the Coolkeeragh-Magherafelt 275kV double circuit is also treated as a single N-1 event in both autumn and summer. This is an addition to the contingency analysis described in table 3.1 above, and is included because:

- The conductor is presently in a poor condition,
- The circuit runs across high ground and is exposed to poor weather conditions,
- The recent outage rate of this double circuit is much greater than what would normally be expected.

3.2 CONSTRAINTS CALCULATION

The methodology used for the constraints calculations is the same as that described in the recent SONI Generator Connection Process consultation. A brief summary is provided below, along with an associated simplified diagram; the full detailed methodology can be found in the consultation document.

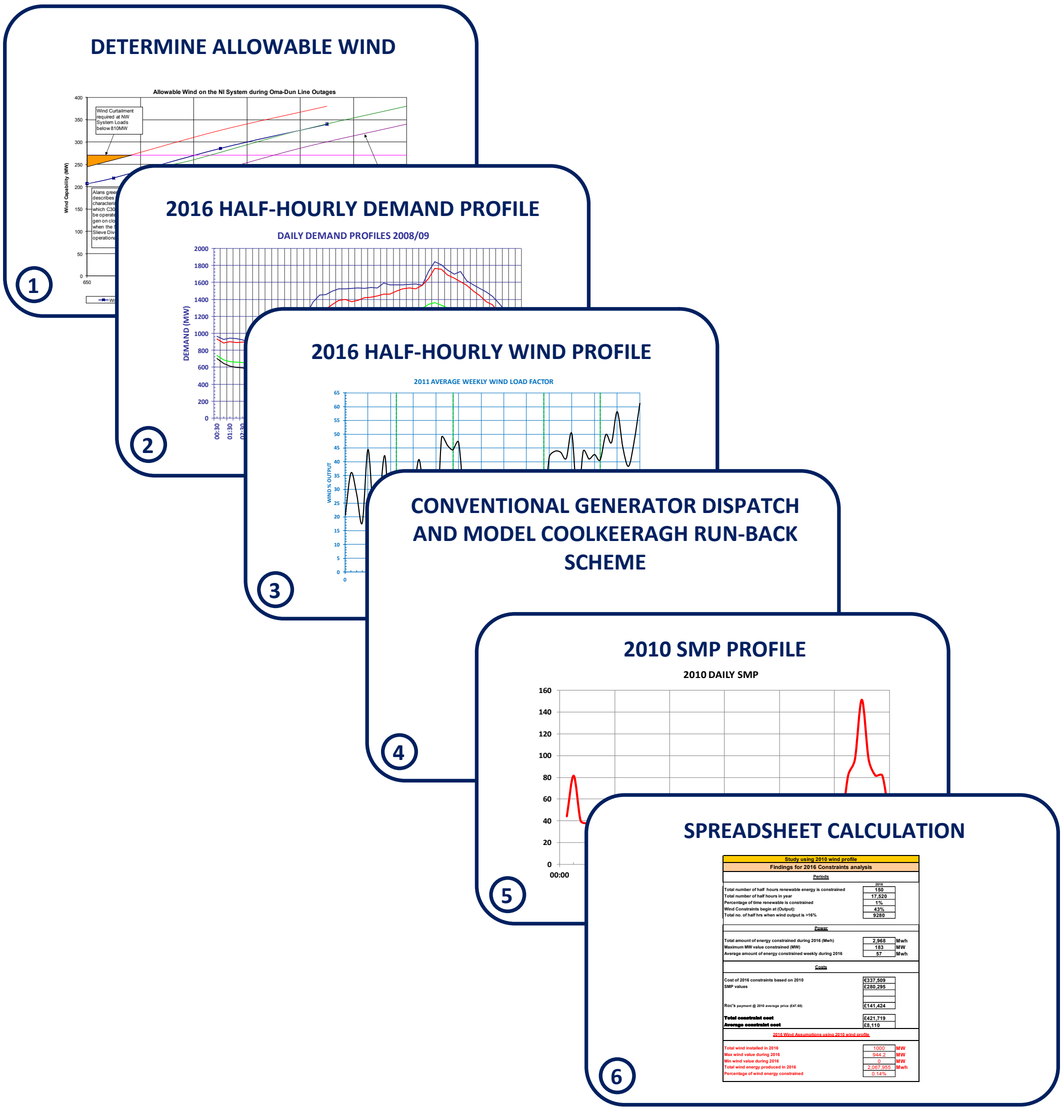


Figure 3.2: Simplified Constraints Spreadsheet Calculation

The worst case scenario in the North-West region is the loss of the Coolkeeragh-Magherafelt 275kV double circuit. In basic terms, the constraint model looks for the amount of pre-fault constraints that have to occur to prevent overloads on the transmission system in the event of the double circuit loss. The inputs to the model are discussed below.

DETERMINE ALLOWABLE WIND

Load flow studies are performed for a range of loads over summer, autumn and winter scenarios. These studies are used to identify how much renewable generation can be connected in the NW of NI before overloads occur under contingency conditions. The results of these studies are then plotted and correlated to determine a linear relationship between maximum renewable generation output and system load, for the three seasons. These transfer capacity equations are input into the constraints model to inform the half-hourly analysis.

HALF-HOURLY DEMAND PROFILE

A pre-recession demand profile from 2007 is used to determine the 2016 demand profile used in the constraints model. The 2007 demand profile is scaled up so that the peak demand meets that stated in section 2.1.

HALF-HOURLY WIND PROFILE

Three separate historic wind profiles are tested in the model, covering the years 2008, 2009 and 2010. This is to reflect the unpredictability of wind, and therefore allows a range of differing renewable generation outputs to be studied.

HALF-HOURLY CONVENTIONAL GENERATION DISPATCH

Conventional generation is dispatched in the model based on the most economic dispatch. Coolkeeragh CCGT is deemed to be must run. For these studies, we are only interested in constraints required in the North-West to prevent overloads following the loss of the Coolkeeragh-Magherafelt 275 kV double circuit. Therefore, Coolkeeragh CCGT is assumed to be dispatched at 160 MW as per the run-back scheme in place for the generator.

HALF-HOURLY SMP PROFILE

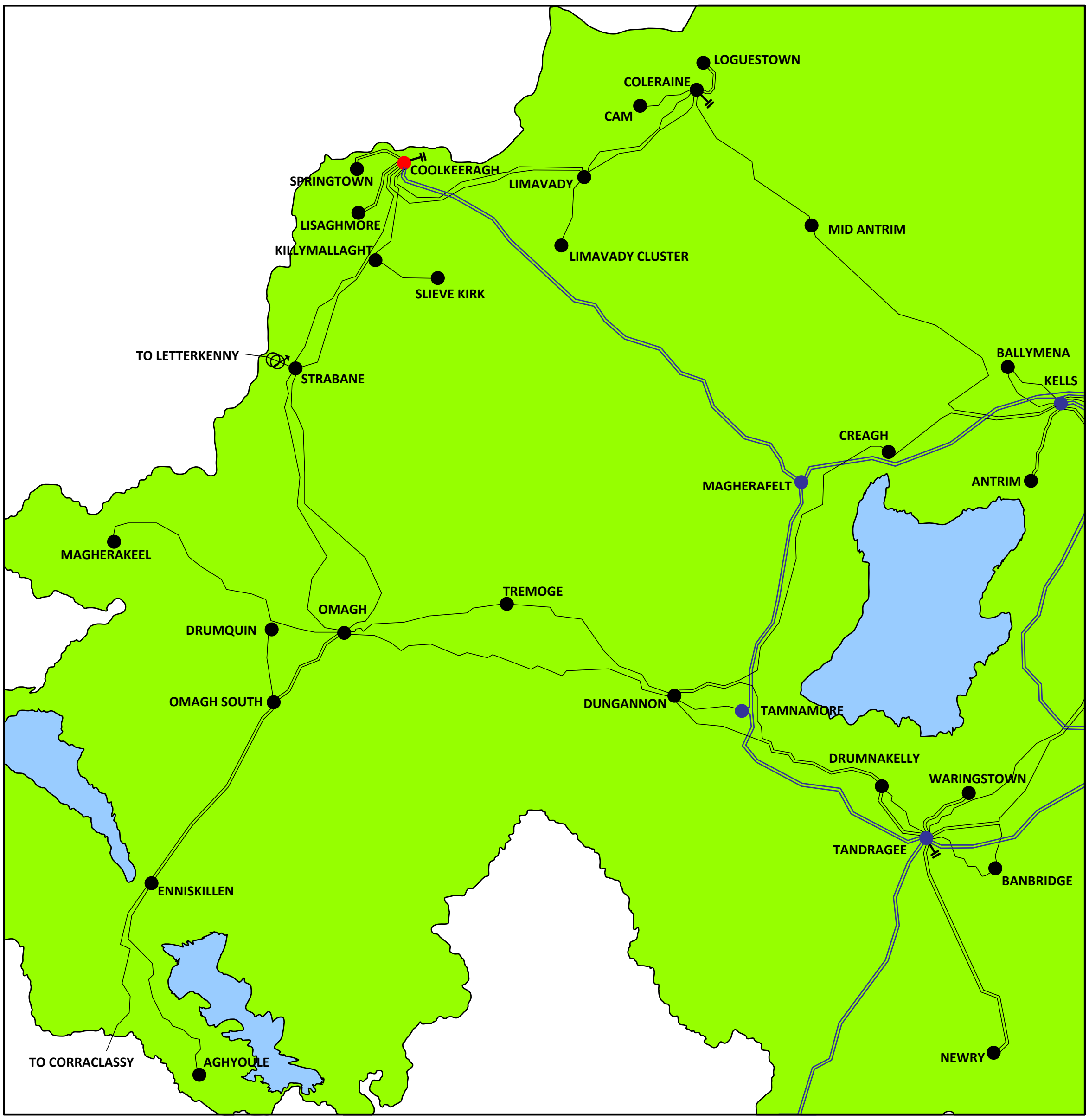
To provide a cost figure for any constrained MW, an SMP profile is used. This is based on the assumption that any MW constrained would be getting paid the SMP at that time. Therefore the constraint model looks at MW constrained for any half-hour, and applies the SMP from the profile for that corresponding half hour. The 2010 SMP profile is used in the constraint model.

CALCULATION

The constrained MW for the entire year, and their associated costs, are finally summated, and presented as single figures. The three different costs, based on the three different wind profiles used, are averaged to produce one final overall constraint cost. The resulting costs are provided in section 13.

4 FAQ- NO REINFORCEMENT

4.1 MAP

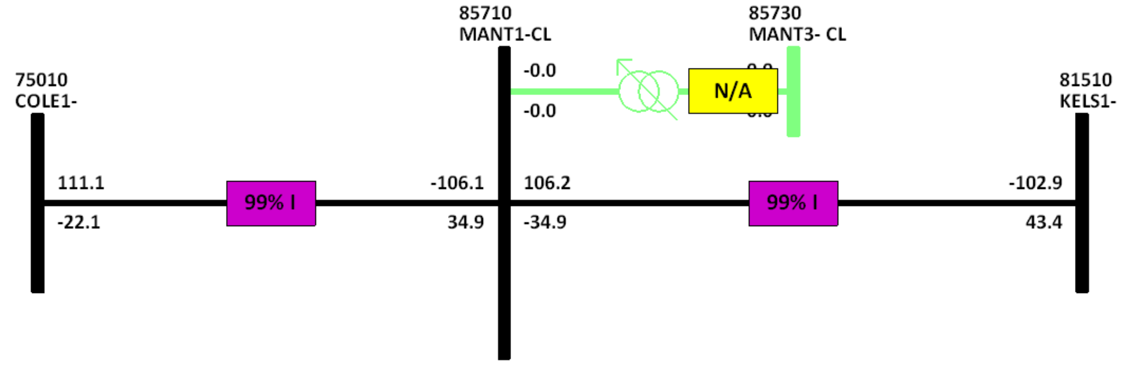


4.2 FIRM GENERATION

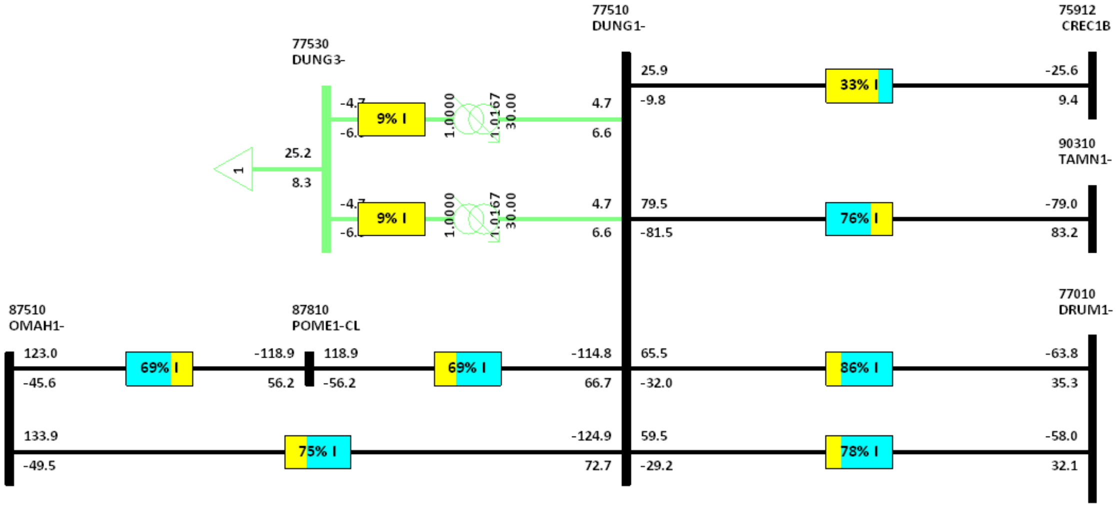
With none of the proposed reinforcements in place in 2016, the total amount of renewable generation that would be firm in the North West region is **383MW**. The power flow diagrams in section 2.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuits between Dungannon and Drumnakelly are overloaded beyond **383MW** of renewable generation in the North-West.

4.3 POWER FLOWS ON 110kV CIRCUITS

4.3.1 COLERAINE - KELLS CORRIDOR

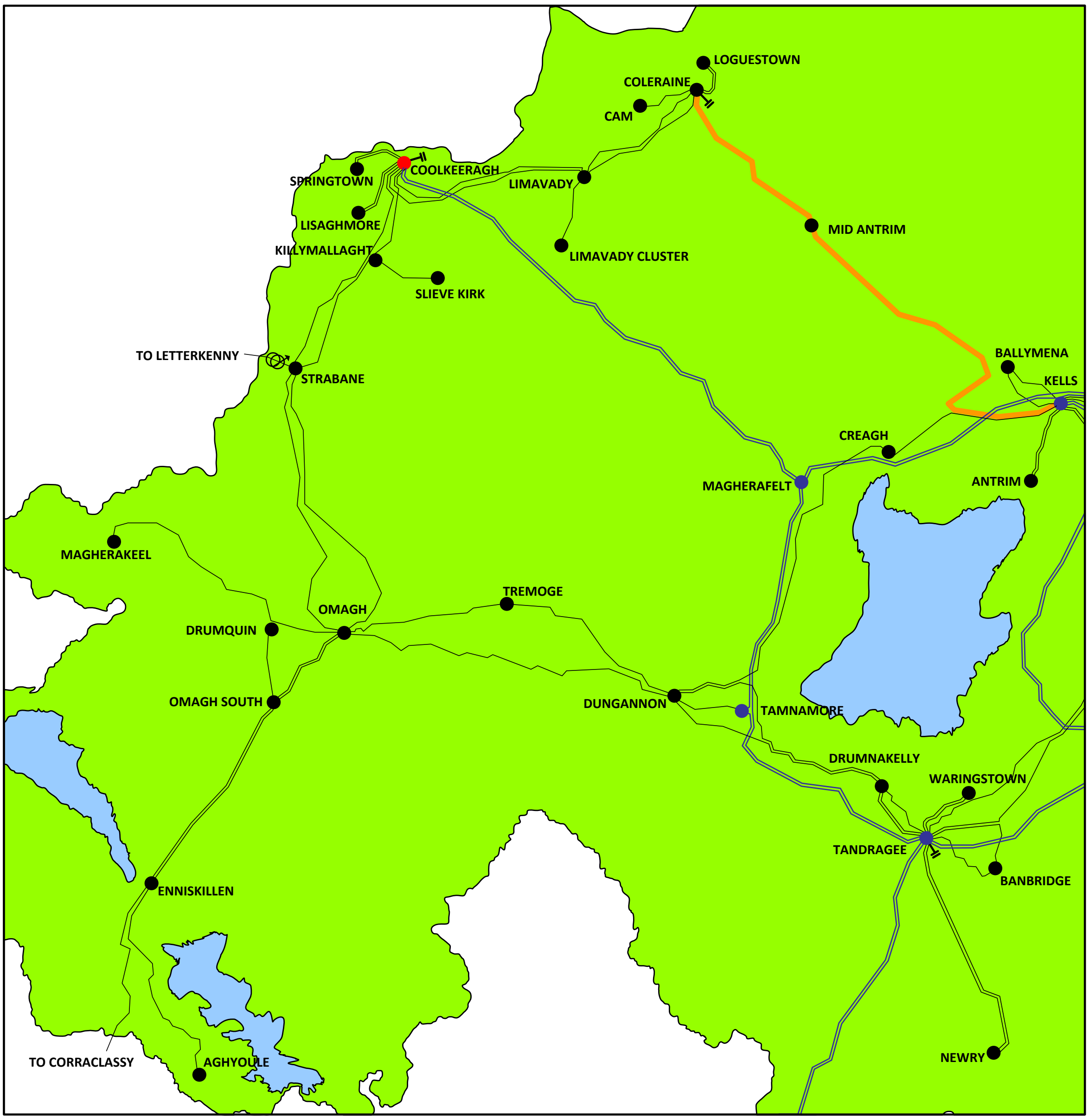


4.3.2 OMAGH - DUNGANNON CORRIDOR



5 FAQ- KELLS-COLERAINE UPRATE ONLY

5.1 MAP

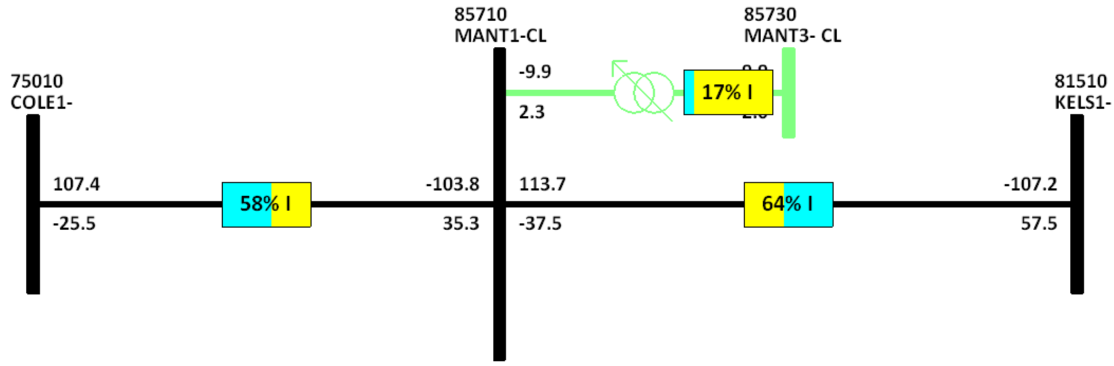


5.2 FIRM GENERATION

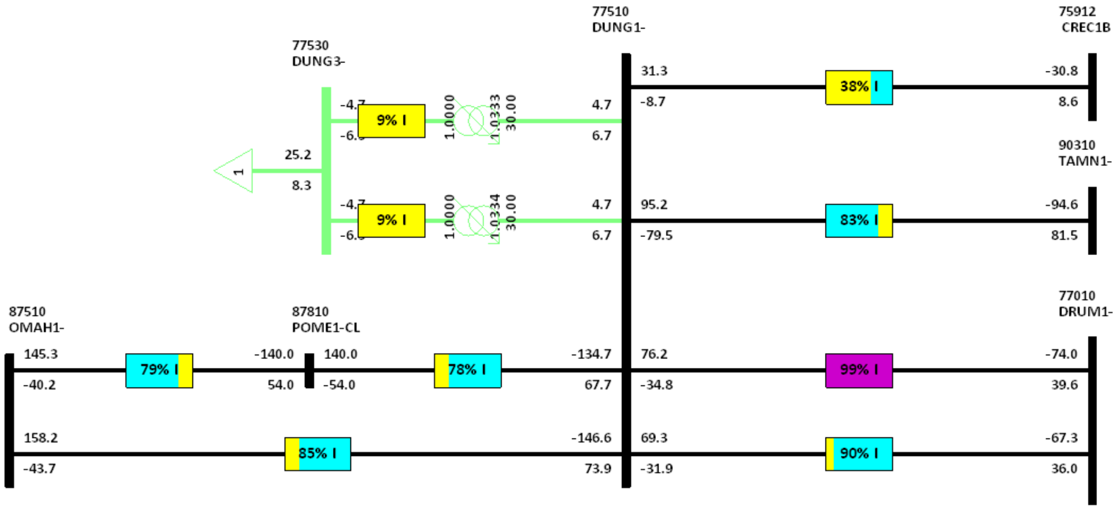
With only the Kells-Coleraine 110kV circuit uprate in place in 2016, the total amount of renewable generation that would be firm in the North West region is **443MW**. The power flow diagrams in section 3.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuits between Dungannon and Drumnakelly are overloaded beyond **443MW** of renewable generation in the North-West.

5.3 POWER FLOWS ON 110kV CIRCUITS

5.3.1 COLERAINE - KELLS CORRIDOR

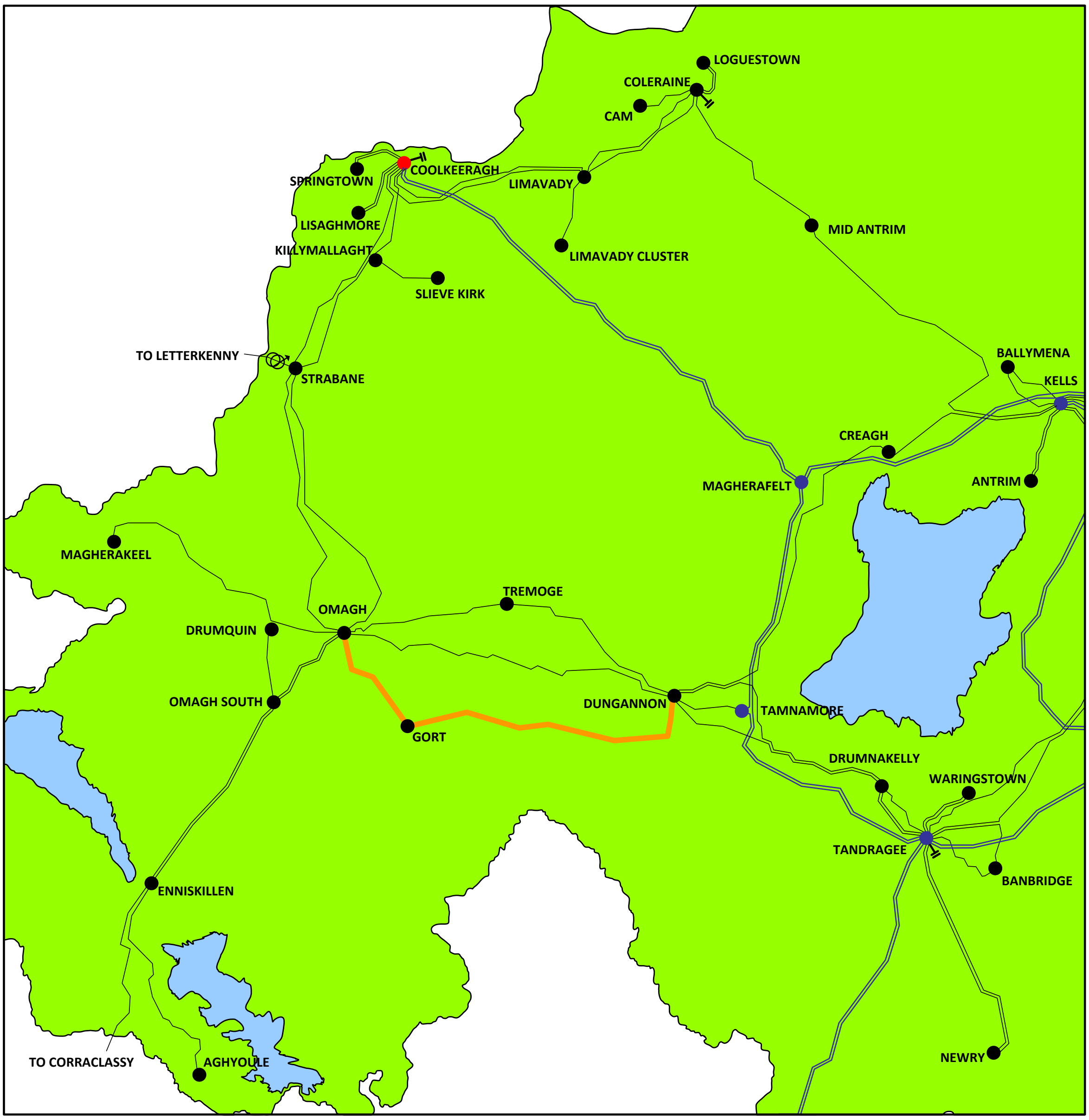


5.3.2 OMAGH - DUNGANNON CORRIDOR



6 FAQ- OMAGH-DUNGANNON THIRD CIRCUIT ONLY

6.1 MAP

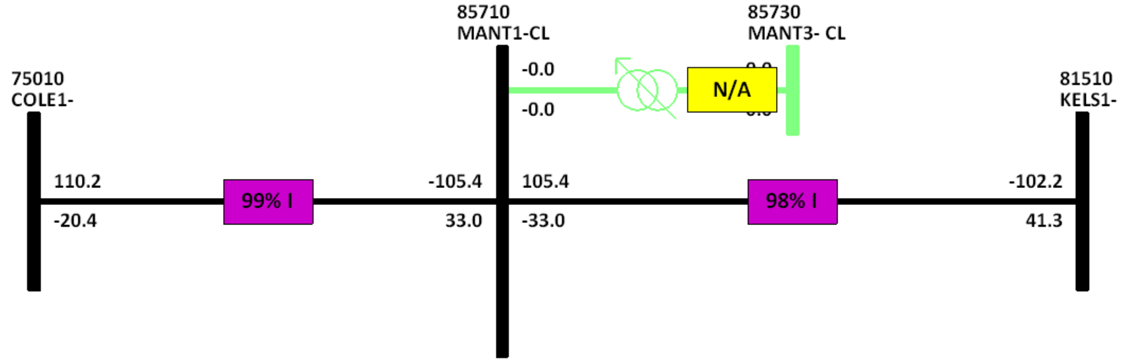


6.2 FIRM GENERATION

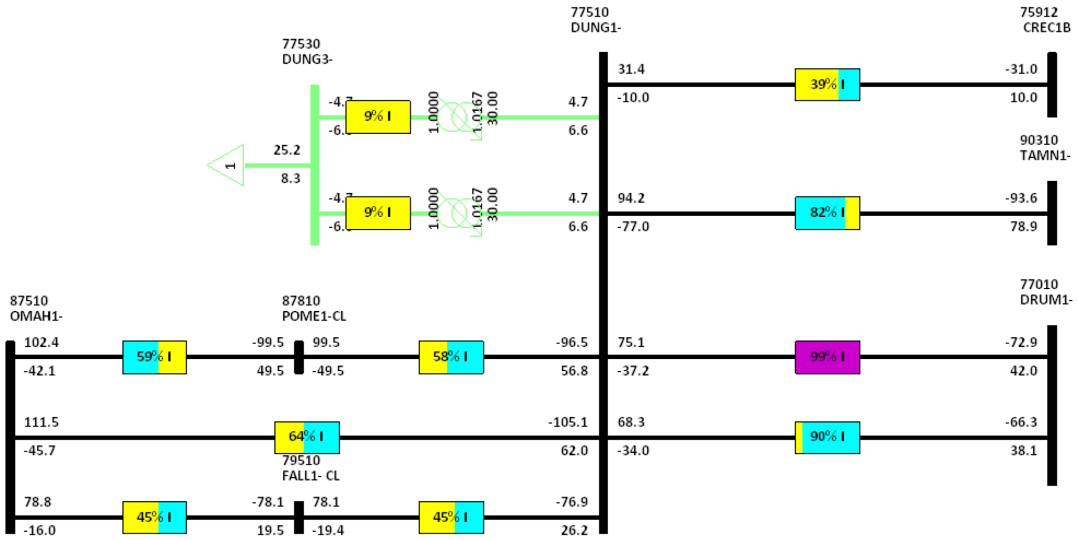
With only the third Omagh-Dunagnnon110kV circuit in place in 2016, the total amount of renewable generation that would be firm in the North West region is **424MW**. The power flow diagrams in section 4.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuits between Dungannon and Drumnakelly and Coleraine and Kells are overloaded beyond **424MW** of renewable generation in the North-West.

6.3 POWER FLOWS ON 110kV CIRCUITS

6.3.1 COLERAINE - KELLS CORRIDOR

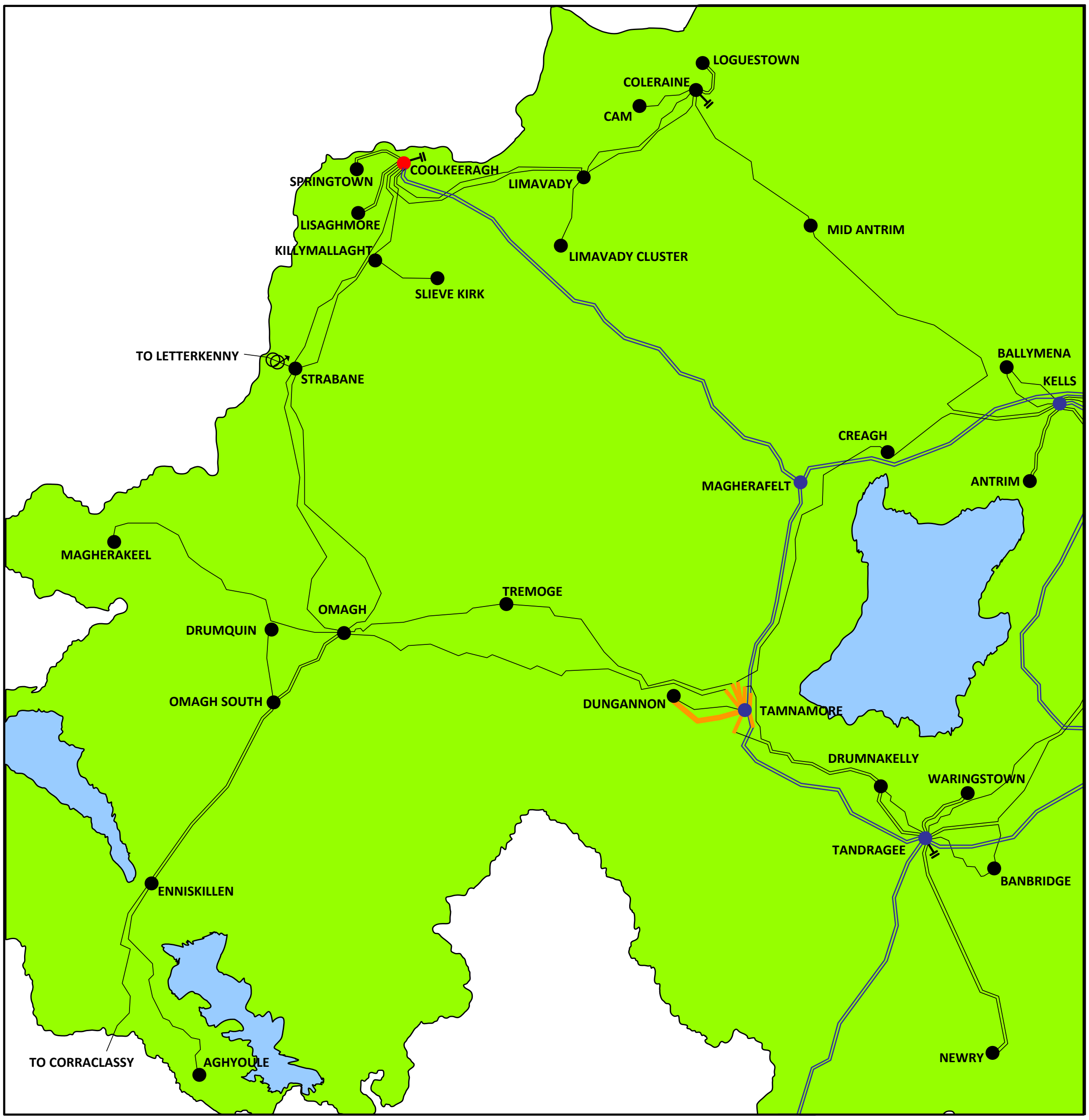


6.3.2 OMAGH - DUNGANNON CORRIDOR



7 FAQ- TAMNAMORE PHASE 2 ONLY

7.1 MAP

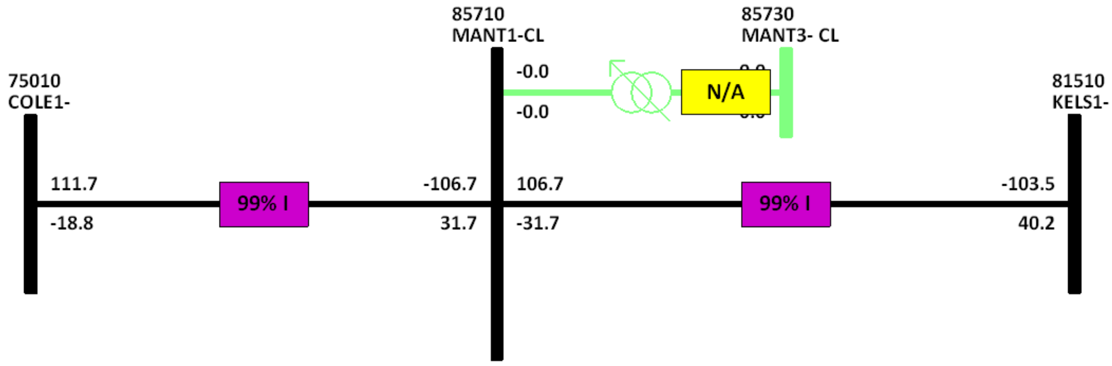


7.2 FIRM GENERATION

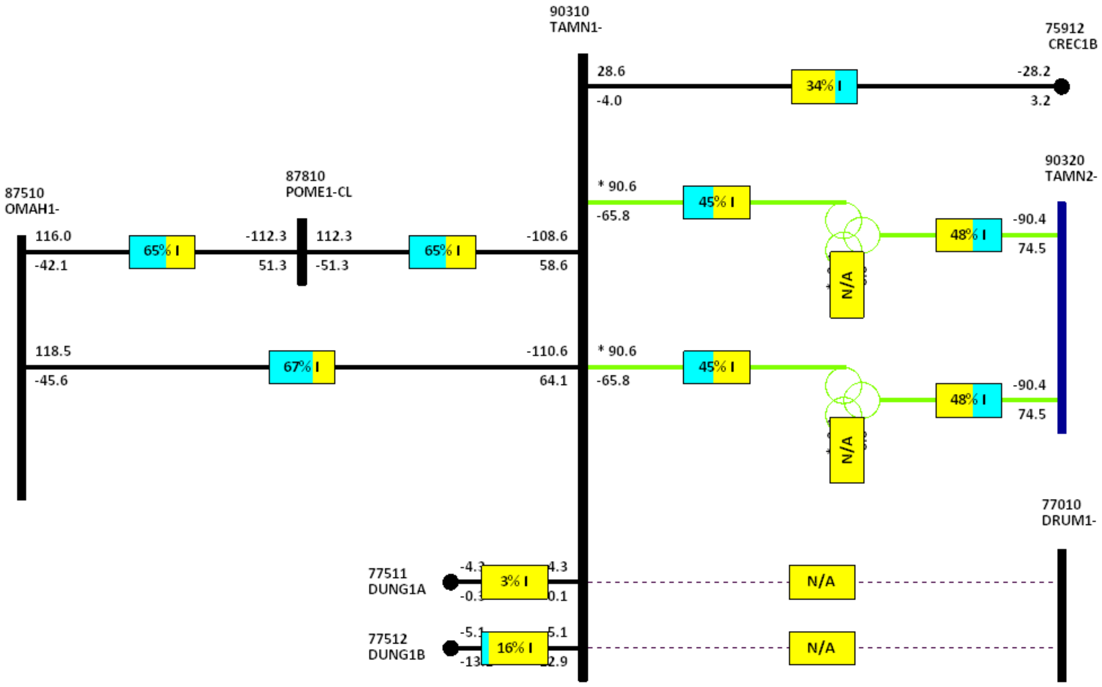
With only Tamnamore Phase 2 completed in 2016, the total amount of renewable generation that would be firm in the North West region is **370MW**. The proposed configuration of Tamnamore Phase 2 includes running the two 110kV ciruits to Drumnakelly normally open. If these were closed, the total amount of firm renewable generation in the North West region is **403MW**. Power flows for both these scenarios are displayed in sections 5.3 and 5.4 respectively.

7.3 POWER FLOWS ON 110kV CIRCUITS WITH DRUMNAKELLY CIRCUITS OPEN

7.3.1 COLERAINE - KELLS CORRIDOR

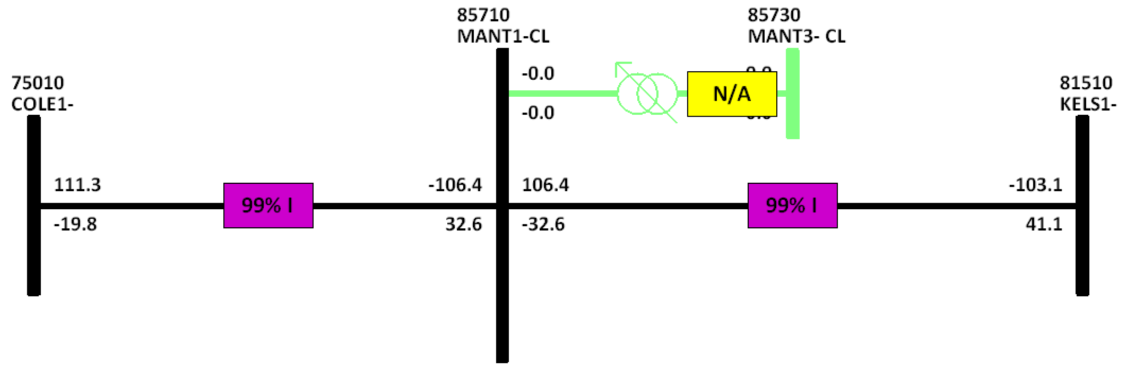


7.3.2 OMAGH - TAMNAMORE CORRIDOR

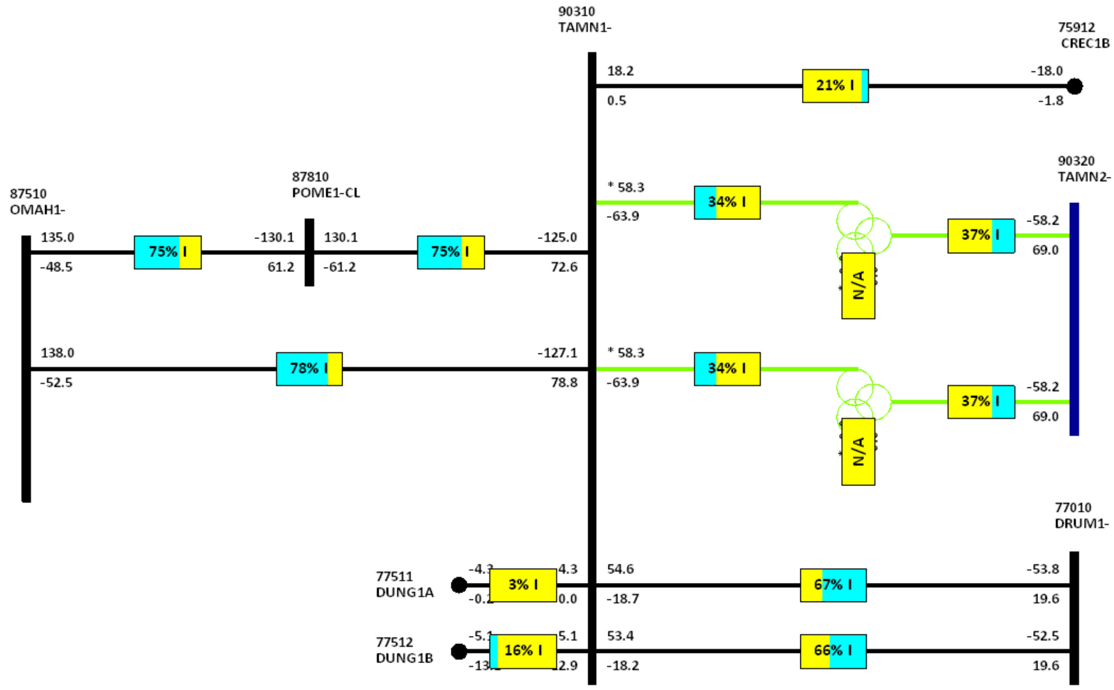


7.4 POWER FLOWS ON 110kV CIRCUITS WITH DRUMNAKELLY CIRCUITS CLOSED

7.4.1 COLERAINE - KELLS CORRIDOR

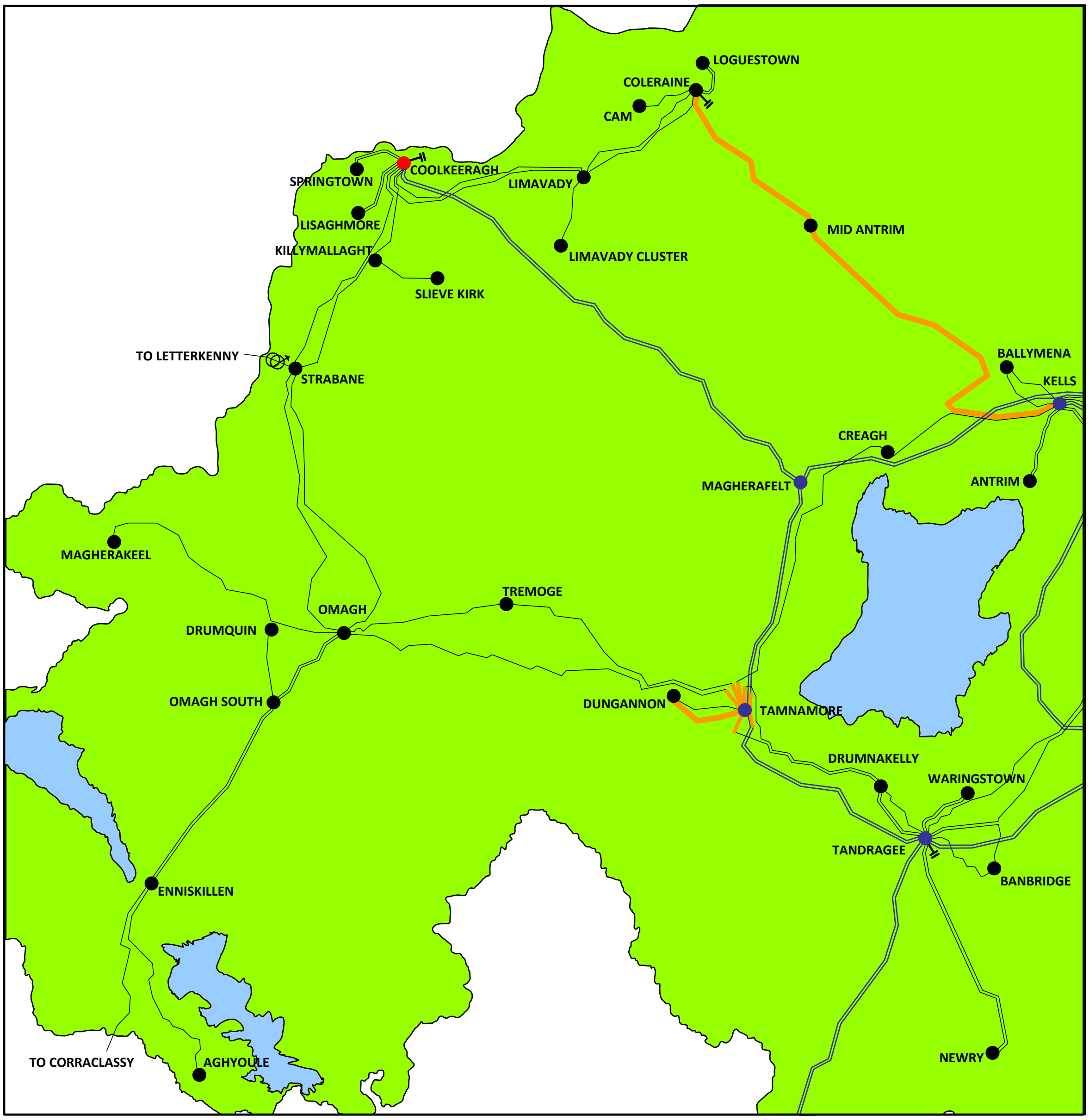


7.4.2 OMAGH - TAMNAMORE CORRIDOR



8 FAQ- TAMNAMORE PHASE 2 AND KELLS-COLERAINE UPRATE

8.1 MAP

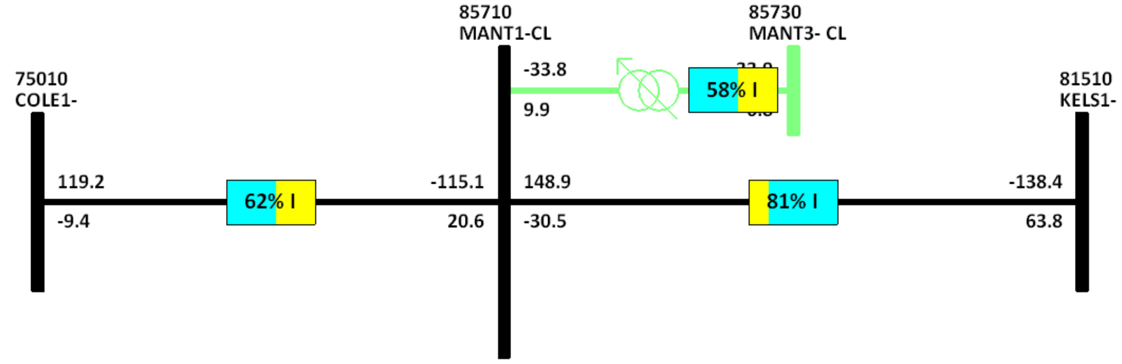


8.2 FIRM GENERATION

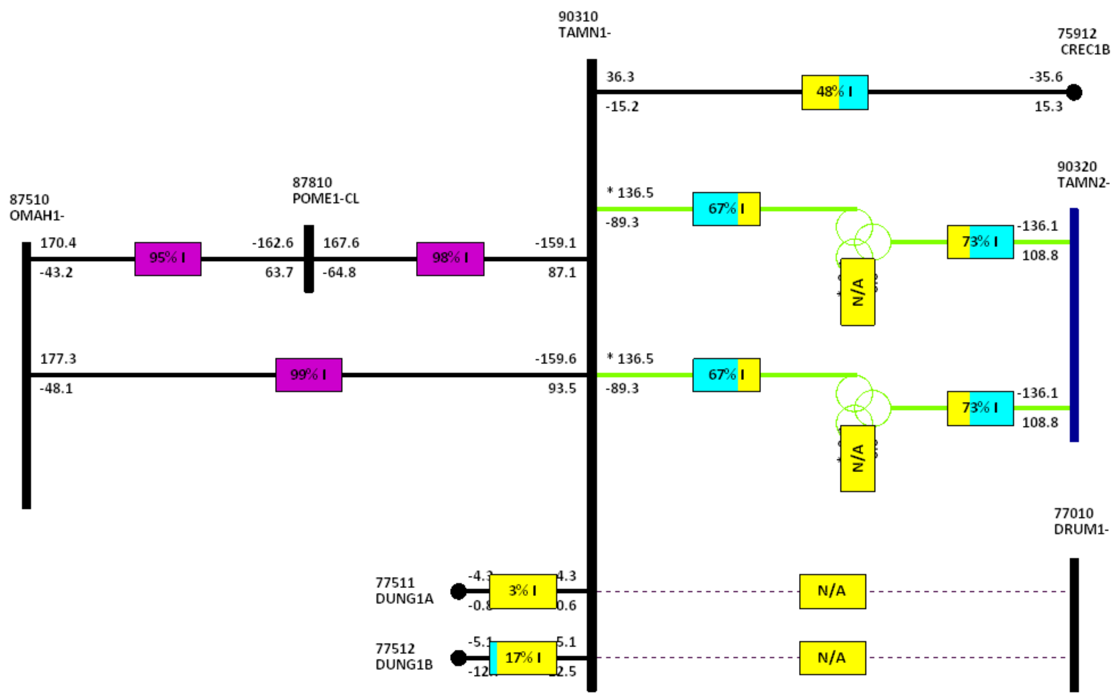
With Tamnamore Phase 2 and the Coleraine-Kells 110kV circuit uprate in place in 2016, the total amount of renewable generation that would be firm in the North West region is **530MW**. The power flow diagrams in section 6.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuits between Omagh and Tamnamore are overloaded beyond **530MW** of renewable generation in the North-West.

8.3 POWER FLOWS ON 110kV CIRCUITS

8.3.1 COLERAINE - KELLS CORRIDOR

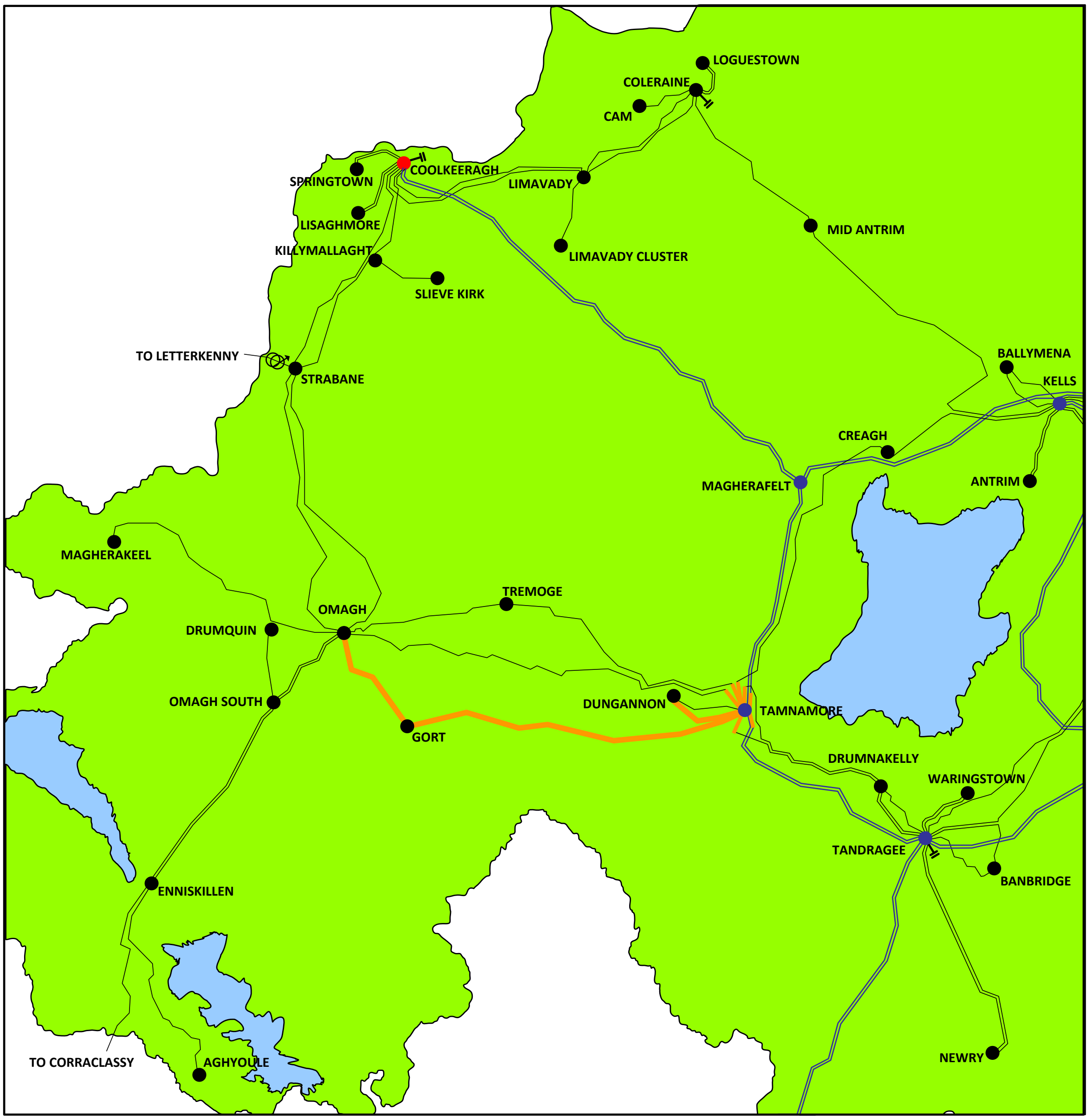


8.3.2 OMAGH - TAMNAMORE CORRIDOR



9 FAQ- TAMNAMORE PHASE 2 AND OMAGH-TAMNAMORE THIRD CIRCUIT

9.1 MAP

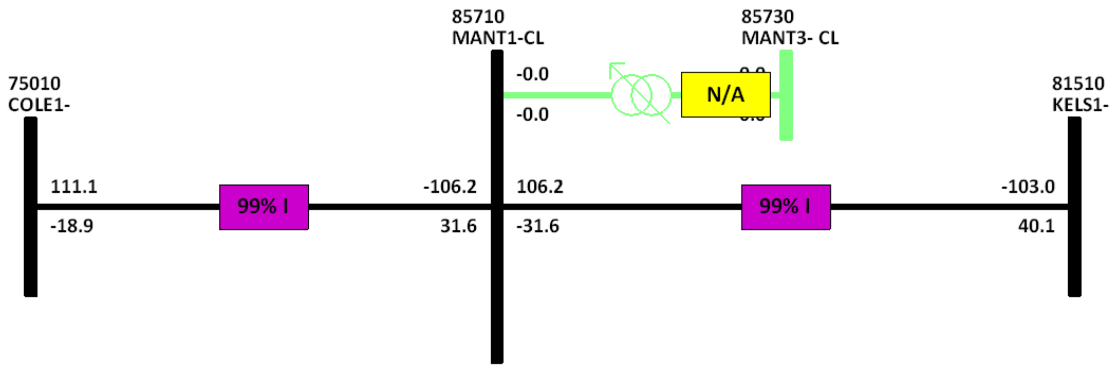


9.2 FIRM GENERATION

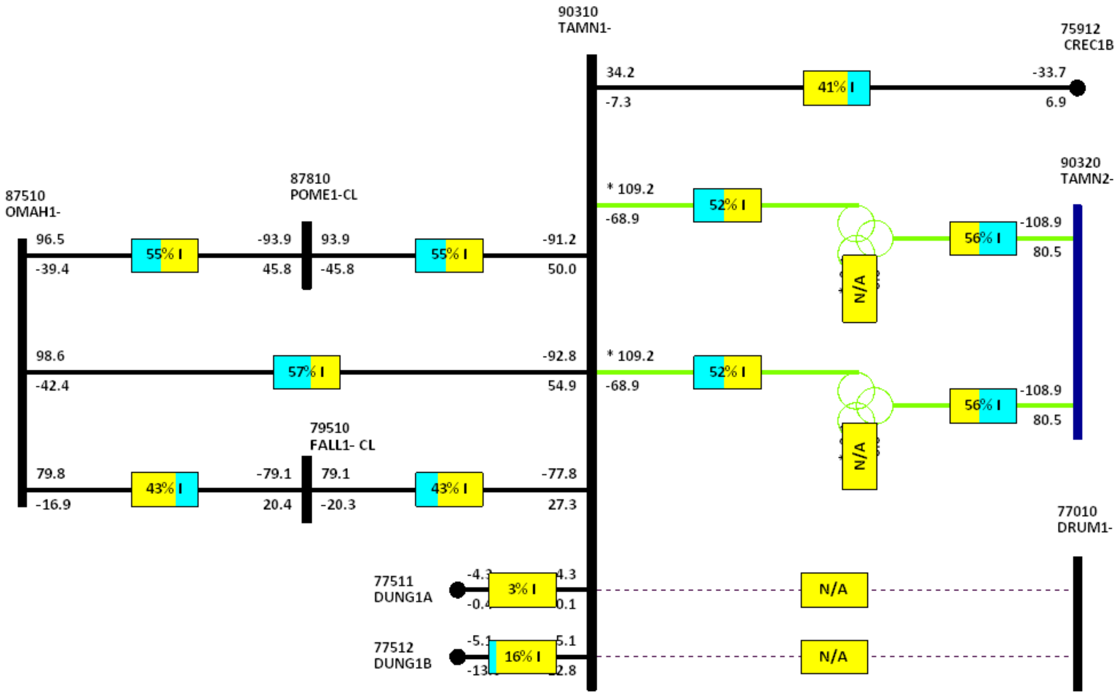
With Tamnamore Phase 2 and the third Omagh-Tamnamore 110kV circuit complete in 2016, the total amount of renewable generation that would be firm in the North West region is **406MW**. The proposed configuration of Tamnamore Phase 2 includes running the two 110kV ciruits to Drumnakelly normally open. If these were closed, the total amount of firm renewable generation in the North West region is **458MW**. Power flows for both these scenarios are displayed in sections 7.3 and 7.4 respectively.

9.3 POWER FLOWS ON 110kV CIRCUITS WITH DRUMNAKELLY CIRCUITS OPEN

9.3.1 COLERAINE - KELLS CORRIDOR

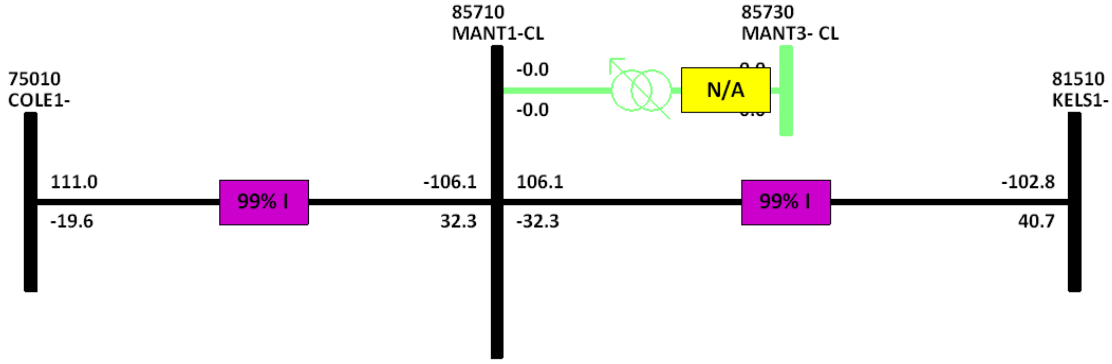


9.3.2 OMAGH - TAMNAMORE CORRIDOR

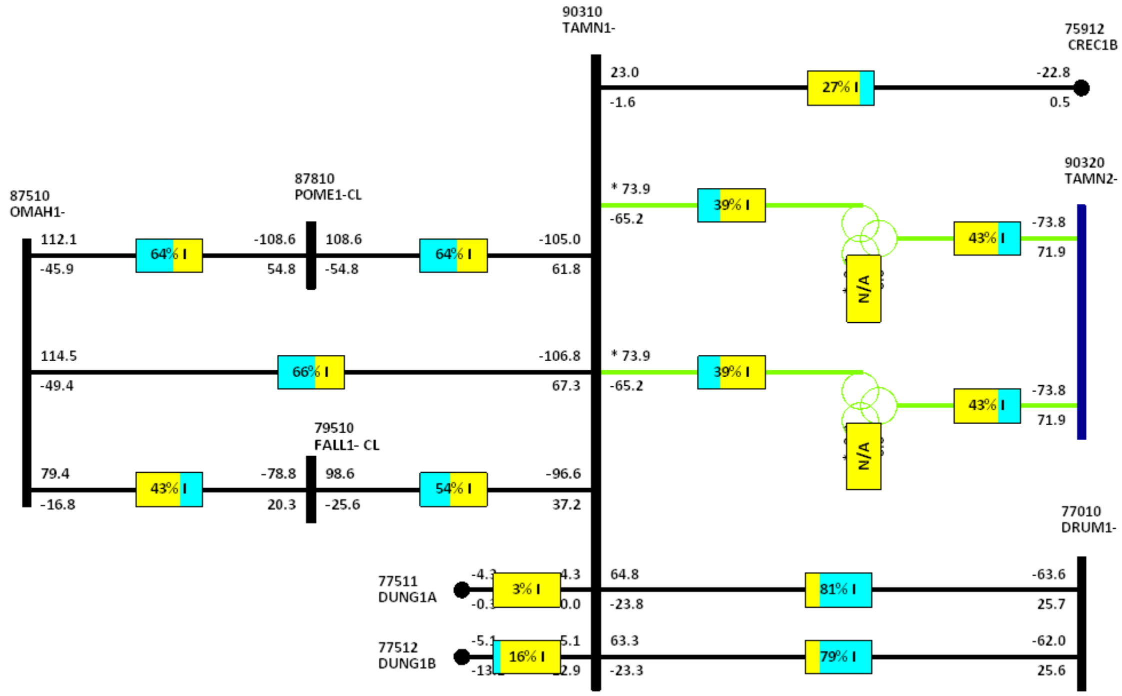


9.4 POWER FLOWS ON 110kV CIRCUITS WITH DRUMNAKELLY CIRCUITS CLOSED

9.4.1 COLERAINE - KELLS CORRIDOR

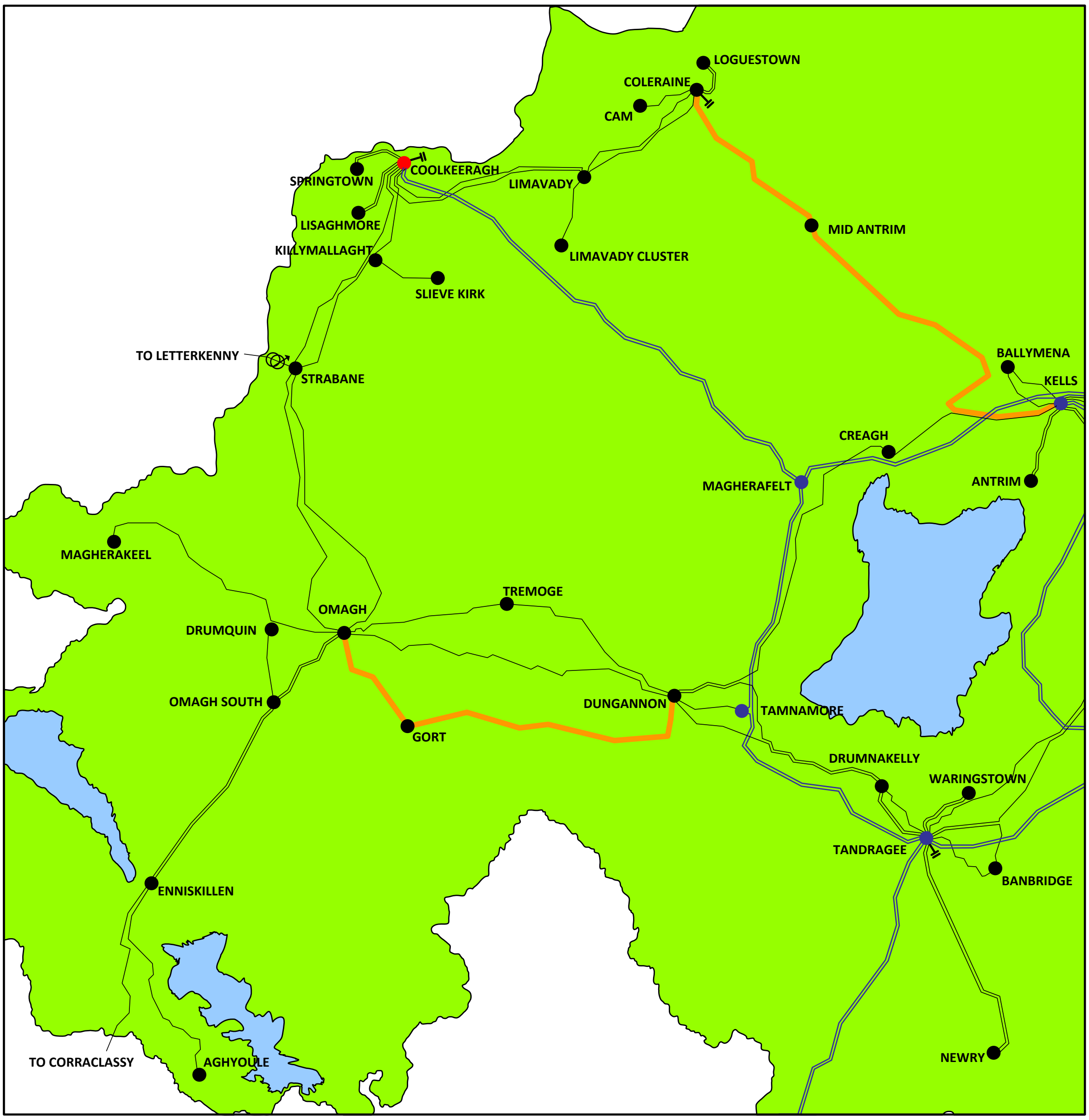


9.4.2 OMAGH - TAMNAMORE CORRIDOR



10 FAQ- KELLS-COLERAINE UPRATE AND OMAGH-DUNGANNON THIRD CIRCUIT

10.1 MAP

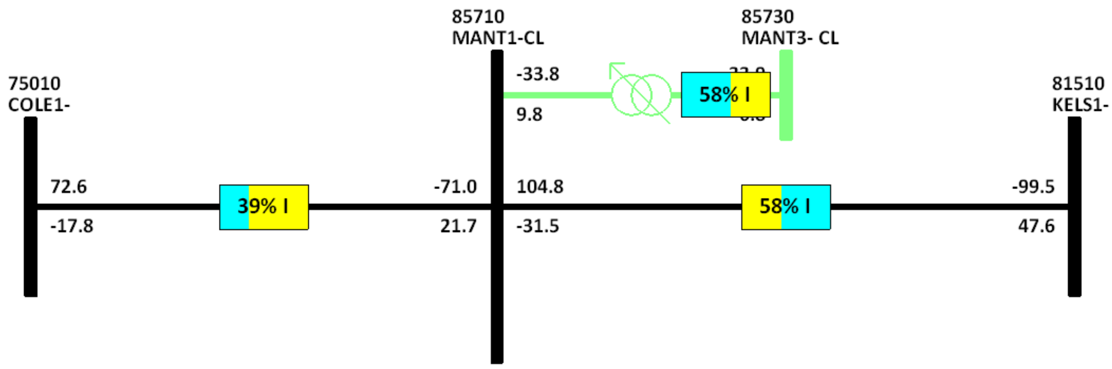


10.2 FIRM GENERATION

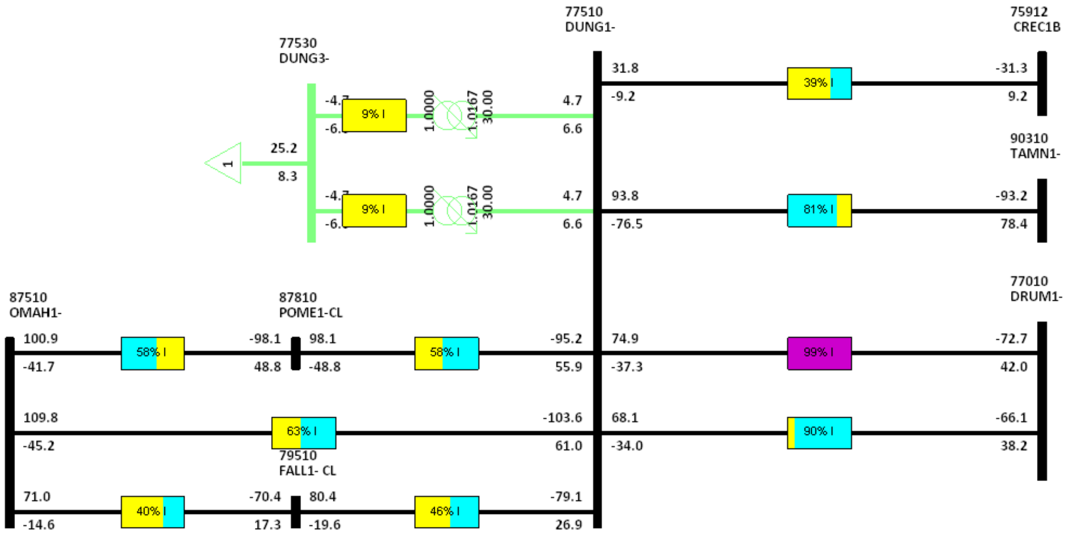
With the third Omagh-Dunagnnon 110kV circuit and the Kells-Coleraine uprate in place in 2016, the total amount of renewable generation that would be firm in the North West region is **477MW**. The power flow diagrams in section 8.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuits between Dungannon and Drumnakelly are overloaded beyond **477MW** of renewable generation in the North-West.

10.3 POWER FLOWS ON 110kV CIRCUITS

10.3.1 COLERAINE - KELLS CORRIDOR

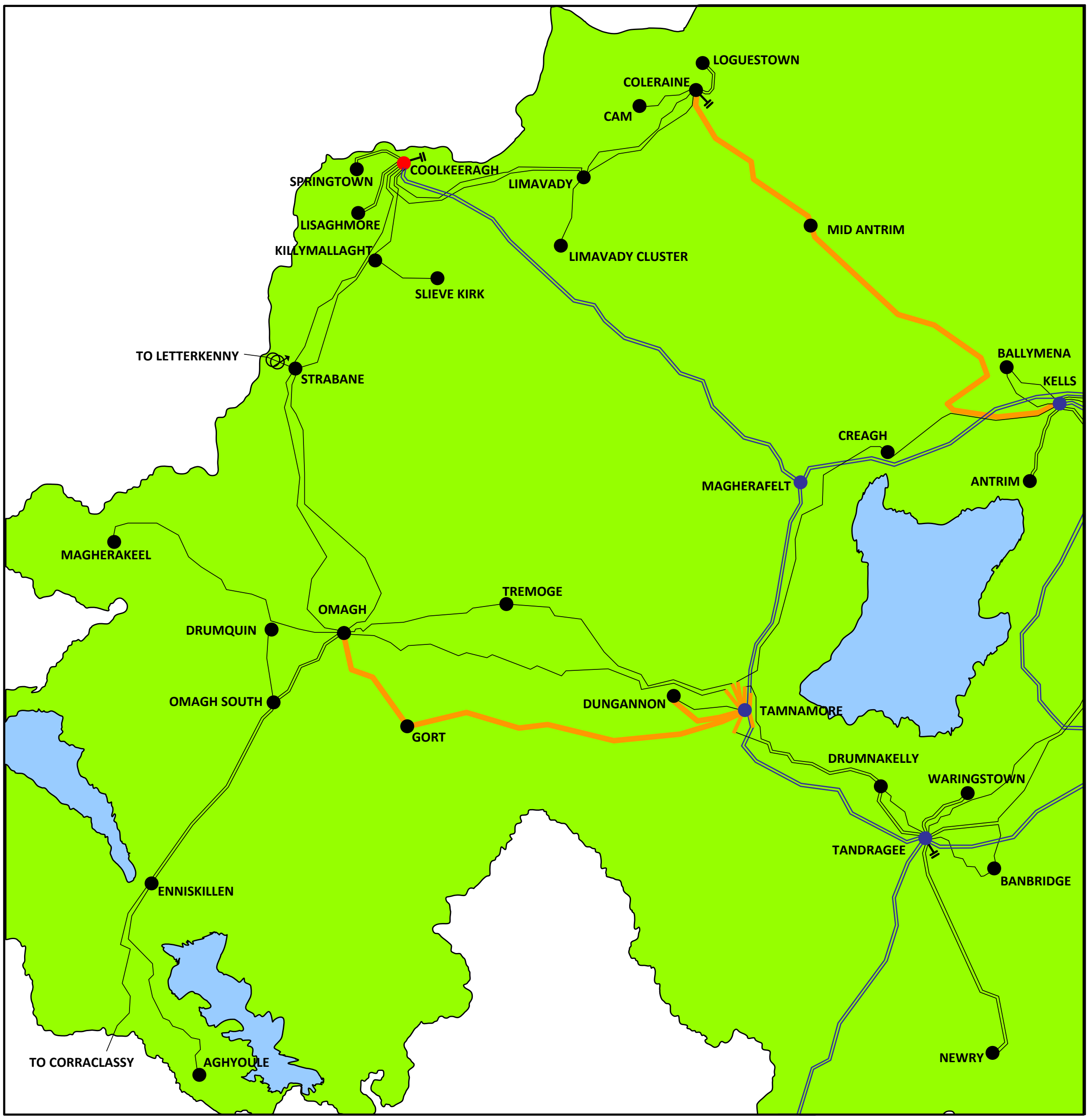


10.3.2 OMAGH - DUNGANNON CORRIDOR



11 FAQ- ALL PROJECTS COMPLETE

11.1 MAP

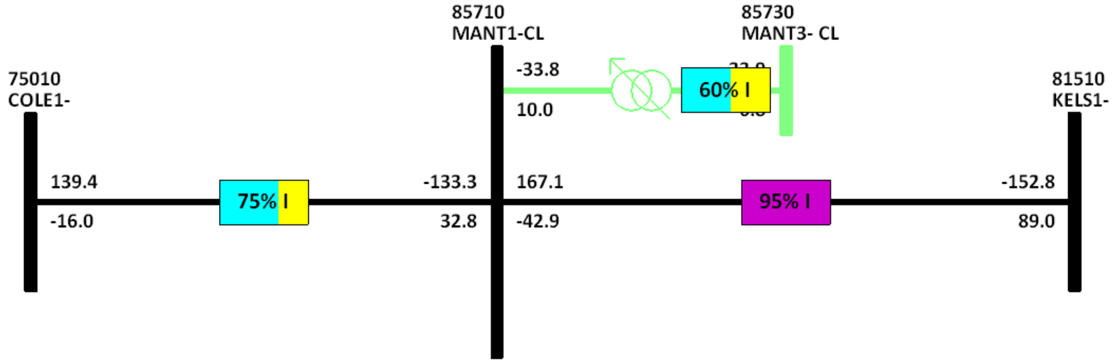


11.2 FIRM GENERATION

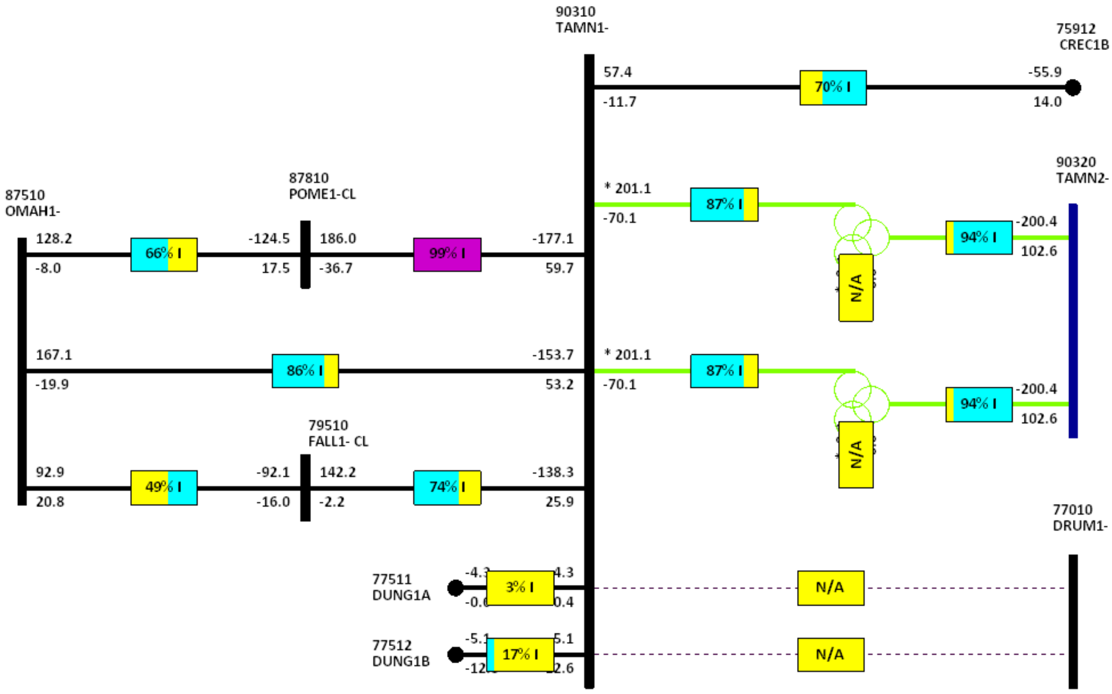
With all reinforcements in place in 2016, the total amount of renewable generation that would be firm in the North West region is **701MW**. The power flow diagrams in section 9.3 indicate that for the loss of the Coolkeeragh-Magherafelt 275kV double circuit, and subsequent run-back of Coolkeeragh CCGT to 160MW, the 110kV circuit between Tremoge cluster and Tamnamore is overloaded beyond **701MW** of renewable generation in the North-West.

11.3 POWER FLOWS ON 110kV CIRCUITS

11.3.1 COLERAINE - KELLS CORRIDOR



11.3.2 OMAGH - TAMNAMORE CORRIDOR



12 REDUCTION OF FAQ RESULTS

REINFORCEMENT	1	2	3	4	5	6	7	8
KELLS - COLERAINE								
OMAGH - TAMNAMORE 3								
TAMNAMORE PHASE 2								
NORTH WEST FAQ (MW)	383	443	424	403	530	458	477	701

Table 12.1: Summary of FAQ Results

There is presently some **430MW** of renewable generation connected in the North West region. Presently, there is not enough transmission capacity to allow all of this generation to be physically firm, as can be seen from column 1 above. There is presently planning approval for in excess of a further **500MW** of renewable generation in the North West region, i.e. leading to a total of over **930MW** in the area.

Columns 2 - 4 show the impact on FAQ in the North West if just one of the three reinforcement projects was approved and completed by 2016. In all cases, the increase on the current FAQ is marginal, and wholly inadequate when considering the proposed new generation.

Columns 5 - 7 show the impact on FAQ if a combination of two of the three reinforcements were completed by 2016. Of the three options, the one with the greatest impact is a combination of Kells-Coleraine uprate and Tamnamore Phase 2, giving an increase in FAQ of 150 MW. This options removes the present constraints on the Kells-Coleraine and Dungannon-Drumnakelly corridors, however, the recently uprated circuits between Omagh and Dungannon quickly become fully loaded as a result.

Column 8 shows that the completion of all three projects allows a significant increase on the FAQ of the North West area of some 320 MW, an impact far in excess of that of any combination of one or two of the reinforcements.

From these results, it has been decided to perform constraint/curtailment analysis for 2016 on the following:

- If no reinforcements were included
- The best performing single reinforcement (Kells-Coleraine uprate)
- The best performing pair of reinforcements (Kells-Coleraine and Tamnamore Phase 2)
- All reinforcements included

13 CONSTRAINTS

Constraints analysis has been performed using the same methodology as described in the recent SONI Generator Connection Process consultation. The critical contingency in the North-West region is the loss of the Coolkeeragh-Magherafelt 275kV double circuit. The analysis looks for the amount of pre-fault constraints that have to occur to prevent overloads on the transmission system in the event of the double circuit loss. Every hour of the year has been analysed, and each MW of energy constrained in the North-West region has been assigned a cost based on the corresponding SMP for that hour (taken from a 2010 SMP profile). The costs are then summated to provide a yearly total. Three different wind profiles have been used, and an averaged annual constraint cost based on the three different profiles is calculated. The results are presented below.

13.1 NO REINFORCEMENTS

YEAR	ANNUAL CONSTRAINTS COSTS			
	2008 WIND PROFILE	2009 WIND PROFILE	2010 WIND PROFILE	AVERAGE
2016	£13,431,651	£7,157,509	£9,999,896	**£10,196,352**

Table 13.1: Constraints Costs- No Reinforcements

13.2 COLERAINE - KELLS UPRATE

YEAR	ANNUAL CONSTRAINTS COSTS			
	2008 WIND PROFILE	2009 WIND PROFILE	2010 WIND PROFILE	AVERAGE
2016	£11,343,614	£6,498,771	£6,601,798	**£8,148,061**

Table 13.2: Constraints Costs- One Reinforcement

13.3 COLERAINE - KELLS UPRATE AND TAMNAMORE PHASE 2

YEAR	ANNUAL CONSTRAINTS COSTS			
	2008 WIND PROFILE	2009 WIND PROFILE	2010 WIND PROFILE	AVERAGE
2016	£7,704,581	£3,805,337	£4,582,725	**£5,346,214**

Table 13.3: Constraints Costs- Two Reinforcements

13.4 ALL REINFORCEMENTS

YEAR	ANNUAL CONSTRAINTS COSTS			
	2008 WIND PROFILE	2009 WIND PROFILE	2010 WIND PROFILE	AVERAGE
2016	£730,441	£96,442	£206,129	**£344,337**

Table 13.4: Constraints Costs- All Reinforcements

13.5 NOTES

- As requested, only constraints costs have been calculated. The impact of curtailment on constraints costs has **not** been included in the analysis. Therefore the impacts of:
    - The dispatch of the Moyle interconnector,
    - The requirement to have 3 conventional machines dispatched at all times in NI,
    - The limits on North-South transfer,
    - The 50% all-island SNSP limits,

  have not been taken into account. The study was carried out purely to check the impact on constraints in the North-West region of the Medium Term Plan projects.
- These studies do not include the cost benefits associated with the increased generation capacity, and the increased security of supply.
- The analysis has assumed that every MW of energy constrained receives a payment.
- The analysis has assumed that all 1000 MW of renewable generation has connected, regardless of what infrastructure has been delivered. Clearly if projects were not progressed, then it would not be viable for renewable generation to connect, and constraints costs would be lower; however, this would then impact on the ability to meet the government's 40% renewable energy target for 2020.
- The results have not been verified with a full all-island economic analysis using software such as PROMOD, however work is presently underway to develop a model in PROMOD to allow this type of analysis to be carried out.
- Coolkeeragh CCGT has been assumed as a must run unit- this is likely to be the case as it will be required for inertial support, voltage support and maintaining fault level in the region.
- The necessary dynamic reactive voltage support required to accommodate these levels of renewable generation is assumed to have been installed. However, it is recognised that wind farm power stations are not the sole driver for the installation for this voltage support.

14 SUMMARY OF RESULTS

The results suggest that all three projects should be progressed to accommodate the present levels of renewable generation that have received planning permission. The three projects together deliver in the region of 700 MW of firm capacity in the North-West region, with little constraints costs. The graph in figure 14.1 below compares the changes in FAQ and constraints costs of the four options studied:

- No reinforcements included (Option A)
- The single reinforcement the provides the greatest increase in FAQ (Option B)
- The two reinforcements that provide the greatest increase in FAQ (option C)
- All three reinforcements (option D)

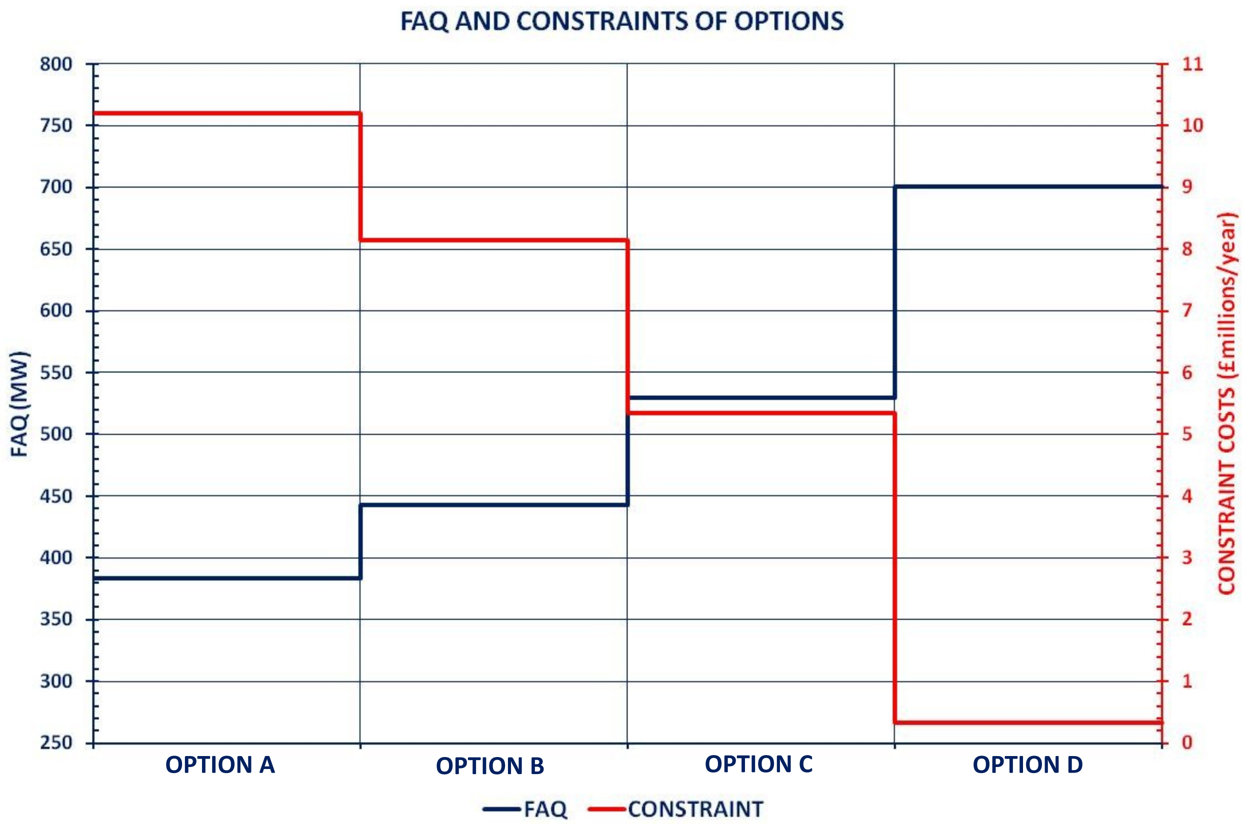


Figure 14.1: Comparison of FAQ and Constraints Costs

The graph reinforces, both from the FAQ analysis and the constraints analysis, that while individual projects on their own may deliver some benefit, all three projects need to occur if the proposed levels of renewable generation are to be accommodated.