Mid Antrim Upgrade

Needs Report

Date: June 2021

Version: Revision 01

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review Date
Rev 01	Needs Report	N. McClements, Engineer, Current Network	R. Smyth, Team Lead, Current Network	Arthur Moynihan, Manager, Current Network	June 2021

Contents:

Tables:

Figures:

Summary

With the connection of renewable generation in Northern Ireland and in particular in the North West region, there is a need for reinforcement of the 110 kV network between Kells and Rasharkin.

In 2015 the existing 110 kV single circuit from Kells to Coleraine was uprated with High temperature, low sag (HTLS) conductor (rated at 193 MVA) as part of the Medium Term Plan[1], which was designed to facilitate the connection of approximately 750 MW of renewable generation in Northern Ireland. These works were carried out in 3 stages and completed in 2016.

In 2016 Rasharkin Main 110/33 kV cluster substation was connected to the transmission network via the existing Kells – Coleraine 110 kV single circuit. In 2018, a new 110 kV circuit was constructed from Rasharkin to connect Brockaghboy windfarm (47.5 MW). NIE Networks have committed connection offers for the connection of renewable generation in the Garvagh area. This is to be connected to a new cluster substation (known as Agivey Cluster). This is to be connected by diverting the existing Rasharkin to Brockaghboy circuit into the new substation.

It has been identified that the existing Kells – Rasharkin 110 kV single circuit is at risk of a potential overload following an outage of the 275 kV double circuit from Coolkeeragh – Magherafelt and during times of high wind generation. This circuit is also at risk of potential overload following a local outage of the Coleraine – Rasharkin 110 kV single circuit.

This report sets out the case of need for reinforcing the 110 kV network between Kells and Rasharkin.

[1] https://www.uregni.gov.uk/files/uregni/media-files/MTP_FAQ_and_Constraints.pdf

1. Introduction

The development of renewables in Northern Ireland to comply with targets set out in the Strategic Energy Framework and supported by the Renewable Obligation Certificates has led to the connection of approximately 1600 MW of renewable generation in Northern Ireland (including small scale generation).

Renewable generation on the system at peak times can cause congestion on the transmission system. This has led to a number of circuits being at risk of overload for certain contingencies. The risk of overload is managed by restricting renewable generation output at peak times. However this establishes points of congestion on the transmission system.

These potential overloads and the associated congestion have been identified and provision was made within the Transmission Development Plan Northern Ireland 2020-2029 to address these issues.

The existing circuit between Kells and Rasharkin is heavily congested. Approval was obtained to restring this circuit with higher rated conductor, this was completed in 2016. Congestion remains on this circuit due to the level of renewables that have been installed to date. This is expected to increase in line with the continued connection of renewable generation in the North and West of Northern Ireland.

In addition the Agivey Cluster will have connected to the transmission system via Rasharkin by 2022, which will further increase congestion. The restriction of significant levels of wind generation on the system results in costs to the consumer and serves as a potential barrier to future energy targets.

A transmission project is required to address these challenges by strengthening the existing 110 kV network. This project will be the first of a number of steps towards removing congestion and lowering constraints in the North West, and is one component of the overall solution.

2. Description of the network

The transmission network, see Figure 1, is based on a strongly meshed 275 kV ring around Lough Neagh with a double circuit spur to Coolkeeragh. There is also an underlying 110 kV network which establishes a meshed ring around the north and west from the 275 kV backbone substations at Kells and Tamnamore.

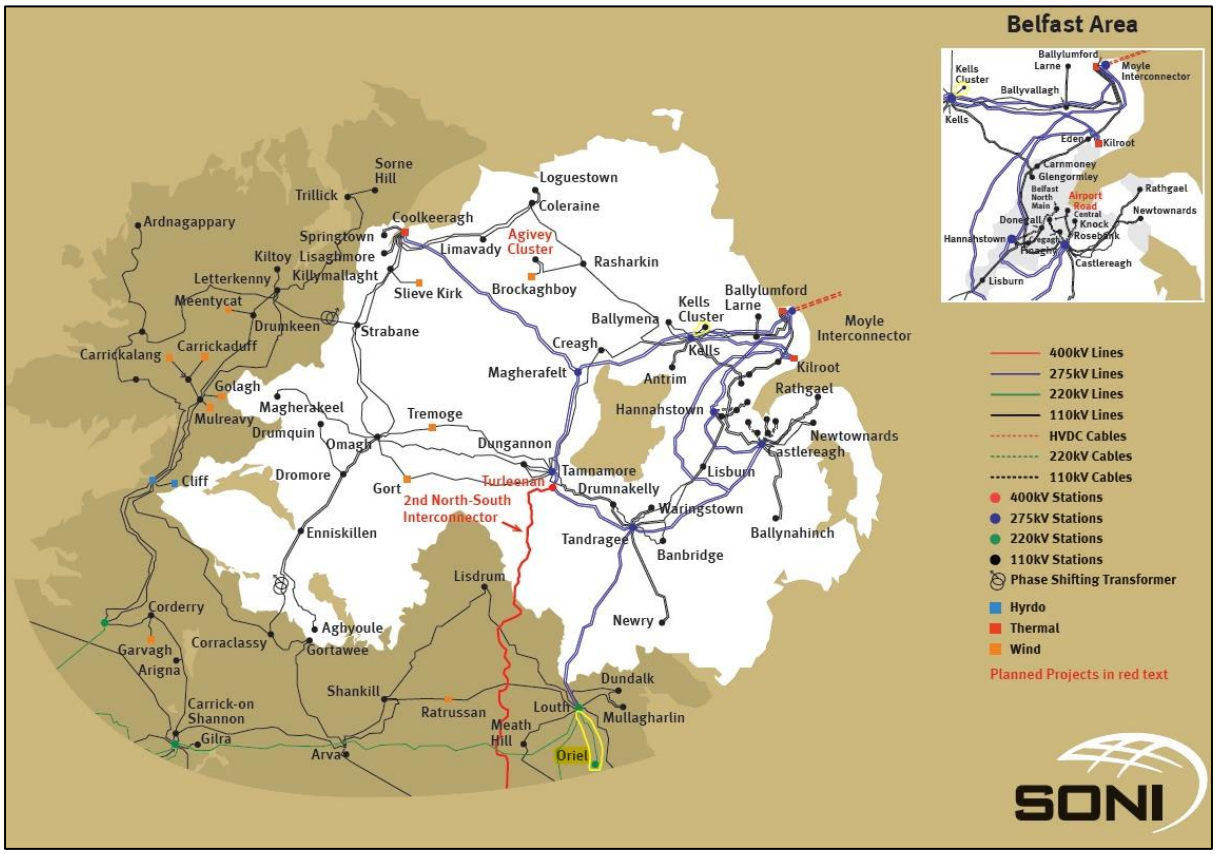

Figure 1: Existing Transmission Network

The majority of renewables has been connected in the North and West of Northern Ireland. This is passed onto the 110 kV system at bulk supply points and cluster substations and onto the 275 kV system at grid supply points.

3. General Network Issues at present

3.1. Medium Term Plan

The Medium Term Plan included for the development of a new circuit from Tamnamore to Omagh through Gort 110/33 kV cluster site, the extension of Tamnamore 275/110 kV substation and the uprate of the other Tamnamore – Omagh circuits and the Kells – Coleraine circuit with high temperature conductor. This work allowed approximately 750 MW of renewable generation to obtain firm access. In addition an assessment also showed that 1000 MW could be connected with acceptable constraints.

3.2. Present Position

The level of renewables connected is now approximately 1600 MW (including small scale generation) and this is causing constraints to become unsustainable.

The most onerous contingency affecting the power flow in Northern Ireland is the loss of the Coolkeeragh – Magherafelt 275 kV double circuit.

When this contingency occurs the remaining generation at Coolkeeragh Power Station and that connected to the 110 kV system in the North and West of Northern Ireland is transferred onto the 110 kV network. This power then flows through Omagh to Tamnamore and through Limavady, Coleraine, Rasharkin and onto Kells.

This combination of conventional generation and renewable generation at Coleraine, Limavady and Rasharkin leads to the potential for overloads on the existing Kells – Rasharkin 110 kV single circuit. With the connection of Brockaghboy Windfarm and the proposed Agivey cluster this risk of overload will increase further.

The Transmission System Security and Planning Standards require renewables output to be tested at the following outputs:

- Summer Valley - 70%
- Summer Peak - 80%
- Winter Peak - 90%

The loadings on the Kells – Rasharkin circuit for the loss of the Coolkeeragh – Magherafelt 275 kV double circuit and operation of the Coolkeeragh run back scheme are set out in Table 1. This includes the flows before and after operation of the Coolkeeragh run back scheme[2]. These circuit loadings were recorded for two case studies - 2025 and 2030. The dispatches for both case studies include renewable generation applicants that are progressing through the SONI connections process. For the 2030 case study the dispatches

[2] The SPS at Coolkeeragh power station operates when triggered by the loss of the double circuit outage or of both interbus transformers at Coolkeeragh substation. The scheme immediately causes a class 2 trip of the steam turbine followed by the run back of the associated gas turbine from pre-fault output to 160 MW.

are based on a pipeline of wind farms planned by NIRIG members (see Appendix 1, tables A1 and A2).

Case year	***Season***	***Before double circuit contingency***	***After double circuit contingency; Before completion of SPS operation***	***After double circuit contingency and SPS operation***
2025	Summer valley	71%	135%	121%
	Summer peak	81%	153%	134%
	Winter peak	83%	158%	139%
2030	Summer valley	97%	171%	157%
	Summer peak	113%	189%	176%
	Winter peak	116%	208%	192%

Table 1: Power flows on Kells - Rasharkin 110 kV circuit after outage of Coolkeeragh - Magherafelt double circuit

The above analysis shows that after operation of the run back scheme the Kells – Rasharkin circuit could be potentially overloaded. By 2030 with the addition of pipeline generation the level of overload could increase to 192% of the winter rating of the circuit.

In addition to the levels of congestion there are large voltage step changes occurring as a result of the double circuit contingency. The Transmission System Security and Planning Standards set out the limits for voltage step change following the loss of a double circuit overhead line. These limits allow for a 10% voltage fall and a 6% voltage rise. For the Coolkeeragh – Magherafelt double circuit contingency there are breaches of the 10% voltage fall limit in some of the 2025 and 2030 cases. The loadings on the Kells – Rasharkin and Rasharkin - Coleraine circuits for localised contingencies are set out in table 2.

Case year	***Season***	***Kells – Rasharkin circuit***		**Coleraine – Rasharkin circuit**	
		Before Coleraine – Rasharkin contingency	*After Coleraine – Rasharkin contingency*	*Before Kells – Rasharkin contingency*	*After Kells – Rasharkin contingency*
2025	Summer valley	71%	72%	3%	72%
	Summer peak	81%	89%	9%	88%
	Winter peak	83%	86%	8%	87%
2030	Summer valley	97%	109%	12%	108%
	Summer peak	113%	132%	19%	131%
	Winter peak	116%	154%	26%	134%

Table 2 – Power flows with the loss of the Kells – Rasharkin circuit and with the loss of the Coleraine – Rasharkin circuit

The above analysis shows that by 2030 with the additional pipeline generation added there will be issues when localised outages occur for both the Kells – Rasharkin and Coleraine – Rasharkin 110 kV single circuits.

3.3. Management of potential overload on Kells – Rasharkin circuit

The potential overload and actual congestion on the Kells – Rasharkin circuit is affected by all of the generation in the North and West of Northern Ireland. The risk of overload is managed by constraining generation using the Wind Dispatch Tool. In these studies the thermal generation at Coolkeeragh is dispatched at minimum generation output. During times of high wind generation the thermal generation at Coolkeeragh would be reduced to minimum generation first, followed by the constraining of wind generation via the Wind Dispatch Tool to manage the loadings of circuits. The windfarms that have the most impact on the existing Kells – Rasharkin circuit and which are constrained in the pre-fault condition to avoid an overload are those within Constraint Group 1, see Figure 2.

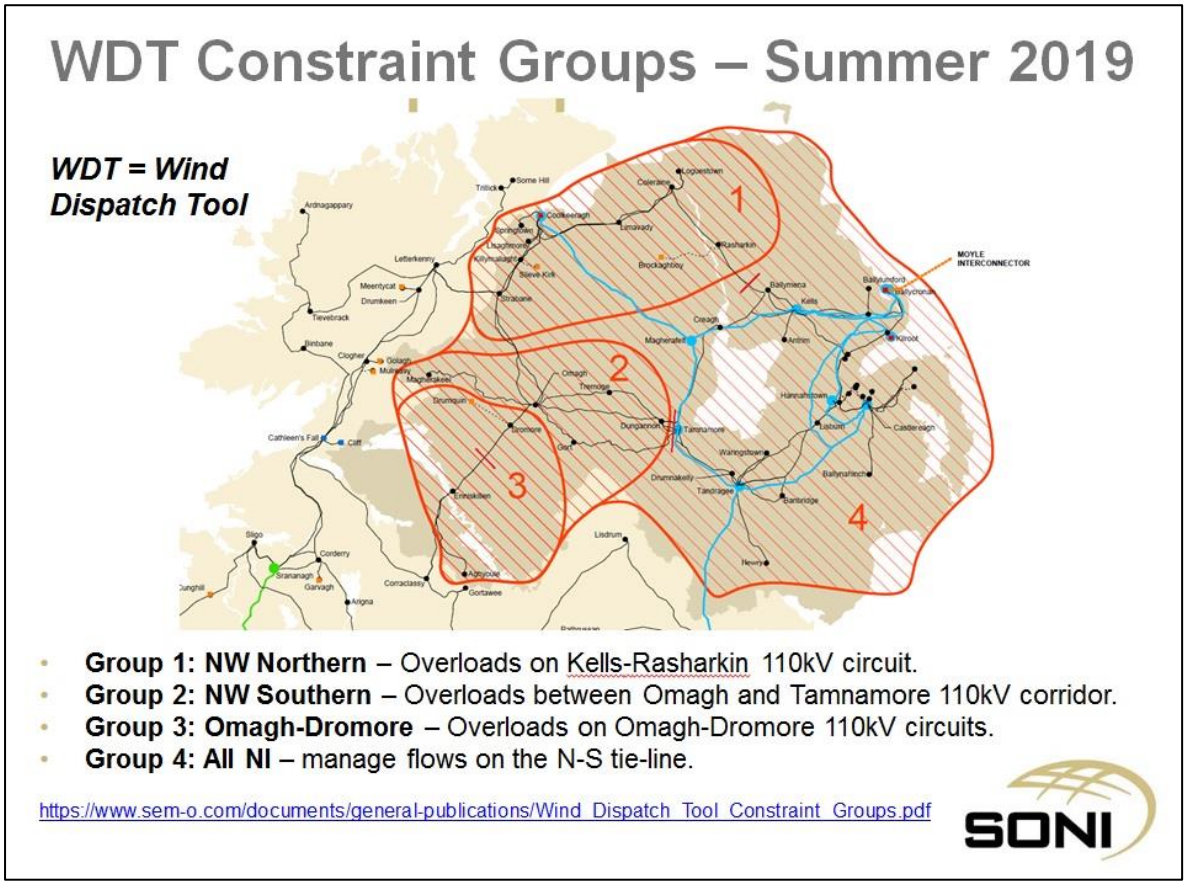

Figure 2: Wind Dispatch Tool Constraint Groups

3.4. Cost of constraint

The cost of constraint was estimated by determining the extent to which the Kells – Rasharkin circuit would be potentially overloaded on an hour by hour basis over the period of one year. Whist many of the wind farms in Constraint Group 1 would currently have a non-firm connection, for the purposes of this assessment they were assumed to be firm and would receive a constraint payment.

Table 3 below shows the number of Mega-watt hours which were constrained for both case files (2025 and 2030). Using the Average day ahead market price[3] of £45.7 per MW/hr an approximation of the constraints costs can be determined.

The additional pipeline of generation in 2030 shows a significant increase in the cost of constraining.

Case year	*Total MWhrs constrained*	*Approx. Constraint costs (£45.7 per MWhr)*
2025	46,590	£2,130k
2030	206,840	£9,450k

Table 3 - Cost of constraining generation locally to avoid potentially overloading the existing Kells - Rasharkin circuit

Note that the above would be assessed further in the justification of any reinforcement options. In addressing the reinforcement of the Kells – Rasharkin circuit it is expected that there will be other constraints. This will be considered in the appraisal of options.

3.5. Phase Angle Issue between Coolkeeragh and Magherafelt substations

Additional to the risk of overload on the 110 kV network, in particular the Kells – Rasharkin circuit, there is also a need to address angular stability associated with the loss of the Coolkeeragh – Magherafelt double circuit tower line.

If the double circuit trips during periods of high wind generation there is an angular difference between the voltage at Magherafelt and Coolkeeragh. This angular difference exceeds 20 Degrees under high wind generation conditions. As this is the setting on the check synchronism feature of the auto-reclose relays at Coolkeeragh and Magherafelt, this has the effect of blocking auto-reclose.

A double circuit tower line fault is a credible contingency although relatively rare. It is associated with ice accretion events, lightning and protection mal-operations. However both circuits can also become disconnected if a fault occurs during a programmed outage.

There are operational measures in place to minimise the risk of this event. During a pre-programmed outage a pre-fault constraint would be applied to ensure an excessive angular difference would not occur. Constraints would also be applied to prevent the angular difference from occurring in the event of ice accretion or lightning being forecasted. However it is difficult to forecast lightning with any accuracy. Finally the risk of a protection mal-operation is also difficult to rule out completely.

[3] Based on an Average Day Ahead Market Price (DAM) of €50.26/MWh – SEMOpx market summary for 2019

The solutions to address congestion on the Kells – Rasharkin circuit should also be assessed for their effectiveness to help in addressing this angular stability issue. This will help to improve the overall resilience of the transmission system during adverse weather.

3.6. Congestion on 33 kV network at Coleraine

Coleraine Main currently has 108 MW of large scale and 10 MW of small scale renewable generation. This exceeds the firm capacity, based on the rating of the 110/33kV transformers at the site of 60 MVA. This is managed by a special protection scheme which in the event of the loss of one transformer trips Dunbeg windfarm (42 MW).

NIE Networks also has capacity issues between Coleraine Main and Ballymoney West substation, which supplies Gruig (25 MW) and Garves (15MW) windfarms. NIE Networks has determined that there is a risk of overloading the Coleraine - Ballymoney West 33 kV circuits under high wind and single circuit conditions.

In order to relieve this congestion NIE Networks has proposed transferring Gruig windfarm from Coleraine Main to Rasharkin Main cluster. Garves windfarm was also identified as being transferrable (due to the routing of its cable circuit which is on the route to Rasharkin from Gruig windfarm).

From this analysis it was determined that for a loss of the Coolkeeragh – Magherafelt 275 kV double circuit and with the proposals in place at Rasharkin, overloads would be made worse on the existing Kells – Rasharkin circuit (the problem was moved from Coleraine to Rasharkin).

Also for the loss of the Kells – Rasharkin 110 kV single circuit it was identified that there would be overloads on the Coleraine – Rasharkin 110 kV single circuit and voltage steps in exceedance of 8% at Coleraine Main which would be a breach in planning standards.

In order to manage the identified 33 kV network congestion in the short term NIE Networks are considering the installation of a new special protection scheme on the 33kV system with the plan to transfer the two wind farms to Rasharkin when the congestion is addressed.

4. Conclusion

In conclusion there is a need to reinforce the existing Kells – Rasharkin 110 kV single circuit in order to manage the level of wind generation in the North West of Northern Ireland.

The loss of the double circuit between Coolkeeragh and Magherafelt will result in overloads on the local 110 kV network as power flows move from North West to the East (in the direction of Kells). This system reinforcement is needed now and in order to meet any future energy incentives such as a new Strategic Environmental Framework for 2030. With increased onshore generation in the North West region beyond what already exists, this overload increases significantly. This will result in a significant level of wind generation constraint and cost to the consumer.

It is considered prudent that system reinforcement is required to support the existing network between Kells and Rasharkin.

Appendices

APPENDIX 1

Assumptions for the 2025 and 2030 case studies

In June 2019 the Climate Change Act 2008 (2050 Target Amendment) 2019 came into effect which set a legally binding target to reduce greenhouse gas emissions (GHG) to net zero by 2050. It also required the UK government to implement system of Carbon budgeting and form a Committee on Climate Change (CCC). This revision demonstrates the UK's commitment to targeting the highest possible ambition.

The current government targets for 2030 for Renewable Energy Share in electricity demand are set out below:

- UK – 75%
- Scotland – 100%
- Wales – 70%
- Ireland – 70%

The Department for Economy are expected to develop a new Energy Strategy up to 2030.

In 2019 SONI consulted on Tomorrow's Energy Scenarios NI. Tomorrow's Energy Scenarios were developed in order to gain a perspective of the long term needs of the transmission system and to inform the energy and climate policy debate focusing on the electricity system. The scenarios ranged as follows:

1. Least Effort – 50% of electricity demand from renewable energy sources by 2030, 35% reduction in CO_2 emissions.
2. Modest Progress – 60% of electricity demand from renewables by 2030, 40% reduction in CO_2 emissions.
3. Addressing Climate Change – 70% of electricity demand from renewables by 2030, 45% reduction in CO_2 emissions.

Following the consultation, SONI would publish the Scenarios and develop the System Needs Assessment. At this point the Least Effort scenario has been removed by SONI.

In developing the dispatch and grid models for the scenarios, SONI received information on where any additional renewable generation would likely be placed from NIRIG (Northern Ireland Renewable Industry Group). This provided a 'pipeline' of generation which has been translated to create study cases for 2025 and 2030. These cases have been used in confirming the need for reinforcement of the existing Kells – Rasharkin 110 kV circuit.

The pipeline generation for each council is set out in Table A1 below. A number of windfarm extensions[4] and connections that are already in progress[5] are displayed in table A2 below.

[4] Windfarm extensions were provided by NIRIG to accompany the 'pipeline' of generation. The two windfarms are transmission connected: Slieve Kirk WF and Brockaghboy WF.
[5] This means they are currently within the connections process. Some of these windfarms have accepted their offers or have been issued offers from SONI.

The planned wind farm at Doraville has been the focus of a Planning Appeals Commission (PAC) inquiry. This windfarm was included in the pipeline provided by NIRIG. The outcome of the Doraville windfarm public enquiry was determined in late 2020. This windfarm did not receive approval from the PAC.

Council	Substation	Allocation of Pipeline (MW)
Fermanagh and Omagh	Omagh Main	58
	Tremoge Cluster	58
Derry City and Strabane	Strabane Main	49
	Killymallaght Main	38.5
Causeway Coast and Glens	Limavady Main	8.3
	Coleraine Main	30
	Loguestown Main	5
	Rasharkin Cluster	40
	Agivey Cluster	60
Mid and East Antrim	Kells Cluster	8
Antrim and Newtownabbey	Antrim Main	16
	Total:	**370.8**

Table A1 - Pipeline of renewable generation (Source: NIRIG)

Substation	Windfarm	MEC (MW)
Rasharkin cluster	Brockaghboy WF extension	5
Coolkeeragh GSP	Aught WF	37
Drumquin Cluster	Dooish WF	42
	Pigeon Top WF	51.9
Gort Cluster	Murley Mountain	22.5
Magherafelt GSP	Doraville WF	118
Killymallaght Main	Slieve Kirk extension	11.5
	Total:	**287.9**

Table A2 - Pipeline of renewable generation - windfarm extensions (Source: NIRIG) and progressing SONI connection applicants

APPENDIX 2

2025 case file

For the 2025 case file the following assumptions for additional renewable generation were included:

- Agivey Cluster – connected with 87.9 MW
- Kells Cluster – connected with 68 MW[6]
- Pigeon Top – transmission connected to Drumquin cluster with 51.9 MW
- Dooish windfarm – transmission connected to Drumquin cluster with 42 MW
- Murley Mountain windfarm – distribution connected into Gort cluster with 22.5 MW.
- Aught windfarm – transmission connected into Coolkeeragh with 37 MW.

2030 case file

For the 2030 case file the following assumptions for additional renewable generation were included:

- Generation included in the 2025 case file
- Windfarm extensions – Brockaghboy (5 MW) and Slieve Kirk (11.5 MW)
- Doraville windfarm[7] – transmission connected into Magherafelt GSP with 118 MW
- Pipeline generation provided by NIRIG (see table 1), which totals 370.8 MW.

The 2030 case file is more onerous with a greater level of renewable generation added. In order to achieve government targets it is expected that this level of renewable generation will be required. To allow for the pipeline generation to be added, each cluster will have a second 90 MVA transformer installed. A second transformer at Agivey and Rasharkin clusters will add to the local overload issue experienced by the existing Kells – Rasharkin 110 kV circuit.

[6] Figure at the time studies were completed. Since then, according to NIE Networks latest cluster update (February 2020), the committed generation for Kells cluster has decreased to 43.1 MW. There are additional generators currently in the queuing process seeking a connection to Kells cluster. Kells cluster does not affect the flow between Rasharkin and Kells substation.

[7] At the time studies were completed, Doraville windfarm was engaged in a public enquiry to determine its planning permission. In late 2020 the Planning Authorities Commission appeal was rejected and this windfarm did not receive planning permission. Doraville windfarm does not significantly affect the flow between Rasharkin and Kells as its proposed grid connection point was Magherafelt GSP which only has connections at the 275 kV voltage level.