# Drumnakelly – Tamnamore 110 kV restring

## Preliminary Preferred Options Report

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# Contents:



## Figures:

## Tables:

# Summary

A Needs Report has been prepared to highlight the risks of overload on a number of 110 kV circuits across Northern Ireland. The two 110 kV circuits from Drumnakelly to Tamnamore substations are included, with overloads expected to occur for significant periods (of their operational hours) as a result of the connection of renewable generation in the west of Northern Ireland.

This report presents SONI's preliminary preferred option which will be used in a Transmission Network Pre-Construction Project (TNPP) submission to the Utility Regulator.

A number of options were identified to reinforce the existing Drumnakelly – Tamnamore circuits. Shortlisted options will be compared according to a multi-criteria assessment including cost, feasibility, environmental impact, timeframe and technical constraints.

These include:

- Option 1: Do nothing;
- Option 2: Restringing of existing 110 kV circuits from Drumnakelly to Tamnamore with a higher capacity conductor
    - 2a) restring to 200 MVA, underground the 'A' circuit around Killyman village to 200 MVA;
    - 2b): restring to 250 MVA, underground the 'A' circuit around Killyman village to 200 MVA;
    - 2c): restring to 250 MVA, underground the 'A' circuit around Killyman village and change all cables to 250 MVA;
    - 2d): restring to 200 MVA, construct a new 110 kV overhead line section to bypass around Killyman village on the 'A' circuit;
- Option 3: Construction of a new 110 kV portal (twin wood pole) circuit from Drumnakelly to Tamnamore and associated substation extension works; and
- Option 4: Installation of a third interbus transformer at Tamnamore substation and associated substation extension works;

The options were appraised using cases based on the Tomorrow's Energy Scenarios, NI (TESNI) and Shaping Our Electricity Future (SOEF) analysis[1]. This analysis uses the 2030 case which represents a more onerous, challenging system with additional generation following the 70% renewable energy target as set by the new Northern Ireland Energy Strategy 2021 and the 80% renewable energy target as set by the Climate Change Act (Northern Ireland) 2022. Wind farm constraint modelling was carried out using these cases to assess the level of constraint each option would incur for each renewables target (options were compared at 70% and 80% renewables). Using the forecast figure of

[1] The need to uprate both of the existing Drumnakelly – Tamnamore 110 kV circuits was identified in Shaping Our Electricity Future Version 1.0 as a candidate reinforcement for 2030 - Shaping_Our_Electricity_Future_Roadmap.pdf (soni.ltd.uk). In Version 1.1 this work was identified as a base case reinforcement - Shaping Our Electricity Future Roadmap: Version 1.1 (soni.ltd.uk).

£76.21/MWh[2] for the average market value of electricity in NI in 2030 it was possible to quantify this constraint financially.

As determined in the associated Needs report, Option 1 – do nothing will result in potential overloads for circuits and a resulting high cost to constrain wind generation within the study area - £10.2 million by 2030 annually based on a constraints study for 80% renewables. Option 2 variants reduced constraints within the study area to £3.6m. The analysis showed that Option 3 – new 110 kV circuit from Drumnakelly to Tamnamore substations would not reduce wind farm constraints within the study area because it reduced the impedance of the route and therefore exacerbated other overloads. Option 4 – installation of a third interbus transformer at Tamnamore substation, reduced wind farm constraint costs to £5.7m. This option involves a difficult extension of both the 110 and 275 kV substation arrangements at Tamnamore and would also result in like for like refurbishment of the Tamnamore – Drumnakelly circuits in any case.

Option 2 – restring existing circuits, involved a number of sub-options to bring the existing circuit capacity to approximately 200-250 MVA. This option reduced constraints within the study area to £3.96m, i.e. a reduction of £6.2m from Option 1. Option 2a and 2d performed best from the restring options due to having a lower net present cost and reduced capital cost. Option 2b and 2c were slightly more expensive due to their capital costs of reinforcing to approximately 250 MVA. All of the sub-options for Option 2 - restring existing circuit had similar reductions in wind farm constraints. Option 2c has the lowest constraints as it provides the most thermal capacity of the sub-options.

It is recognised that significant other reinforcements will be required to address the level of renewables expected for the 2030 target (as determined in the Accelerated Ambition (AA) – 80% renewables scenario - particularly in the mid Tyrone and northwest of NI areas on the 110 kV system). Additional projects are described in the SONI Transmission Development Plan, NI (TDPNI) 2021[3].

A desktop comparison exercise was completed to rationalise the long list which assessed the technical merit, deliverability and cost aspect of each option. Option 3 – new 110 kV circuit from Drumnakelly to Tamnamore was rejected from the longlist. Despite increasing the line capacity between Drumnakelly and Tamnamore this option did not reduce wind farm constraints any further than the do-nothing option when under contingency i.e. the level of constraint remained similar. Additionally, with the construction of a new overhead line circuit and extension of both Tamnamore and Drumnakelly substations the deliverability of this option was considered very poor. From a capital cost perspective, it was significantly more expensive than other options in the long list.

Option 4 – installation of a third interbus transformer at Tamnamore substation was also rejected from the longlist. Despite increasing the transformer capacity at Tamnamore substation, with this option the windfarm constraints are still high when compared to Option 2 – restring existing circuits. The option requires the Tamnamore – Drumnakelly circuits to be opened to direct the power flow through the transformers, however this

[2] Based on the Average compensation rate of €88.62/MWh – Page 104, Shaping Our Electricity Version 1.1, published July 2023 and a euro to sterling conversion of £76.21/MWh

[3] https://www.soni.ltd.uk/media/documents/Transmission-Development-Plan-Northern-Ireland-2021-2030.pdf

reduces the resilience of the system during adverse weather conditions. It also leads to a risk of overloading the Tamnamore – Turleenan 275 kV double circuit (once Turleenan and the second North-South interconnector is established – an issue previously noted in the TDPNI). This would need to be addressed in a separate project in a timely manner. Additionally, an extension of both the 110 kV and 275 kV arrangements at Tamnamore substation is required in order to make this option feasible. The lead times for new plant orders, in particular transformers, has been raised by NIE Networks. There is a risk that with the associated planning requirements and plant delivery timescales, this option may not be deliverable before 2030.

The shortlisted options included Option 1 – do nothing and the various Option 2 – restring existing circuits sub-options. Based on a multi-criteria analysis of cost (capital and lifecycle – net present value), technical merit, deliverability as well as consideration of environmental impact, to date the preliminary preferred option is identified as Option 2 – restring existing circuits, with a recommendation of Option 2a - Restring to 200 MVA only. This option consists of:

- Uprating the double circuit towerline (16.2 km) between Drumnakelly and Bonds Bridge (close to Tamnamore substation) to approximately 200 MVA;
- Uprating the A and B circuit wood pole overhead line sections to approximately 200 MVA (approx. 3.08 km on the A circuit and 4.05 km on the B circuit);
- Establishing OPGW (Optical Ground Wire) on the double circuit towerline section (via an earthwire replacement) and the wood pole overhead line arrangement for the A circuit (via the construction of upwards earthing brackets and duplicate earthwires with OPGW);
- Establishing a new cable sealing end tower and 200 MVA cable section (approx. 2.9 km in length) on the A circuit jointed to the existing 200 MVA cable section entering Tamnamore substation. Following this the portal section through Killyman village and the AP1 section of overhead line would be recovered; and
- Installation of a fibre in the new cable sections and in existing ducting for the existing cables for the 'A' circuit - required to provide a full communications path between Drumnakelly and Tamnamore (the existing A circuit cable trench has a fibre duct available for these works).

This option is the second least cost option with a capital cost of £18.44 million and has a low net present value cost over a 40-year period (considering the capital costs, wind farm constraints and operation and maintenance). Sub-option 2a is considered more deliverable than sub-option 2d, which requires 1.7 km of new overhead line circuit. SONI is requesting that NIE Networks (as part of their pre-construction works) investigate suitable conductors between approximately 200 and 250 MVA, and the need for 250 MVA conductor will be reassessed at Part 2.

For the purposes of our stakeholder engagement exercises and TNPP submission this is selected as preliminary preferred option.

# Introduction

The need for the reinforcement of the existing Drumnakelly – Tamnamore 110 kV circuits has been confirmed in the associated Needs Report. The need occurs under high wind conditions, with the assumptions as set out in the Transmission System Security and Planning Standards (TSSPS) and with level of onshore renewable generation expected to meet the new energy strategy for 2030 (80% renewables). SONI currently operates with 49% of electricity demand coming from renewable energy sources[4].

The Drumnakelly – Tamnamore 110 kV circuits have the potential to be overloaded by approximately 200% of their seasonal rating (max rating of 124 MVA in Winter). This is shown in figures 1 and 2 below for the 'A' circuit, as highlighted in the Tomorrow's Energy Scenario, NI System Needs Assessment[5]. This was tested against the forced outage of the Coolkeeragh – Magherafelt 275 kV double circuit (N-DCT) and operation of the Coolkeeragh run back scheme, alongside other local contingencies such as the loss of one of the existing Drumnakelly – Tamnamore circuits (N-1). These contingencies put the local 110 kV networks in the north and west at risk of overload as generation flows along the 110 kV network towards Kells and Tamnamore substations. This analysis confirms that these circuits would be at risk of overload for 25% of the year in the event of the loss of the Coolkeeragh – Magherafelt double circuit (N-DCT) or loss of either existing Drumnakelly – Tamnamore circuit (N-1), for the Accelerated Ambition scenario (80% renewables) in 2025, and 30% of the year for this scenario in 2030.

This is currently managed by constraining wind farms and other renewable generation in Constraint Group 2[6] using the Wind Dispatch Tool, although this in turn leads to congestion on the 110 kV system, between Omagh and Tamnamore. Upon real time warnings in the control room this measure is carried out first to reduce the risk of overload on the Drumnakelly – Tamnamore circuits. The control room then implement an operational mitigation measure which involves switching out of service the Tamnamore – Drumnakelly 110 kV circuits, allowing the generation to flow through the interbus transformers at Tamnamore and onto the 275 kV system. However, this measure reduces the strength, integrity and resilience of the transmission system and can cause further issues if an unexpected outage of an interbus transformer at Tamnamore occurs, causing the other interbus transformer to overload.

As electricity demand continues to increase through the electrification of heating and transport, and with the connection of onshore renewable generation to meet the 2030 target, the level of constraint and system risk will continue to increase for these circuits. It is recognised that other significant reinforcements will be required to address the level of renewables expected for the 2030 target (as determined in the Accelerated Ambition (AA) – 80% renewables scenario - particularly in the mid Tyrone and northwest of NI areas on the 110 kV system. Additional projects are described in the SONI Transmission Development Plan, NI (TDPNI).

[4] https://www.economy-ni.gov.uk/news/electricity-consumption-and-renewable-generation-northern-ireland-year-ending-march-2023
[5] TESNI-SNA-2020.pdf (soni.ltd.uk)
[6] Wind-Dispatch-Tool-Constraint-Group-Overview.pdf (eirgridgroup.com)

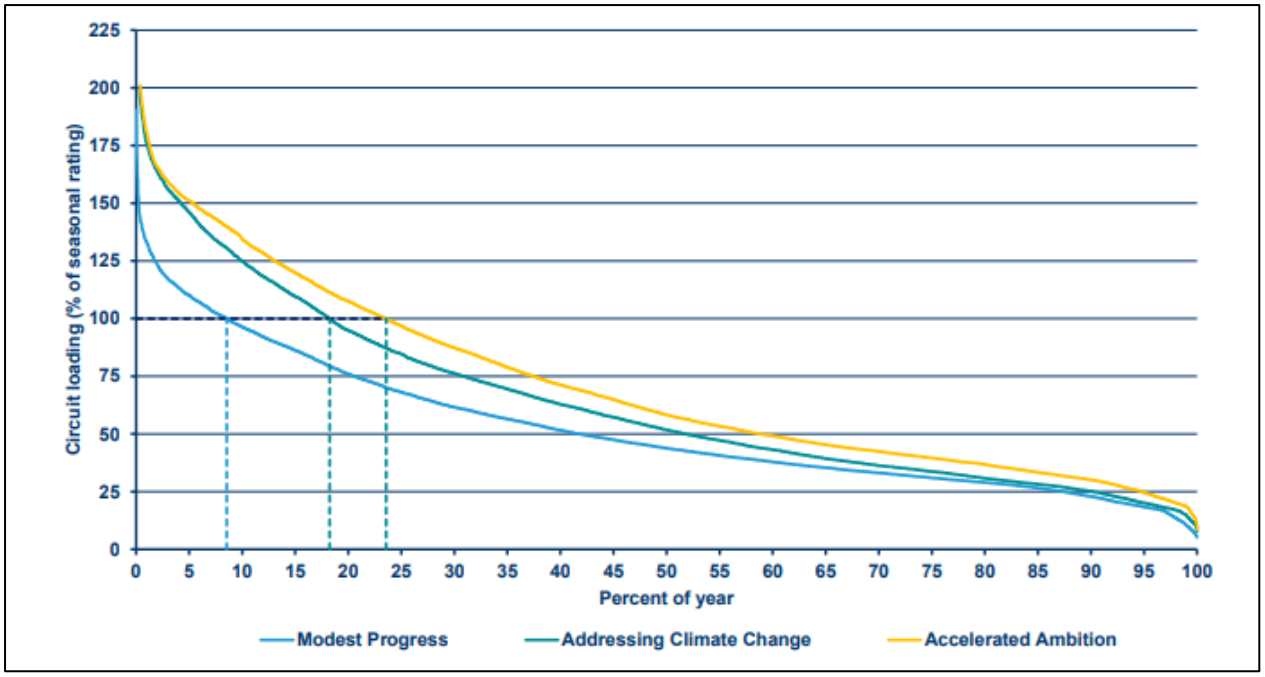


Figure 1 - N-1 loading for the Drumnakelly - Tamnamore circuits in 2025

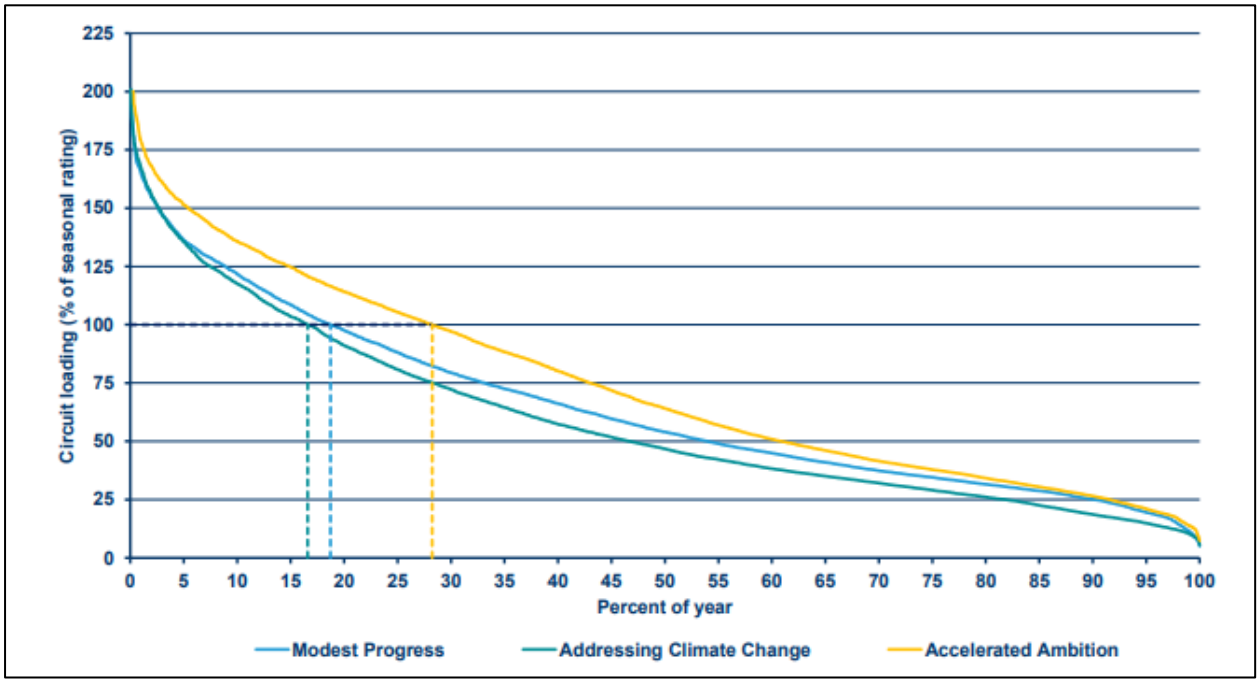


Figure 2 - N-1 loading for the Drumnakelly - Tamnamore circuits in 2030

# Description of the network

The transmission network, see figure 3 below, 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.

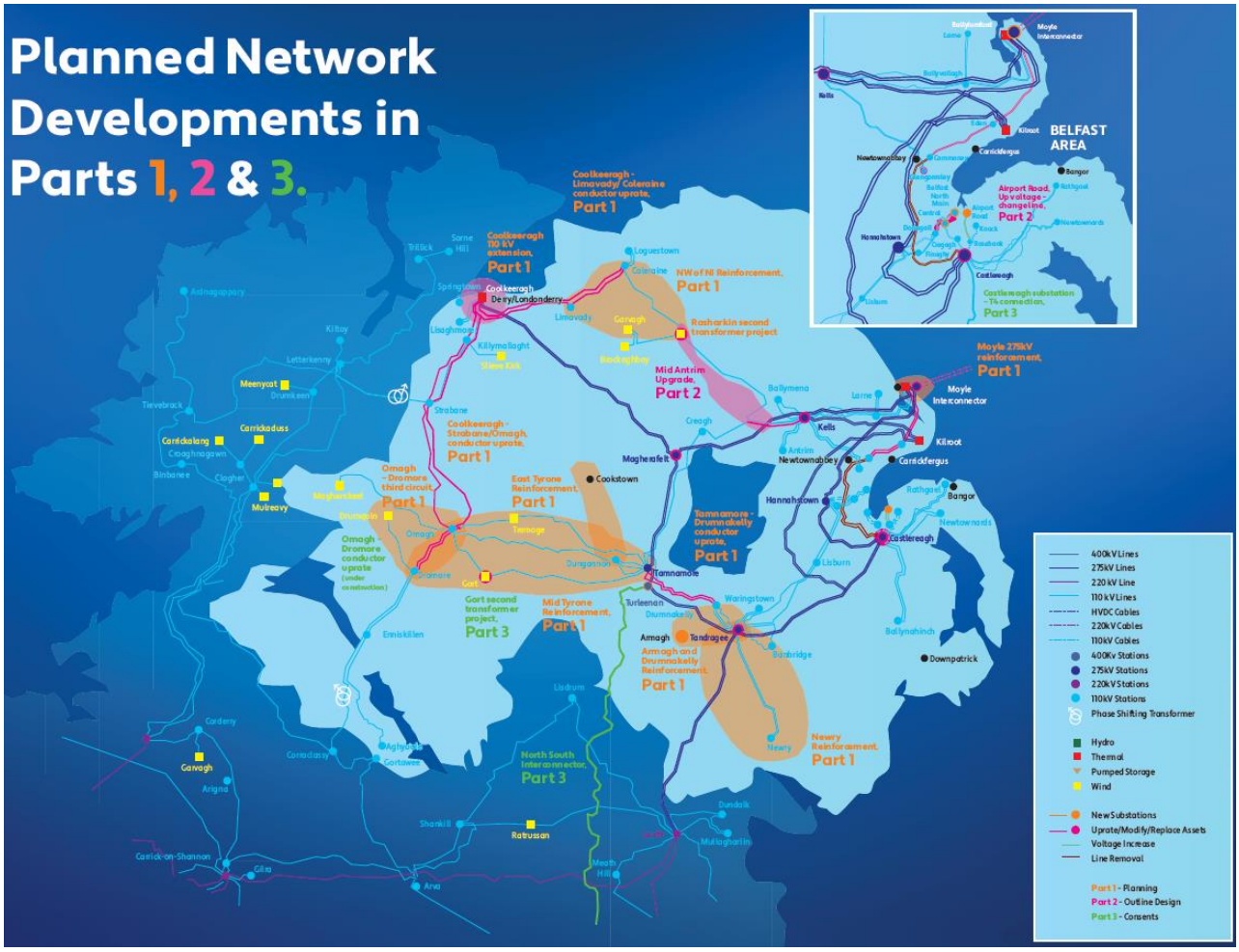


Figure 3 - Transmission System in Northern Ireland

The majority of renewable generation, to date, 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. Currently there is 1600 MW of generation from Renewable Energy Sources (RES), large scale and small scale, installed in Northern Ireland and SONI operates with 49% of electricity demand coming from renewable energy sources.

The existing 110 kV circuits between Drumnakelly and Tamnamore substation are comprised as follows;

- Double circuit towerline ('A' and 'B' circuits) from Drumnakelly to Bond's Bridge (5km south-east of Tamnamore substation) – 16.2 km;
- 'A' circuit;
    - Portal (twin wood pole) arrangement through Killyman village (Laghey Corner) – 3.94 km;

- AP1 (single wood pole) arrangement north of the M1 – 1.37 km;
- Underground cable section and connection into Tamnamore 110 KV substation – 1.18 km;

- ‘B’ circuit;
  - Portal (twin wood pole) arrangement terminating near Killyman St Mary’s GAC (less than 1 km from Tamnamore substation) – 4.05 km; and
  - Underground cable section and connection into Tamnamore 110 KV substation – 1.4 km.

Figure 4 below shows these arrangements. The circuits were constructed in the 1950’s when they connected Dungannon and Drumnakelly substations. They will be due for refurbishment in the near future given their asset age. When Tamnamore 275/110 kV substation was constructed, the circuits were diverted into the new site and new connections were also made between Dungannon and Tamnamore substations.

The circuits are currently rated to 109/119/124 MVA using ACSR Lynx conductor (with a 75° Design Operating Temperature (DOT)). The underground cable sections for both circuits are rated at 200 MVA using 2000mm$^2$ Aluminium XLPE.

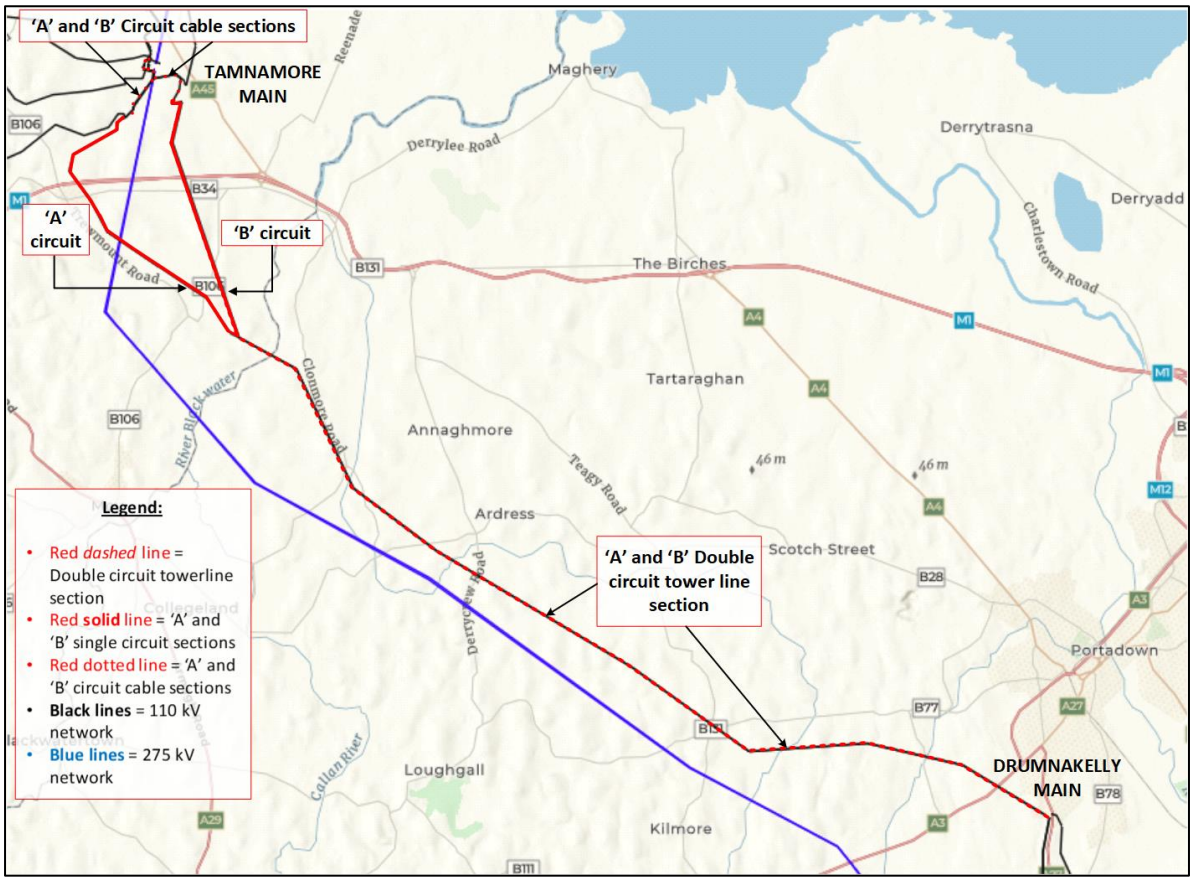


Figure 4 - Drumnakelly - Tamnamore 'A' and ‘B’ circuit arrangements

# Long list of options

## Option 1 – Do Nothing

This option would result in the existing constraint remaining on the Drumnakelly – Tamnamore 110 kV circuits. As identified by Tomorrow's Energy Scenario's, NI System Needs Assessment and Shaping Our Electricity Future consultations, the potential maximum overload of the circuits could be as high as 200% of the existing rating – therefore approx. 250 MVA. These circuits can also experience overloads more than the existing rating for approx. 25% of the year in 2025, and 30% of the year in 2030 (in the event of the loss of the Coolkeeragh – Magherafelt 275 kV double circuit).

The above potential overload risks are not permitted on the transmission system. This is currently managed by constraining wind farms and other renewable generation in Constraint Group 2, see figure 5 below, using the Wind Dispatch Tool, although this in turn leads to congestion on the 110 kV system, between Omagh and Tamnamore. Upon receipt of real time warnings in the control room, this measure is carried out first to remove the risk of overload on the Drumnakelly – Tamnamore circuits. The control room then implement an operational mitigation measure which involves switching out of service the Tamnamore – Drumnakelly 110 kV circuits, forcing power to flow through the interbus transformers at Tamnamore and onto the 275 kV system[7]. However, this measure reduces the strength and integrity of the transmission system and can cause an interbus transformer to overload for a forced outage of the other.

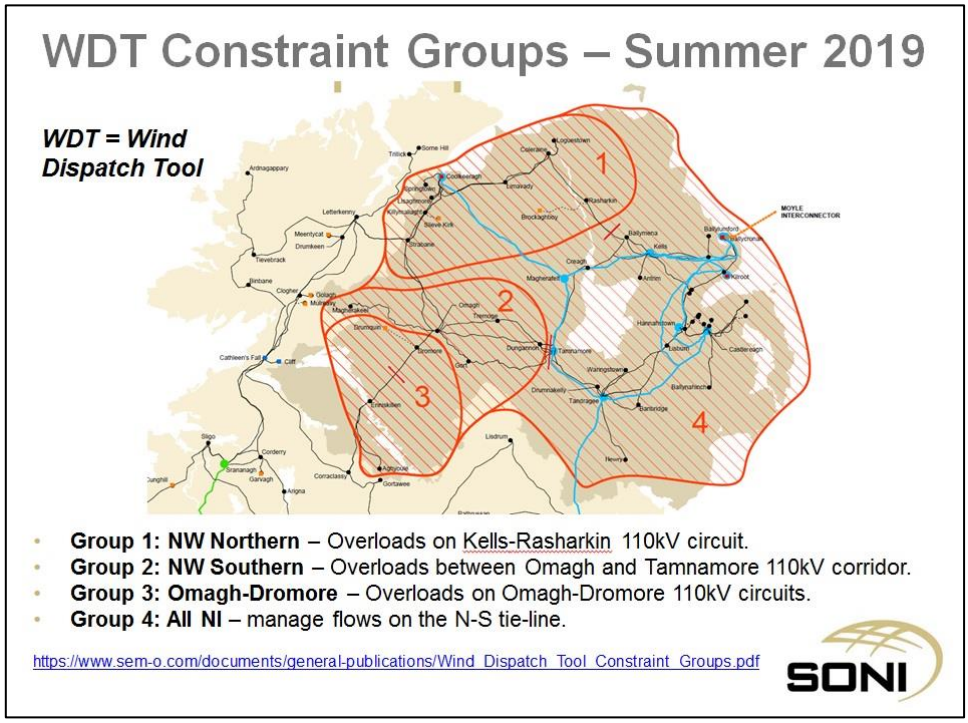


Figure 5 - Wind Dispatch Tool Constraint Groups

Wind farm constraint modelling was undertaken to determine the cost to constrain renewable generation to prevent overloads on the Drumnakelly – Tamnamore circuits. Using the forecast figure of £76.21/MWh for the average market value of electricity in NI

[7] This constraint is then relaxed once the operational measure is in place.

in 2030 it was possible to quantify this constraint financially. On the basis that this constraint would be compensated the costs are as presented in Table 1 below.

| Renewables target/ Scenario | *Total MWhrs constrained per year* | *Approx. Constraint costs per year (£76.21/MWh[8])* |
|---|---|---|
| Addressing Climate Change (ACC) – 70% | 51,891 | £3.96m |
| Accelerated Ambition (AA) – 80% | 133,292 | £10.2m |

Table 1 - Cost of constraining renewables to manage congestion

The above constraint costs would accumulate to a net present cost over a 40-year period to £191m.

The total energy consumed in Northern Ireland is approximately 7.47 TWh[9]. In order to reach a target of 80% renewables in Northern Ireland, approximately 6 TWh will be required to come from renewables. A 2030 constraint of 0.133 TWh is a constraint of approximately 2% of the required energy coming from renewable sources.

In the Do Nothing option, the circuits will require to be refurbished in any case. For the purposes of the net present cost analysis, it has been estimated that the refurbishment would cost £12.24m and would be completed in 2035.

## Option 2 - Restring existing circuits

This option, which has four variants, is based on restringing the existing Drumnakelly – Tamnamore circuits with a higher rated conductor. The circuits are currently constructed with a double circuit tower line section (Drumnakelly – Bonds Bridge), splitting into two single circuits. The 'A' circuit has a section of Portal, then AP1 (single wood pole) and finally underground cable into Tamnamore. The 'B' circuit is Portal and also has a underground cable section into Tamnamore.

The overhead line sections are currently strung with ACSR Lynx conductor, rated to 124 MVA. The existing cable sections that form the connections into Tamnamore substation are rated to 200 MVA. This option has four sub-options which propose to uprate the existing circuits to approximately 200 MVA or 250 MVA with variations regarding upgrade of the cable sections.

Through engagement with NIE Networks during Part 1 of this project it has been determined that a restring of the portal section of the 'A' circuit through the village of Killyman is not considered to be feasible. This is due to the position of an angle tower

[8] Based on the Average compensation rate of €88.62/MWh – Page 104, Shaping Our Electricity Version 1.1, published July 2023 and a euro to sterling conversion of £76.21/MWh

[9] "Between April 2022 and March 2023, some 7,471 Gigawatt hours (GWh) of total electricity was consumed in Northern Ireland" - https://www.economy-ni.gov.uk/news/electricity-consumption-and-renewable-generation-northern-ireland-year-ending-march-2023

close to housing, which could impact access and other construction phase activities required to complete the restring works. Therefore, all options include either a new overhead line or underground cable section to bypass Killyman village. This approach has been considered across all the sub options described below.

**Option 2a – Restring to 200 MVA only (£18.44m)**

This sub-option would involve restringing both circuits with two types of high temperature, low sag (HTLS) conductor. The double circuit tower line section from Drumnakelly to Bonds Bridge, would be restrung with a Gap type conductor (rated to 195 MVA). The portal sections on both the 'A' and 'B' circuits would be restrung using an Invar type conductor (rated to 193 MVA). Additionally, the replacement of the existing earthwire on the double circuit section with Optical Ground Wire (OPGW) is proposed, along with the establishment of twin earth wires also with OPGW on the portal section for the 'A' circuit. This will enhance communications into Tamnamore substation allowing for reliable main protection schemes to be established. The upgrade to 200 MVA rating necessitates the change and upgrade of protection.

To avoid restringing the 'A' circuit through Killyman village, a new underground cable section (2.9km of 2000mm$^2$ Aluminium XLPE) would be established allowing the AP1 and part of the portal sections on the 'A' circuit to be recovered. This cable is rated to 200 MVA. Horizontal directional drilling is expected to be required to cross the M1 motorway between Killyman village and the Tamnamore roundabout junction. This new cable section would also require the construction of a new cable sealing end tower south of Killyman village where the existing portal section would terminate. Following this a recovery of the AP1 and portal sections would be required. The new cable would be jointed onto the existing cable section entering Tamnamore substation. The existing cable sections entering Tamnamore for the 'A' and 'B' circuit would remain, as these cables are already rated to 200 MVA. In order to continue the enhancement of communications into Tamnamore substation an additional fibre cable would be established within the new and existing cables trench for the 'A' circuit.

Figure 6 shows an explanation of these works. The new cable section will where possible use the existing road network to route towards the existing cable section for the A circuit entering Tamnamore substation. This option is expected to cost approximately £18.44m. For a breakdown of this cost estimate see Appendix 1.

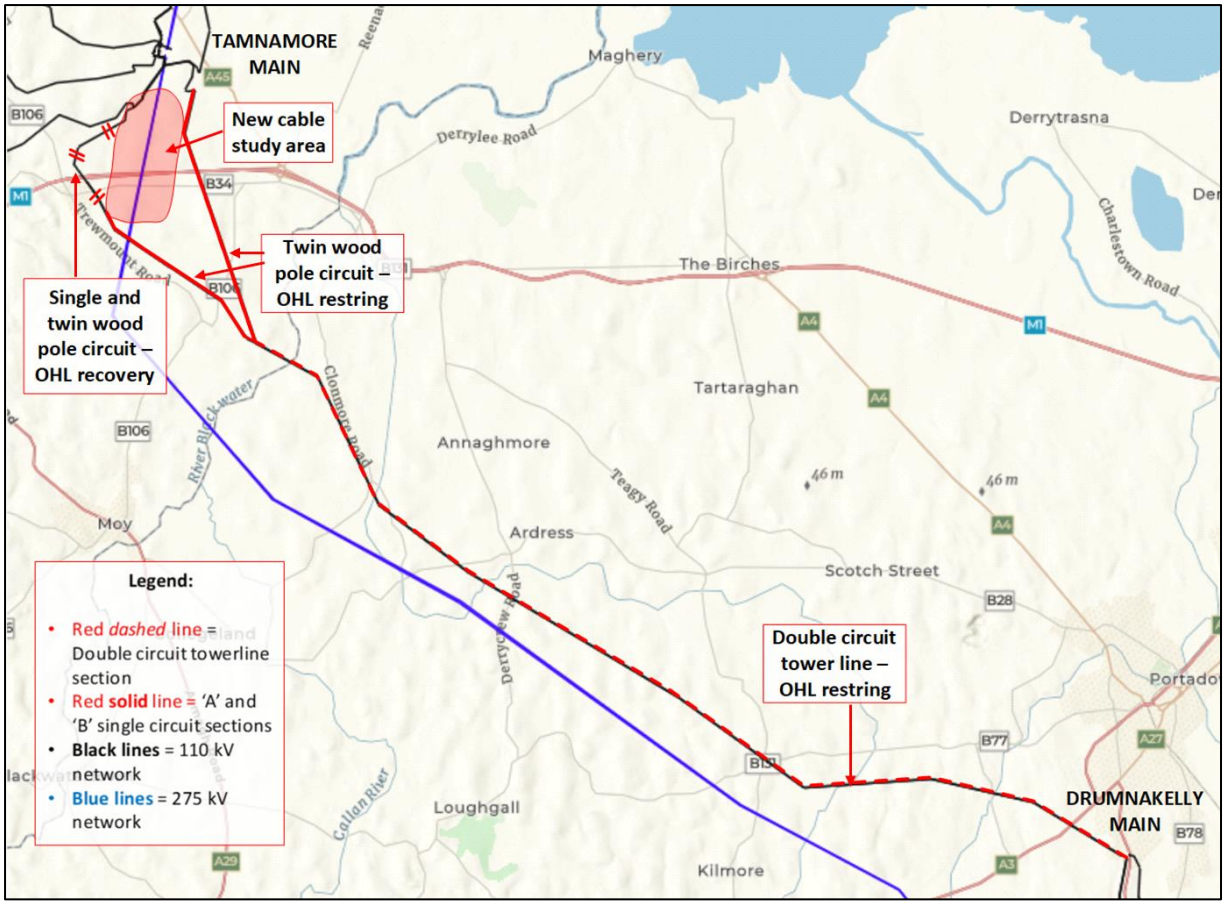


Figure 6 - AP1 (single wood pole) and Portal (twin wood pole) sections to be replaced with a new cable section

**Option 2b - Restring to 250 MVA and use the existing 200 MVA cable sections (£23.33m)**

This option would involve restringing both circuits with higher capacity conductor, rated to approximately 250 MVA, on the double circuit towerline section from Drumnakelly to Bonds Bridge[10], and the portal sections on both the 'A' and 'B' circuits. The feasibility of a conductor of this capacity will be determined in Part 2 of SONI's Process for Developing the Grid. Additionally, the replacement of the existing earthwire on the double circuit section with OPGW is proposed, along with the establishment of an earthwire with OPGW on the portal section for the 'A' circuit. This will enhance communications into Tamnamore substation allowing for reliable main protection schemes to be established.

The AP1 and part of the portal sections on the 'A' circuit would require full replacement with a new 200MVA underground cable section using 2000mm$^2$ Aluminium XLPE, approximately 2.9 km in length. This replacement is required due to the limited capacity available with the AP1 arrangement and the issues described previously with restringing the portal section through Killyman village. The option also includes the removal of both these sections of overhead line which would no longer be required. Horizontal directional drilling is assumed to be required for a crossing of the M1 motorway between Killyman village and the Tamnamore roundabout junction. The new cable section would also require the construction of a new cable sealing end tower south of Killyman village where

[10] 'Bond's Bridge is a bridge over the River Blackwater within the National Trust Argory. This is used as a reference point to describe the location of end of the double circuit towerline, which is nearby.

the existing portal section would terminate. The new cable would be jointed onto the existing cable section entering Tamnamore substation. The existing cable sections entering Tamnamore for the 'A' and 'B' circuit would remain, as these cables are rated to 200 MVA. In order to continue the enhancement of communications into Tamnamore substation an additional fibre cable would be established within the new cable trench for the 'A'.

This option is expected to cost approximately £23.33m. For a breakdown of this cost estimate see Appendix 1.

**Option 2c – Restring / Re-cable all sections to 250 MVA (£28.0m)**

This option would involve restringing both circuits with higher capacity conductor, rated to approximately 250 MVA, on the double circuit towerline section from Drumnakelly to Bond's Bridge, and the portal sections on both the 'A' and 'B' circuits. The feasibility of a conductor of this capacity will be determined in Part 2 of SONI's process for developing the Grid. Additionally, the replacement of the existing earthwire on the double circuit section with OPGW is proposed, along with the establishment of an earthwire with OPGW on the portal section for the 'A' circuit. This will enhance communications into Tamnamore substation allowing for reliable main protection schemes to be established.

Additionally, the existing cable sections entering Tamnamore for the 'A' and 'B' circuit would require replacement with higher capacity cables rated to 250 MVA. The AP1 and part of the portal sections on the 'A' circuit would require full replacement with a new underground cable section – this would form part of the replacement of the 'A' circuit cable section entering Tamnamore substation. This replacement is required due to the limited capacity available with the AP1 arrangement and the issues described previously with restringing the portal section through Killyman village. The option also includes the removal of both these sections of overhead line which would no longer be required. Horizontal direction drilling may be required for a crossing of the M1 motorway between Killyman village and the Tamnamore roundabout junction. The new cable sections for both circuits would use the existing road network to route towards Tamnamore substation. It is estimated that approximately 4 km of new underground cable would be required for the 'A' circuit and approximately 1.4 km for the 'B' circuit. The new cable sections would require the construction of two new cable sealing end towers close to where the existing portal sections terminate for both circuits – a new cable sealing end tower for the 'A' circuit and a new cable sealing end tower close to the existing cable sealing end tower for the 'B' circuit. In order to continue the enhancement of communications into Tamnamore substation an additional fibre cable would be established within the new cable trench for the 'A' circuit.

This option is expected to cost approximately £28.0m. For a breakdown of this cost estimate see Appendix 1.

**Option 2d - Restring to 200 MVA and construct a new overhead line to bypass Killyman on the A circuit (£14.50m)**

This option would involve restringing both circuits with two types of high temperature, low sag (HTLS) conductor. The section from Drumnakelly to Bond's Bridge, on the double circuit towerline using Gap conductor (rated to 195 MVA) and the section of portal on both the 'A' and 'B' circuits using Invar conductor (rated to 193 MVA). This option would also include for the replacement of the existing earthwire on the double circuit section

with OPGW, along with the establishment of an earthwire with OPGW on the portal section for the 'A' circuit. This will enhance communications into Tamnamore substation allowing for reliable main protection schemes to be established.

This option proposes replacing part of the existing Portal section and the entirety of the AP1 section on the 'A' circuit by constructing a new portal overhead line section on a different alignment. This new OHL section would by-pass Killyman village and proceed towards the existing cable section entering Tamnamore substation. The new OHL section would be approximately 1.7 km and rated to approximately 200 MVA. The construction of a new cable sealing end tower close to where the existing cable section entering Tamnamore substation would also be required. The existing cable sections entering Tamnamore for the 'A' and 'B' circuit would remain, as these cables are rated to 200 MVA. In order to continue the enhancement of communications into Tamnamore substation an additional fibre cable would be established within the new and existing cable trench for the 'A' circuit.

Figure 7 shows the study area where a new overhead line section could be located.

This option is expected to cost approximately £14.50m. For a breakdown of this cost estimate see Appendix 1.

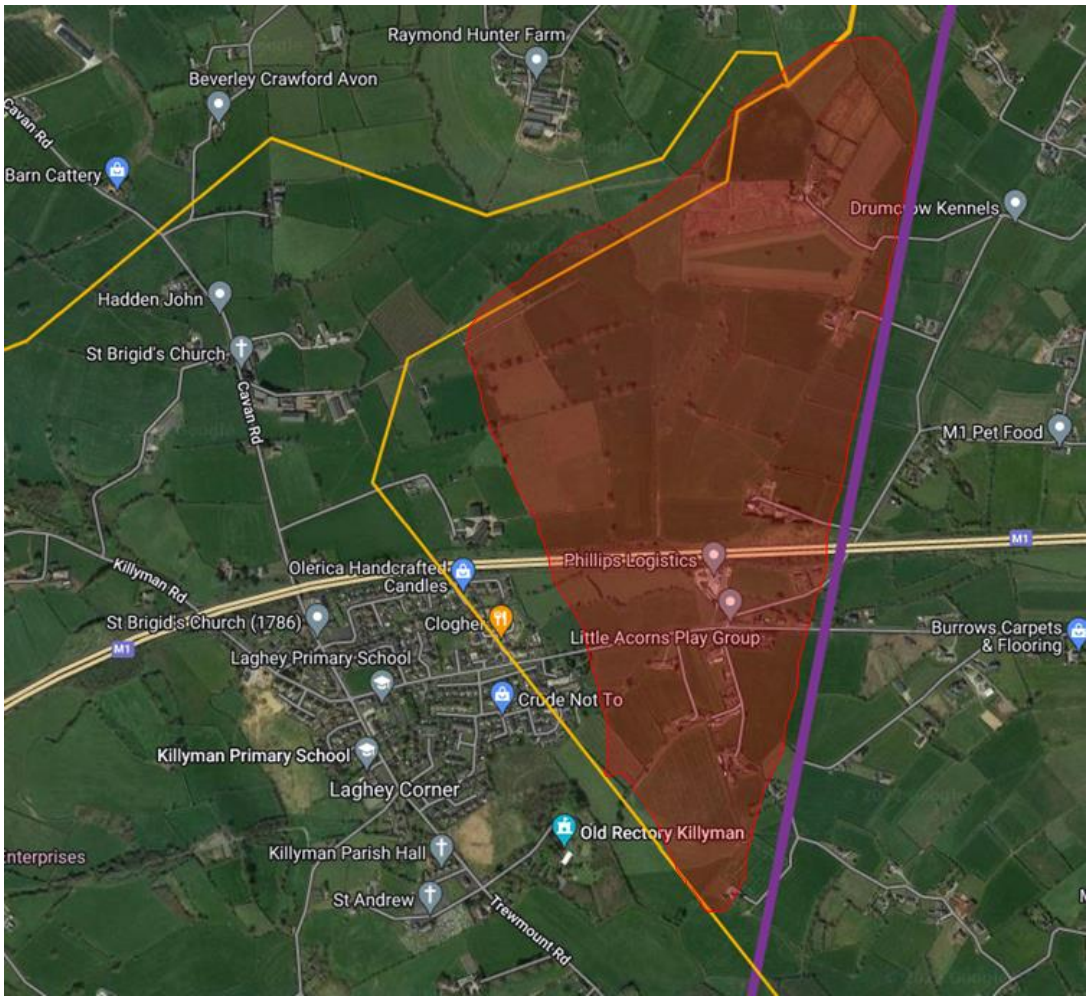


**Figure 7 - Potential study area for a new overhead line section on a new alignment on the 'A' circuit**

## Option 3 - New 110 kV circuit from Drumnakelly to Tamnamore substations (£26.05m)

This option would involve the construction of a new 110 kV circuit directly from Drumnakelly to Tamnamore substation. This circuit would be comprised of Portal construction, rated to approximately 200 MVA. Based on the line of sight between these substations with an allowance for routing, the new circuit would be approximately 24 km. Cable sections would be required to enter both substations, with an allocation of 1km allowed for at each substation.

Tamnamore 110 kV substation has one spare bay currently. Due to the number of connections already at 110 kV it would be necessary to establish the second bus coupler for security of supply. Therefore, two spare bays would be required at Tamnamore, requiring an extension of the existing double busbar arrangement. This would require land purchase north of Tamnamore substation, pre-enabling and a diversion of the sterile zone. The busbar extension would create one additional 110 kV bay, both the new and existing bays would then be equipped for switchgear to make the associated connections for the new circuit, second bus coupler and bus section switches.

Drumnakelly 110 kV substation has no spare bays in the existing mesh arrangement. In order to connect a new 110 kV circuit, a mesh extension would be required. There is space within the existing substation environs to allow this to occur, once an existing terminal tower (which caters for the existing Drumnakelly – Tamnamore 110 kV circuits) is repositioned. A mesh extension would create two additional 110 kV bays, one of which would be equipped and used for the new circuit. Pre-enabling and a diversion of the sterile zone would be required.

This option is expected to cost approximately £26.05m. For a breakdown of this cost estimate see Appendix 1.

## Option 4 - Installation of a third interbus transformer at Tamnamore substation (£19.53m)

This option is based on establishing the third interbus transformer at Tamnamore substation. During times of high renewable generation, the existing Drumnakelly – Tamnamore 110 kV circuits can be switched out of service by the control room as an operational mitigation measure to protect them from overloading in the event of contingency. This measure could potentially lead to further issues if an unexpected outage of an interbus transformer at Tamnamore occurs, causing the other interbus transformer to overload. By establishing a third interbus transformer this reduces this risk and allows the generation to pass upwards onto the 275 kV system at Tamnamore through three transformers.

Tamnamore 110 kV and 275 kV substations have one spare bay currently. Due to the number of connections already at both 110 kV and 275 kV it would be necessary to establish the second bus coupler for security of supply at both the 110 kV and 275 kV substation arrangements. Therefore, two spare bays would be required at both substations requiring an extension of the existing double busbar arrangements. This

would require land purchase north and south of Tamnamore substation, pre-enabling and a diversion of the sterile zone. The busbar extensions would create one additional 110 kV bay and one additional 275 kV bays. All new and existing bays would then be equipped for switchgear to make the associated connections for the new interbus transformer, second bus couplers and bus section switches.

This option is expected to cost approximately £19.53m. For a breakdown of this cost estimate see Appendix 1.

# Rationalising the long list

## Comparison on capital cost

The estimated costs of each the options in the long list are set out in Table 2 and Figure 8 below. For a full breakdown see Appendix 1.

| Option | Cost (£m) | Comments |
|---|---|---|
| Option 1 - Do nothing | - | - |
| Option 2a - Restring to 200 MVA only | 18.44 | Uprate with Gap and Invar conductor and install OPGW for communications. Install a new 200 MVA cable section and cable sealing end tower to replace the AP1 section and part of the portal section on the 'A' circuit |
| Option 2b - Restring to 250 MVA and use the existing 200 MVA cable sections | 23.33 | Uprate with Oslo conductor and install OPGW for communications. Install a new 200 MVA cable section and cable sealing end tower to replace the AP1 section and part of the portal section on the 'A' circuit |
| Option 2c - Restring all sections to 250 MVA | 28.0 | Uprate with Oslo conductor, install OPGW for communications and install new 250 MVA cable sections and cable sealing end towers (to replace the AP1 section and part of the portal section on the 'A' circuit and the existing 200 MVA cable sections on both circuits) |
| Option 2d - Restring to 200 MVA and construct a new overhead line to bypass Killyman on the A circuit | 14.50 | Uprate with Gap and Invar conductor and install OPGW for communications. Install a new overhead line section using heavy portal design with Zebra conductor to change the alignment of the 'A' circuit around Killyman - replacing the existing AP1 and part of the portal sections (approx. 1.7km). Construct a new cable sealing end tower near the existing 'A' circuit cable section |
| Option 3 - New 110 kV circuit from Drumnakelly to Tamnamore substations | 26.05 | New 110 kV circuit using heavy portal design with Zebra conductor and 250 MVA cable sections. Associated substation works at Tamnamore and Drumnakelly |
| Option 4 - Installation of a third interbus transformer at Tamnamore substation | 19.53 | New 275/110 kV interbus transformer at Tamnamore and associated substation works at Tamnamore 110 and 275 kV substations |

Table 2 - Cost estimate for long list options

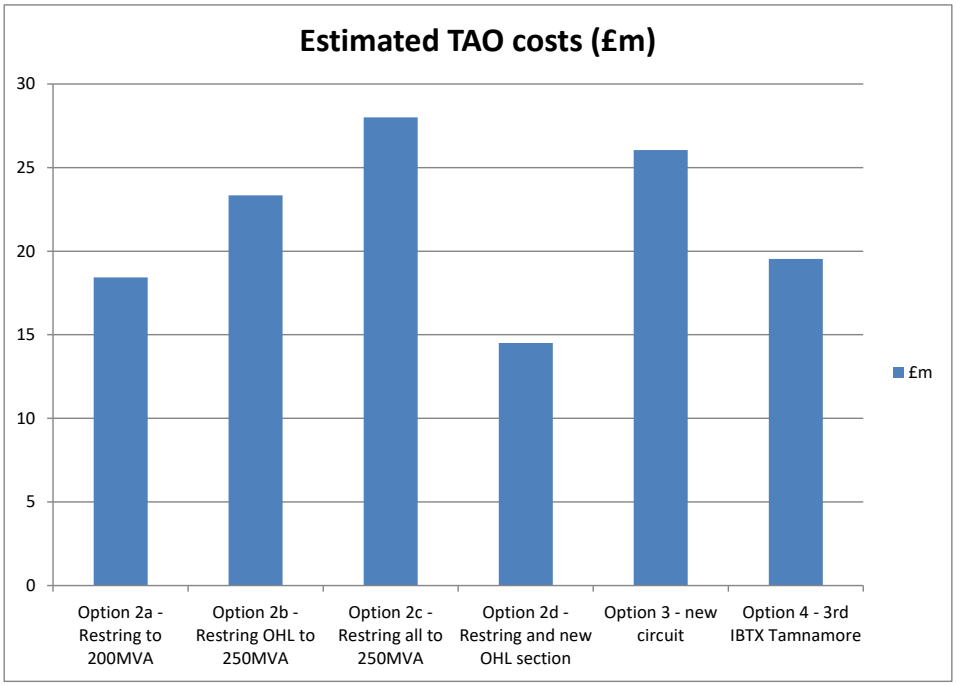


Figure 8 - Comparison of cost estimates for long list options (obtained from NIE Networks)

## Wind farm Constraint Costs

Cases were prepared from the Tomorrow's Energy Scenarios, NI (TESNI) and Shaping Our Electricity Future (SOEF) version 1.0 analysis for 2030 with the level of renewable generation expected for the 70% renewable energy target as set by the new Northern Ireland Energy Strategy, 2021, revised with the 80% renewable energy target as set by the Climate Change Act 2022. Wind farm constraint modelling was carried out using these cases to assess the level of constraint each option would incur. Using the forecast figure of £76.21/MWh for the average market value of electricity in NI in 2030 it was possible to quantify this constraint financially. Tables 3 and 4 below present the results of this analysis, with table 3 showing the number of Giga Watt hours (GWhs) of constraint and table 4 showing the associated constraint costs.

| Renewables target/ Scenario | Option Constraint /GWhs | | | | | | |
|---|---|---|---|---|---|---|---|
| | *1 - Do nothing* | *2a – Restring to 200 MVA* | *2b – Restring OHL to 250 MVA* | *2c – Restring all sections to 250 MVA* | *2d – Restring and new OHL section* | *3 – new 110 kV circuit* | *4 – 3rd IBTX at Tamnamore* |
| Addressing Climate Change (ACC) – 70% | 51.9 | 10.9 | 10.9 | 10.4 | 10.9 | 52.0 | 13.5 |
| Accelerated Ambition (AA) – 80% | 133.3 | 52.0 | 52.0 | 48.1 | 52.0 | 133.9 | 74.6 |

Table 3 - Wind farm constraints for each option in GWhrs

| Renewables target/ Scenario | Option Constraint Cost /£m | | | | | | |
|---|---|---|---|---|---|---|---|
| | *1 - Do nothing* | *2a – Restring to 200 MVA* | *2b – Restring OHL to 250 MVA* | *2c – Restring all sections to 250 MVA* | *2d – Restring and new OHL section* | *3 – new 110 kV circuit* | *4 – 3rd IBTX at Tamnamore* |
| Addressing Climate Change (ACC) – 70% | 3.96 | 0.83 | 0.83 | 0.80 | 0.83 | 3.96 | 1.03 |
| Accelerated Ambition (AA) – 80% | 10.2 | 3.96 | 3.96 | 3.66 | 3.96 | 10.2 | 5.68 |

Table 4 - Wind farm constraints for each option in £/m

**Observations**

- Constraints are higher with 80% renewables. These costs will be used in the net present cost assessments from 2030 onwards.
- Option 1 – Do nothing and Option 3 – New 110 kV circuit from Drumnakelly to Tamnamore substations have the highest constraint costs, approximately £10.2m each by 2030 annually for 80% renewables. For Option 1 this is due to the N-1 risk of overloading an interbus transformer at Tamnamore substation in the event of a forced outage of the other transformer. For Option 3 this is due to the risk of overloading the existing circuits in the event of a forced outage of the Coolkeeragh – Magherafelt 275 kV double circuit (N-DCT) or the new Drumnakelly – Tamnamore 110 kV circuit (N-1).
- All of the sub-options for Option 2 - Restring had similar reductions in wind farm constraints and are therefore fully comparable. The analysis showed that Option 3 – new circuit would not reduce wind farm constraints, due to the risk of N-1 of the new circuit leading to the existing circuits being overloaded. The new circuit would reduce the impedance of this route for renewable generation coming from the west and increase the flows.
- Option 4 – installation of a third interbus transformer at Tamnamore substation, had a significant difference in wind farm constraint costs compared to the various Option 2 – Restring existing circuits sub-options.

## Net Present Cost Analysis

An assessment of the lifecycle costs of each of the options in the long list has been undertaken. This has included the capital cost of each of the options, TSO costs, wind farm constraint costs and an allowance for operation and maintenance. The constraint costs follow an estimate of the level of renewable generation that is expected to be connected by 2030 in order to reach the statutory targets. In Northern Ireland currently 49% of our electricity demand is met through renewable energy sources.

For the purposes of this analysis it is assumed that with the continued connection of renewable generation to meet the 2030 target, by 2025 we will have increased this to 60% (the constraint figures for 60% renewables will be also be used to appraise the years 2022-2025, given we are close to 50% renewables in Northern Ireland currently), by 2029 to 70% and by 2030 to 80%. From 2030 onwards constraints are considered constant using the figure for 80% renewables. The discount rate was assumed to be 3.5% and the model was extended to 40 years (anticipated asset lifetime).

The existing Drumnakelly – Tamnamore circuits were constructed in the 1950s. Given the asset age of these circuits they will require a refurbishment at some time in the near future - however SONI has not been informed of any concerns on the assets' condition to date from NIE Networks. For these assessments it is assumed that by 2035 a like for like asset refurbishment will have been carried out. This will include a conductor replacement and refurbishment to existing tower steelwork, pole sets and foundations as required. A cost estimate for these works has been prepared using figures from other recent transmission projects. The estimated cost for this asset replacement is £12.24m. These works will apply to Option 1 – do nothing, Option 3 – new 110 kV circuit from Drumnakelly to Tamnamore substations and Option 4 – installation of a third interbus transformer at Tamnamore substation.

The net present cost for each of the options is presented in table 5 below. For a full breakdown of this analysis see Appendix 2.

| Option | Net Present Cost (£m) |
|---|---|
| Option 1 - Do nothing | 191.34 |
| Option 2a - Restring to 200 MVA only | 107.00 |
| Option 2b - Restring to 250 MVA and use the existing 200 MVA cable sections | 113.00 |
| Option 2c - Restring all sections to 250 MVA | 114.11 |
| Option 2d - Restring to 200 MVA and construct a new OHL section on the A circuit. | 102.17 |
| Option 3 - New 110 kV circuit from Drumnakelly to Tamnamore substations | 222.87 |
| Option 4 - Installation of a third interbus transformer at Tamnamore substation | 145.93 |

Table 5 - Net present cost of each option

## Technical Performance

A discussion of the technical performance for each option, based on the analysis carried out in the Tomorrow's Energy Scenarios and Shaping our Electricity Future (version 1.0) cases is presented below.

#### Option 1 – Do nothing

This option results in the existing constraint remaining and increasing in severity as the level of renewable generation connecting increases to meet the 2030 targets. To prevent the existing circuits being at risk from overload the operational mitigation measure will

need to be more frequently adopted, resulting in the existing circuits being switched out of service more. This can cause further issues if an unexpected outage of an interbus transformer at Tamnamore occurs, causing the other interbus transformer to overload. This option reduces system strength and resilience, puts other assets at risk of overload and should not be considered as a long-term solution.

#### Options 2a-d – Restring existing circuits

These sub-options result in a reduction in the existing and expected constraint due to increased renewable generation. They also provide a significant increase in thermal capacity of both existing circuits. Sub-option 2c performs best technically as both circuits would establish a rating of approx. 250 MVA once completed.

#### Option 3 – new 110 kV circuit from Drumnakelly to Tamnamore

This option would provide an increase in thermal capacity that would reduce the need for the operational mitigation measure currently used during times of high renewable generation. However, the level of constraint remains the same as Option 1 – do nothing, with the existing circuits being at risk in the event of a N-1 or N-DCT as indicated by the wind farm constraint analysis. During times of high wind if an unforced outage of the new circuit occurs (or one of the existing circuits), the existing circuits will still be at risk, and would require a reduction in output of local renewable generation and potential redispatch of thermal generation at a high merit cost to the consumer. In reality the control room would not allow this as this would take time to implement and therefore wind generation would be constrained when the control room is alerted of the risk before the contingency occurs.

#### Option 4 – installation of a third interbus transformer at Tamnamore substation

This option would increase the transformer capacity at Tamnamore substation and reduce the risk of overload to the interbus transformers at Tamnamore substation through the operational mitigation measure where the existing circuits are switched out of service during times of high wind generation. This measure allows renewable generation flowing into Tamnamore substation to pass onto the 275 kV system through the interbus transformers, whilst protecting the existing circuits from overloading as they are switched out of service with no power flows present. With this option the further risk to the existing interbus transformers is mitigated - if one transformer is unexpectedly forced out of service, there are still two transformers available with sufficient capacity for the level of renewables expected. However, windfarm constraints are still high with this option due to the level of generation that is present on the 110 kV network between Omagh and Tamnamore substations and it reduces system strength and stability by relying on an operational mitigation measure involving switching out circuits. This could not be relied on as a long-term solution. It also leads to a risk of overloading the Tamnamore – Turleenan 275 kV double circuit (once Turleenan and the second North-South interconnector is established – an issue previously noted in the TDPNI). This would need to be addressed in a separate project in a timely manner.

## Deliverability

An assessment of the deliverability of each option is provided below. This is based on the complexity of the option, availability of spacing/bays at existing substations and knowledge gained in completing other transmission projects. Option 1 – do nothing is not discussed as this option does not involve any transmission works (other than allowing existing measures in the operating of the transmission system to remain).

The deliverability ranges from very good to very poor. For the options appraisal a very poor deliverability would be designated a dark blue colour and very good deliverability would be designated a yellow colour. This is presented in table 6 in section 4.6.

Option 2 – restring existing circuits:

Option 2 involves the uprate of the existing Drumnakelly – Tamnamore circuits. There are four sub-options which propose to uprate the existing circuits to approximately 200 MVA or 250 MVA.

Option 2a – Restring to 200 MVA only:

- The existing Drumnakelly - Tamnamore circuits are comprised of a L4 double circuit tower line section, portal sections for both 'A' and 'B' circuit, an AP1 section for the 'A' circuit and cable sections for both 'A' and 'B' circuit to enter Tamnamore substation.
- The existing portal sections may require additional pole sets and angle tower foundation upgrades to be able to carry a new conductor and to establish an earth wire with upward earthing brackets to existing pole sets and steel towers ('A' circuit only). The existing L4 double circuit section may require similar work including foundation upgrades and tower steel work. The extent of this is not yet known. The existing earth wire would be replaced with OPGW.
- A new cable section is required to replace the existing AP1 and part of the existing portal section on the 'A' circuit. This cable section would be jointed onto the existing cable section entering Tamnamore substation and requires a new cable sealing end tower south of Killyman village where the existing portal section would terminate. The establishment of a fibre duct would also be required for the new and existing cable section on the 'A' circuit to complete the communications paths from Drumnakelly to Tamnamore. This will require underground pulling and splicing chambers at the appropriate points along the new and existing cable routes. Horizontal direction drilling may be required to cross the M1 motorway between Killyman village and the Tamnamore roundabout junction.
- This option would require two years for construction and would require a number of outages with associated constraints, including double circuit outages for the earth wire replacement. The estimated completion date is 2028.
- The restring works for these circuits could theoretically be carried out under permitted development rights and should not require planning permission with access arrangements to allow for stringing points. However, the establishment of a new cable section, cable sealing end tower and addition of an earth wire on the portal sections will require planning permission and as a result the whole project may need to be within the red line. This will be better understood during Part 1 stakeholder engagement and if necessary full planning permission will be checked for all construction works associated with this proposal. An uprate of the existing circuits would still be considered significantly easier to deliver than a new overhead line circuit despite. The deliverability of this option is considered as good.

Option 2b - Restring to 250 MVA and use the existing 200 MVA cable sections:

- Option 2b proposes a new type of conductor rated to approximately 250 MVA (potentially of the composite type). This will require type testing as this conductor has not been used on the Northern Ireland system previously. There is a risk that these tests are delayed or the conductor does not pass the tests.
- The existing portal sections may require additional pole sets and foundation upgrades to be able to carry a new conductor of this type and to establish an earthwire with upward earthing brackets to existing pole sets and steel towers ('A' circuit only). The existing L4 double circuit section may require similar work including foundation upgrades and tower steel work. The extent of this is not yet known. The existing earthwire would be replaced with OPGW.
- A new cable section is required to replace the existing AP1 and part of the existing portal section on the 'A' circuit. This cable section would be jointed onto the existing cable section entering Tamnamore substation and requires a new cable sealing end tower south of Killyman village where the existing portal section would terminate. The establishment of a fibre duct would also be required for the new and existing cable section on the 'A' circuit to complete the communications paths from Drumnakelly to Tamnamore. This will require underground pulling and splicing chambers at the appropriate points along the new and existing cable routes. Horizontal direction drilling may be required to cross the M1 motorway between Killyman village and the Tamnamore roundabout junction.
- This option would require two years for construction and would require a number of outages with associated constraints, including double circuit outages for the earthwire replacement. The estimated completion date is 2028.
- The restring works for these circuits could be carried out under permitted development rights and should not require planning permission. There would need to be access arrangements to allow for stringing points. However, the establishment of a new cable section, cable sealing end tower and addition of an earthwire on the portal sections may require planning permission. This will be better understood during Part 1 stakeholder engagement and if necessary full planning permission will be checked for all construction works associated with this proposal.
- The main issues however that would affect the delivery of this option is the fact that the new conductor is not in the technology toolbox at present and the conductor needs to be suitable for both the portal and double circuit towerline sections. An uprate of existing circuits would still be considered easier to deliver than a new overhead line circuit despite these challenges. The deliverability of this option is considered as medium.

Option 2c - Restring all sections to 250 MVA:

- Option 2c proposes a new type of conductor rated to approximately 250 MVA (potentially of the composite type). This will require type testing as this conductor type

has not been used on the Northern Ireland system previously. There is a risk that these tests are delayed, or the conductor does not pass the tests.

- The existing portal sections may require additional pole sets and foundation upgrades to be able to carry a new conductor of this type and to establish an earthwire with upward earthing brackets to existing pole sets and steel towers ('A' circuit only). The existing L4 double circuit section may require similar work including foundation upgrades and tower steel work. The extent of this is not yet known. The existing earthwire would be replaced with OPGW.
- New cable sections are required on both the 'A' and 'B' circuit to replace the existing cable sections which are rated to 200 MVA and to match the overhead line rating of approximately 250 MVA. The cable section for the 'A' circuit will also need to replace the existing AP1 and part of the existing portal section which cannot be uprated to the rating required for this restring or due to access issues in Killyman village associated with all of the sub options. This will require two new cable sealing end towers close to where the existing portal sections terminate (the new location south of Killyman for the 'A' circuit and close to the existing location for the 'B' circuit) and new cable routes into Tamnamore substation. This may be difficult due to the number of 110 kV circuits already entering Tamnamore substation via underground cable sections. Horizontal direction drilling may be required for a crossing of the M1 motorway between Killyman village and the Tamnamore roundabout junction. The establishment of a fibre duct would also be required for the new cable section on the 'A' circuit to complete the communications paths from Drumnakelly to Tamnamore. This will require underground pulling and splicing chambers at the appropriate points along the new cable routes.
- This option would require two years for construction and would require a number of outages with associated constraints, including double circuit outages for the earthwire replacement. Significant works will be required to establish new 250 MVA cable sections. It is not yet understood if this will affect the existing cable sections – if so it may lead to longer circuit outages and a greater level of constraints during this time. The estimated completion date is 2028.
- The restring works for these circuits could be carried out under permitted development rights and should not require planning permission. There would need to be access arrangements to allow for stringing points. However, the establishment of new cable sections, cable sealing end towers for both circuits and the addition of an earth wire on the portal sections may require planning permission. This will be better understood during Part 1 stakeholder engagement and if necessary full planning permission will be checked for all construction works associated with this proposal.
- The main issues however that would affect the delivery of this option is the fact that the new conductor is not in the technology toolbox at present and the conductor needs to be suitable for both the portal and double circuit towerline sections. Additionally, the cable works associated with this option will be quite complex and may lead to longer outage requirements. Due to this the deliverability of this option is considered as poor.

Option 2d - Restring to 200 MVA and construct a new OHL section on the A circuit:

- Option 2d is similar to Option 2a but proposes replacing part of the existing Portal section and the entirety of the AP1 section on the 'A' circuit by constructing a new portal overhead line section on a different alignment. This new OHL section would by-pass Killyman village and proceed towards the existing cable section entering Tamnamore substation (approximately 1.7 km in length). The AP1 and part of the portal overhead line sections would then be recovered.
- For this uprate, the existing portal sections may require additional pole sets and foundation upgrades to be able to carry a new conductor and to establish an earth wire with upward earthing brackets to existing pole sets and steel towers. The existing L4 double circuit section may require similar work including foundation upgrades and tower steel work. The extent of this is not yet known. The existing earthwire would be replaced with OPGW.
- A new portal overhead line section is required to replace the existing AP1 section on the A circuit and part of the existing portal section alignment passing through Killyman Village. A study area identified for approximately 1.7 km of circuit would be subject to landowner engagement, environmental appraisal and planning permission. A new cable sealing end tower is required at the end of this new section of overhead line to connect to the existing section entering Tamnamore substation. The remaining sections of AP1 and Portal would then be recovered.
- The establishment of a fibre duct would also be required for the existing cable section on the 'A' circuit to complete the communications paths from Drumnakelly to Tamnamore. This will require underground pulling and splicing chambers at the appropriate points along the new and existing cable routes.
- This option would require two years for construction and would require a number of outages with associated constraints, including double circuit outages for the earth wire replacement. The estimated completion date is 2028.
- The restring works for these circuits could be carried out under permitted development rights. There would need to be access arrangements to allow for stringing points. However, the new overhead line section, establishment of a new cable sealing end tower and addition of an earth wire on the portal sections will be subject to planning permission. With the associated timelines for this and to get the necessary consents in place it is expected that this sub-option would take longer to deliver than the other sub-options. The deliverability of this option is considered as medium.

Option 3 – New 110 kV circuit from Drumnakelly to Tamnamore substations:

- Option 3 proposes approximately 24 km of new overhead line. Cable sections would be required to enter both substations due to congestion, with an allocation of 1 km allowed for at each substation. This is based on the line of sight between both substations. It is not yet clear of the environmental or technical challenges

associated with this option; however, it would be considered that a new circuit would have a greater impact than the other options in the long list.

- In terms of bay availability there is currently one spare bay at Tamnamore, but this option would require two bays in order to connect the new circuit and establish a second bus coupler. A substation extension would be required to extend the existing 110 kV arrangement, including land purchase north of Tamnamore substation and the associated transmission works. This would lead to a longer project timeline for planning permission and to get the necessary landowner consents in place. Additionally, there are no spare bays at Drumnakelly. In order to connect the new circuit a mesh extension would be required. There is sufficient space in the existing substation site to allow this once an existing terminal tower is repositioned. However, these works would be significant and may lead to long outages of the circuits associated with this terminal tower (this tower caters for both the existing Drumnakelly – Tamnamore circuits).
- This option would require two years for construction and would require a number of major outages with associated constraints at both substations due to the substation extensions. The estimated completion date is 2029. However, the timeline for the associated planning requirements could delay the delivery of this project before the 2030. The deliverability of this option is considered as very poor.

<u>Option 4 - Installation of a third interbus transformer at Tamnamore substation:</u>

- Option 4 proposes to establish a third interbus transformer at Tamnamore substation. At present there is currently one spare bay in the 110 kV and 275 kV substations. Due to the number of connections a second bus coupler is required at both substations. Therefore, both substations would require an extension in order to construct new bays for the third interbus transformer connection and second bus coupler connections.
- This would require land purchase to the north of Tamnamore substation which could lead to a longer project timeline for planning permission and to get the necessary landowner consents in place. Additionally, a number of major outages would be required firstly to extend both substation arrangements, then to establish the second bus coupler (which could involve reconfiguring existing connections into particular bays) and finally to then connect the third interbus transformer.
- Lead times for substation plant, in particular transformers, has been greatly affected by the Ukrainian crisis. NIE Networks has informed SONI that new plant may take longer than expected for manufacture and delivery, as companies prepare to prioritise orders for the rebuilding of the Ukrainian Transmission system. The estimated completion date is 2029, however there is a risk that with the associated planning requirements and plant delivery timescales, this option may not be deliverable before 2030. The deliverability of this option is considered as poor.

## Comparison of options from the long list

Table 6 below provides a comparison of the long list of options based on the technical performance, deliverability in the given time frame and to meet the needs of the project and capital cost. SONI considers these criteria as important in rationalising the long list of options. Additional criteria are used to appraise the short list of options including lifecycle (net present) costs over the asset's lifetime. An option with a very good performance is designated a yellow colour and an option with a very poor performance is designated a dark blue colour, as per the key in table 6 below.

Key: **Less favourable** **More favourable**

| Option | Technical performance | Deliverability[11] | Cost of option (£m)[12] |
|---|---|---|---|
| 1 - Do nothing | | N/A | N/A |
| 2a - Restring to 200 MVA only | | | 18.44 |
| 2b - Restring to 250 MVA and use the existing 200 MVA cable sections | | | 23.33 |
| 2c - Restring all sections to 250 MVA | | | 28.0 |
| 2d - Restring to 200 MVA and construct a new OHL section on the A circuit | | | 14.50 |
| 3 – New 110 kV circuit from Drumnakelly to Tamnamore substations | | | 26.05 |
| 4 - Installation of a third interbus transformer at Tamnamore substation | | | 19.53 |

Table 6 - Comparison of options in long list

[11] Technical performance and Deliverability colour scale: very good – yellow; good – light green; medium – dark green; poor – blue; and very poor – dark blue.
[12] Cost of option (£m) colour scale: less than £15m – yellow; between £15m and £20m – light green; between £20m and £25m – dark green; between £25m and £30m – blue; and greater than £30m – dark blue.

## Rejection of options from long list

Based on the criteria shown in the previous section the following options have been rejected from the long list.

Option 3 – New 110 kV circuit from Drumnakelly to Tamnamore substations:

Option 3 would provide a significant additional thermal capacity between Drumnakelly and Tamnamore. However, the option does not reduce windfarm constraints with the level of constraint remaining similar to Option 1 – do nothing. This is because a new circuit would reduce the impedance of the route towards the demand centres in the east therefore increasing the flow from the high renewables' area. This in turn results in heavier loading and potential increased overloads of other Omagh – Tamnamore circuits under continency.

Additionally, with the construction of a new overhead line circuit approximately 24 km in length and the extension of both Tamnamore and Drumnakelly substations the deliverability is considered very poor. The timeline for the associated planning requirements could delay the delivery of this option to well beyond 2030.

From a capital cost perspective this option is the most expensive of the options in the longlist. As a result of the above this option is therefore rejected.

Option 4 - Installation of a new interbus transformer at Tamnamore substation:

Option 4 would provide a significant increase the transformer capacity at Tamnamore substation and improve the reliability of the operational mitigation measure where the existing Drumnakelly - Tamnamore circuits are switched out of service during times of high wind generation. However, windfarm constraints are still high with this option compared to Option 2 – restring existing circuits and it reduces system strength and stability by relying on the operational mitigation measure involving switching out circuits. This could not be relied on as a long-term option. It also leads to a risk of overloading the Tamnamore – Turleenan 275 kV double circuit (once Turleenan and the second North-South interconnector is established – an issue previously noted in the TDPNI). This would need to be addressed in a separate project in a timely manner.

With an extension of both the 110 kV and 275 kV arrangements required in order to make this option feasible the deliverability is considered poor. The lead times for new plant orders, in particular transformers, has been raised by NIE Networks. There is a risk that with the associated planning requirements and plant delivery timescales, this option may not be deliverable before 2030.

The capital cost of this option is lower than some of the options in the longlist, but it is still not comparable with the lowest costing options. As a result of the above this option is also rejected.

# Preliminary appraisal of shortlisted options

## Shortlisted options

The following options are shortlisted for further investigation:

- Option 1 - Do nothing;
- Option 2a - Restring to 200 MVA only;
- Option 2b - Restring to 250 MVA and use the existing 200 MVA cable sections;
- Option 2c - Restring all sections to 250 MVA; and
- Option 2d - Restring to 200 MVA and construct a new OHL section on the A circuit.

## Environmental impact of the options

From an environmental perspective a circuit restring is considered to be less environmental impacting than constructing a new circuit. The options that remain in the shortlist mainly consist of a restring of the existing Drumnakelly – Tamnamore circuits. Option 2 was therefore considered less environmentally impacting than Option 3 – new 110 kV circuit which was rejected from the shortlist.

For sub-options 2a, 2b and 2c there is a requirement for new cable section between Killyman and Tamnamore substation. This which may be via road network and agricultural land. These cable sections are required to replace the existing AP1 and part of the portal sections on the 'A' circuit, and the existing cable sections with Option 2c. Rivers and the M1 motorway would be considered a constraint for new cable sections as they require horizontal directional drilling during the construction stage. SONI and NIE Networks will include for this during detailed design in Part 2 of the Grid development process.

Sub-option 2d proposes a small section (approximately 1.7km) of new overhead line circuit in order to divert the line around Killyman village. This would also result in the existing AP1 and part of the portal sections on the 'A' circuit being recovered. Normally, a new overhead line section would be considered more environmentally impacting than a new cable section. If this option was to be selected an environmental report would be undertaken to assess the impact of this new section and would form part of associated planning application.

## Multi-criteria assessment

Table 7 combines the technical performance, deliverability, capital cost, net present cost and environmental scoring for each of the reinforcement options. The best performing option is Option 2a. For more details see Appendix 2.

Key: Less favourable  More favourable

| Option | Technical Performance | Deliverability | Cost of option (£m) | Net Present Cost (£m)[13] | Environmental Appraisal |
|---|---|---|---|---|---|
| 1 - Do nothing | | N/A | N/A | 191.34 | N/A |
| 2a - Restring to 200 MVA only | | | 18.44 | 107.00 | |
| 2b - Restring to 250 MVA and use the existing 200 MVA cable sections | | | 23.33 | 113.00 | |
| 2c - Restring all sections to 250 MVA | | | 28.0 | 114.11 | |
| 2d - Restring to 200 MVA and construct a new OHL section on the A circuit | | | 14.50 | 102.17 | |

Table 7 - Comparison of options

[13] Net present cost colour scale: less than £100m – yellow; between £100m and £110m – light green; between £110m and £120m – dark green; between £120m and £130m – blue; greater than £130m – dark blue.

# Preliminary preferred option

Sub-option 2a – Restring to 200 MVA only, is selected as preliminary preferred option. This option is the second least cost (estimated at £18.44 million) and has a low net present value cost over a 40-year period (considering the capital costs, wind farm constraints and operation and maintenance). This option performs well in reducing wind farm constraints by providing a significant increase in thermal capacity of the Drumnakelly to Tamnamore 110 kV circuits. Sub-option 2a is considered more deliverable than the lower cost Sub-option 2d, which requires 1.7 km of new overhead line circuit.

However, SONI is requesting that NIE Networks (as part of their preconstruction works) investigate suitable conductors up to a rating of 250 MVA, and the option of a 250 MVA conductor will be reviewed at Part 2.

It is recognised that significant other reinforcements will be required to address the level of renewables expected for the 2030 target (as determined in the Accelerated Ambition (AA) – 80% renewables scenario - particularly in the mid Tyrone and northwest of NI areas on the 110 kV system. Additional projects are described in the SONI Transmission Development Plan, NI (TDPNI).

Selection of the preferred solution and completion of the Part 1 stage of the SONI Grid Development Process was subject to stakeholder engagement.

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# Next steps

This Preliminary Preferred Option Report has been updated following stakeholder engagement with statutory consultees and elected representatives.

The report will be used as the basis for the preparation of the Transmission Network Pre-construction Project (TNPP) submission.

The next steps for the project will be as follows:

- Prepare and submit TNPP;
- Publish decision and accompanying reports on the SONI website;
- Upon approval of TNPP funding commence Part 1 governance steps; and
- Commence Part 2 of the SONI Grid Development Process.

# Stakeholder engagement

SONI has carried out a high-level stakeholder engagement exercise with the local authorities affected by the project. This has allowed the TNPP submission to be finalised and submitted to the Utility Regulator.

The local constituencies that are affected by this project include;

- Upper Bann Constituency;
- Newry and Armagh Constituency; and
- Fermanagh and South Tyrone Constituency.

The local authorities that are affected by this project include:

- Armagh, Banbridge and Craigavon Borough Council; and
- Mid Ulster District Council.

SONI has engaged with these local representatives and authorities to discuss the project and any concerns that may arise.

Wider stakeholder engagement will be carried out in the latter parts of the SONI Grid Development Process[14]. By then SONI and NIE Networks will have carried out investigations into the detailed design requirements of this project. Stakeholder engagement at this stage will help to inform the public of the project proposals and take on board any feedback to help finalise proposals.

## Part 1 stakeholder engagement:

The table collates the main stakeholders that SONI has engaged with for the 'Drumnakelly – Tamnamore 110 kV restring' project. In accordance with SONI's Three Part Process for Grid Development for Northern Ireland this stakeholder engagement was commenced during Part 1 of project development.

The project area encompasses two council areas and three Parliamentary Constituencies. The project team has engaged with each area on separate basis at this stage of the project.

| Parliamentary Constituencies: | Council Areas: |
|---|---|
| Newry and Armagh | Armagh, Banbridge and Craigavon |
| Fermanagh and South Tyrone | Mid Ulster District |
| Upper Bann | |

[14] http://www.soni.ltd.uk/the-grid/grid-development-process/

**Stakeholder Engagement feedback:**

SONI met with elected representatives and planning officials within the project study area along the route of the preliminary preferred option. This engagement took place virtually and SONI has also provided a project summary to stakeholders.

Feedback collated from the stakeholder engagement meetings was analysed and the emergence of seven key themes has been identified. The themes and extracts from the meetings with the stakeholders are outlined below.

In total, nine individual stakeholders were consulted as part of the process; many elected representatives were contacted and offered briefings and we anticipate more meetings will arise following the submission of the TNPP and ahead of our transition to Part 2 of our process[15]. In Part 2 of our process for developing the Grid we identify the extent of any modifications. This will involve meeting with landowners to determine where we will locate any new terminal towers and cable easements. A more extensive public engagement exercise will be required in this part to help finalise our proposals in preparation for our planning application.

We have analysed the emerging key themes from our engagement; the frequency of the issues raised is outlined in Figure 9 below.

The majority of the feedback raised by stakeholders was in relation to any new infrastructure and early engagement with landowners. There was some positive feedback regarding the use of underground cable section to divert around Killyman in preference to an overhead line. However, there was feedback regarding potential difficulties regarding the underground cable going through private land. Finally, there were also some questions regarding the impact of the project on renewable energy target.

[15] https://www.soni.ltd.uk/media/SONIs-Powering-The-Future-Grid-Development-Process-brochure.pdf

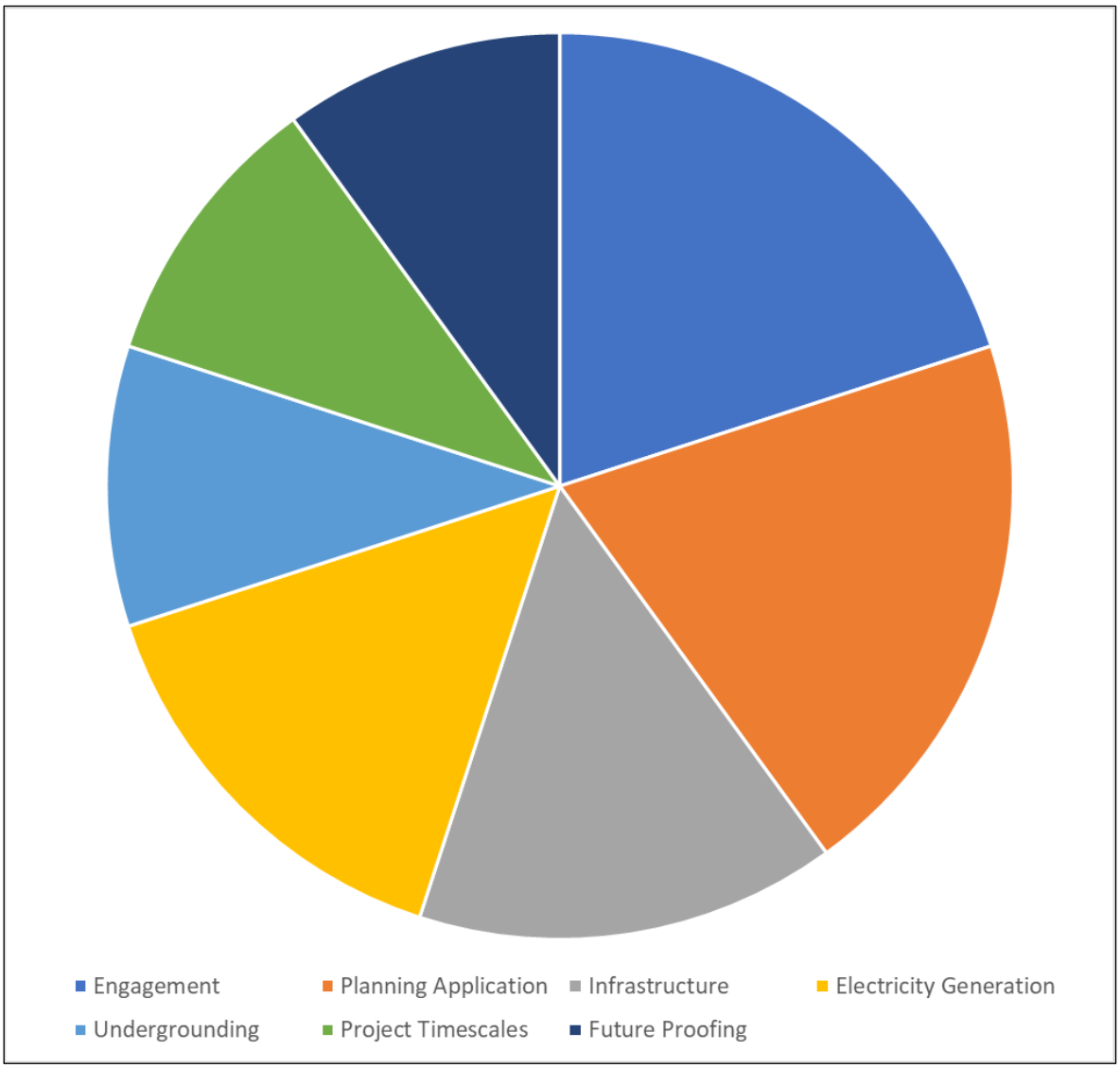


Figure 9 - Key feedback from Part 1 Stakeholder Engagement

# Appendices

# Appendix 1 - Estimated TAO costs for each option

**Option 2a: Restring to 200 MVA only**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Overhead line** | | | |
| Restring towerline section - A circuit | 16.2 | 2.99 | Gap conductor |
| Restring towerline section - B circuit | 16.2 | 2.99 | Gap conductor |
| Restring portal section - A circuit | 3.08 | 0.45 | Invar conductor |
| Restring portal section - B circuit | 4.05 | 0.59 | Invar conductor |
| New cable sealing end tower - A circuit | 1 | 0.09 | For the new 200 MVA cable connection to the existing OHL |
| Portal circuit section removal | 1 | 0.30 | Removal of part of portal section from A circuit (0.86km) |
| AP1 circuit section removal | 1 | 0.30 | Removal of AP1 section from A circuit (1.37km) |
| Earthwire with fibre/Comms provision - double circuit section | 16.2 | 0.76 | Replacement of existing earthwire on double circuit towerline with OPGW |
| Earthwire with fibre/Comms provision - Portal sections A circuit | 3.08 | 0.18 | Earthwire installation on portal sections - earthwire upstand brackets installed and earthwire added in restring |
| Refurb existing towerline and portal sections for restring works | 1 | 1.72 | Approx. cost estimate for double circuit towerline and portal section foundation replacements - based off recent transmission projects |
| | | | |
| **Cable sections** | | | |
| New 200 MVA cable section - A circuit | 2.89 | 3.74 | new cable to replace AP1 and portal sections |
| Cable joint between new and existing 200 MVA cables | 1 | 0.09 | Approx. cost of cable joint |
| Directional drill under motorway | 1 | 0.55 | Directional drilling for new cable section under motorway |
| Fibre/Comms provision - A circuit | 4.07 | 0.24 | Assumes Fibre/Comms added to existing cable duct for A circuit (4.07km) |
| | | | |
| **Undercrossings** | | | |
| 33 kV undercrossings - A circuit | 3 | 0.18 | |
| 33 kV undercrossings - B circuit | 3 | 0.18 | |
| 11 kV undercrossings - A circuit | 23 | 0.69 | |
| 11 kV undercrossings - B circuit | 24 | 0.72 | |
| | | | |
| **Estimate of TAO costs** | | **16.76** | |
| | | | |
| Contingency (10%) | | 1.68 | |
| **Total** | | **18.44** | |

Figure A1-1- Option 2a cost estimate

**Option 2b: Restring OHL to 250 MVA, but keep existing 200 MVA cable sections**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Overhead line** | | | |
| Restring towerline section - A circuit | 16.2 | 4.70 | Oslo conductor |
| Restring towerline section - B circuit | 16.2 | 4.70 | Oslo conductor |
| Restring portal section - A circuit | 3.08 | 0.89 | Oslo conductor |
| Restring portal section - B circuit | 4.05 | 1.17 | Oslo conductor |
| New cable sealing end tower - A circuit | 1 | 0.09 | For the new 200 MVA cable section connection to the existing portal section |
| Portal circuit section removal | 1 | 0.30 | Removal of part of portal section from A circuit (0.86km) |
| AP1 circuit section removal | 1 | 0.30 | Removal of AP1 section from A circuit (1.37km) |
| Earthwire with fibre/Comms provision - double circuit section | 16.2 | 0.76 | Replacement of existing earthwire on double circuit towerline with OPGW |
| Earthwire with fibre/Comms provision - Portal sections A circuit | 3.08 | 0.18 | Earthwire installation on portal sections - earthwire upstand brackets installed and earthwire added in restring |
| Refurb existing towerline and portal sections for restring works | 1 | 1.72 | Approx. cost estimate for double circuit towerline and portal section foundation replacements - based off recent transmission projects |
| | | | |
| **Cable sections** | | | |
| new 200 MVA cable section - A circuit - rural | 2.89 | 3.74 | new cable to replace AP1 and portal sections |
| Cable joint between new and existing 200 MVA cables | 1 | 0.09 | Approx. cost of cable joint |
| Directional drill under motorway | 1 | 0.55 | Directional drilling for new cable section under motorway |
| Fibre/Comms provision - A circuit | 4.07 | 0.24 | Assumes Fibre/Comms added to existing cable duct for A circuit (4.07km) |
| | | | |
| **Undercrossings** | | | |
| 33 kV undercrossings - A circuit | 3 | 0.18 | |
| 33 kV undercrossings - B circuit | 3 | 0.18 | |
| 11 kV undercrossings - A circuit | 23 | 0.69 | |
| 11 kV undercrossings - B circuit | 24 | 0.72 | |
| | | | |
| **Estimate of TAO costs** | | **21.21** | |
| | | | |
| Contingency (10%) | | 2.12 | |
| **Total** | | **23.33** | |

Figure A1-2 - Option 2b cost estimate

**Option 2c: Restring to 250 MVA - OHL and cable all 250 MVA**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Overhead line** | | | |
| Restring towerline section - A circuit | 16.2 | 4.70 | Oslo conductor |
| Restring towerline section - B circuit | 16.2 | 4.70 | Oslo conductor |
| Restring portal section - A circuit | 3.08 | 0.89 | Oslo conductor |
| Restring portal section - B circuit | 4.05 | 1.17 | Oslo conductor |
| New cable sealing end tower - A and B circuit | 2 | 0.18 | For the new 250 MVA cable section connection to the existing portal sections |
| Portal circuit section removal | 1 | 0.30 | Removal of part of portal section from A circuit (0.86km) |
| AP1 circuit section removal | 1 | 0.30 | Removal of AP1 section from A circuit (1.37km) |
| Earthwire with fibre/Comms provision - double circuit section | 16.2 | 0.76 | Replacement of existing earthwire on double circuit towerline with OPGW |
| Earthwire with fibre/Comms provision - Portal sections A circuit | 3.08 | 0.18 | Earthwire installation on portal sections - earthwire upstand brackets installed and earthwire added in restring |
| Refurb existing towerline and portal sections for restring works | 1 | 1.72 | Approx. cost estimate for double circuit towerline and portal section foundation replacements - based off recent transmission projects |
| | | | |
| **Cable sections** | | | |
| new 250 MVA cable section - A circuit - rural | 4 | 5.84 | Approx. estimate of 250 MVA cable |
| new 250 MVA cable section - B circuit - rural | 1.4 | 2.04 | Approx. estimate of 250 MVA cable |
| Directional drill under motorway | 1 | 0.55 | Directional drilling for new cable section under motorway |
| Fibre/Comms provision - A | 5.84 | 0.35 | Assumes Fibre/Comms added to new cable ducts for A circuit (5.84km) |
| | | | |
| **Undercrossings** | | | |
| 33 kV undercrossings - A circuit | 3 | 0.18 | |
| 33 kV undercrossings - B circuit | 3 | 0.18 | |
| 11 kV undercrossings - A circuit | 23 | 0.69 | |
| 11 kV undercrossings - B circuit | 24 | 0.72 | |
| | | | |
| **Estimate of TAO costs** | | **25.46** | |
| | | | |
| Contingency (10%) | | 2.55 | |
| **Total** | | **28.00** | |

Figure A1-3 - Option 2c cost estimate

**Option 2d: Restring to 200 MVA - replace A circuit from Killyman with new twin portal OHL**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Overhead line** | | | |
| Restring towerline section - A circuit | 16.2 | 2.99 | Gap conductor |
| Restring towerline section - B circuit | 16.2 | 2.99 | Gap conductor |
| Restring portal section - A circuit | 3.09 | 0.45 | Invar conductor (from bonds bridge to new diversion short of Killyman/Laghey Corner) |
| Restring portal section - B circuit | 4.05 | 0.59 | Invar conductor |
| New 230 MVA Portal section | 1.7 | 0.78 | New Portal OHL section - approx 1.7km diversion to existing cable section. Includes earthwire with Comms |
| New cable sealing end tower - A circuit | 1 | 0.09 | For the new OHL connection to the existing 200 MVA cable section |
| Portal circuit section removal | 1 | 0.30 | Removal of part of portal section from A circuit (0.86km) |
| AP1 circuit section removal | 1 | 0.30 | Removal of AP1 section from A circuit (1.37km) |
| Earthwire with fibre/Comms provision - double circuit section | 16.2 | 0.76 | Replacement of existing earthwire on double circuit towerline with OPGW |
| Earthwire with fibre/Comms provision - Portal section A circuit | 4.78 | 0.29 | Earthwire installation on portal sections - earthwire upstand brackets installed and earthwire added in restring |
| Refurb existing towerline and portal sections for restring works | 1 | 1.72 | Approx. cost estimate for double circuit towerline and portal section foundation replacements - based off recent transmission projects |
| | | | |
| **Cable sections** | | | |
| Cable joint between new and existing 200 MVA cables | 1 | 0.09 | Approx. cost of cable joint |
| Fibre/Comms provision - A circuit | 1.18 | 0.07 | Assumes Fibre/Comms added to existing cable duct for both A circuit (1.18km) |
| | | | |
| **Undercrossings** | | | |
| 33 kV undercrossings - A circuit | 3 | 0.18 | |
| 33 kV undercrossings - B circuit | 3 | 0.18 | |
| 11 kV undercrossings - A circuit | 23 | 0.69 | |
| 11 kV undercrossings - B circuit | 24 | 0.72 | |
| | | | |
| **Estimate of TAO costs** | | **13.18** | |
| | | | |
| Contingency (10%) | | 1.32 | |
| **Total** | | **14.50** | |

Figure A1-4 - Option 2d cost estimate

**Option 3: New 110 kV circuit Drumnakelly - Tamnamore**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Substation works** | | | |
| Equip one bay (Tamnamore) | 1 | 0.30 | For the new circuit |
| Land purchase North of Tamnamore - substation extensions | 1 | 0.50 | approx. |
| Pre-enabling and diversion of sterile zone at Tamnamore | 1 | 0.35 | |
| Pre-enabling and diversion of pallisade fencing at Drumnakelly | 1 | 0.35 | |
| 110 kV double busbar extension at Tamnamore | 1 | 1.11 | Double busbar extension at Tamnamore |
| New 110 kV AIS bays - Tamnamore | 1 | 0.86 | For new 110 kV bus coupler bay |
| New 110 kV bus section switches | 4 | 1.32 | |
| 110 kV mesh extension at Drumnakelly and 1 bay equipped | 1 | 1.11 | Mesh extension for 2 new bays, 1 equipped for new circuit connection |
| reposition terminal tower at Drumnakelly | 1 | 1.33 | approx. |
| Protection costs | 7 | 0.54 | 6 x Tamnamore, 1 x Drumnakelly |
| | | | |
| **Overhead line** | | | |
| 230 MVA Portal line | 24 | 11.06 | Zebra conductor |
| | | | |
| **Cable sections** | | | |
| Substation entry - Tamnamore - 250 MVA cable - rural | 1 | 1.46 | Approx. estimate of 250 MVA cable - rural |
| Substation entry - Drumnakelly - 250 MVA cable - urban | 1 | 2.19 | Approx. estimate of 250 MVA cable - urban |
| Sealing ends | 4 | 0.35 | |
| | | | |
| **Undercrossings** | | | |
| 33 kV undercrossings | 6 | 0.36 | Based on the line of sight between Drumnakelly and Tamnamore substations |
| 11 kV undercrossings | 17 | 0.51 | Based on the line of sight between Drumnakelly and Tamnamore substations |
| | | | |
| **Estimate of TAO costs** | | **23.68** | |
| | | | |
| Contingency (10%) | | 2.37 | |
| **Total** | | **26.05** | |

Figure A1-5 - Option 3 cost estimate

**Option 4: New interbus transformer at Tamnamore**

| Item Description | No | £m | Comments |
|---|---|---|---|
| | | | |
| **Substation works** | | | |
| Land purchase North and South of Tamnamore for substation extensions | 1 | 1.00 | approx. |
| Pre-enabling and diversion of sterile zone at Tamnamore | 1 | 0.35 | |
| New 275/110 kV interbus transformer (including cabling) | 1 | 5.48 | |
| Equip one 110 kV bay (Tamnamore) | 1 | 0.30 | For new interbus transformer |
| 110 kV double busbar extension at Tamnamore | 1 | 1.11 | |
| Equip one 275 kV bay (Tamnamore) | 1 | 0.50 | For new interbus transformer |
| 275 kV double busbar extension at Tamnamore | 1 | 1.11 | |
| New 110 kV AIS bay | 1 | 0.86 | For new 110 kV bus coupler |
| New 275 kV AIS bay | 1 | 1.43 | For new 275 kV bus coupler |
| New 110 kV bus section switches | 4 | 1.32 | |
| New 275 kV bus section switches | 4 | 2.20 | |
| Protection 110 kV | 6 | 0.46 | IBTX, new bays and devices |
| Protection 275 kV | 6 | 1.65 | IBTX, new bays and devices |
| | | | |
| **Estimate of TAO costs** | | **17.76** | |
| | | | |
| Contingency (10%) | | 1.78 | |
| **Total** | | **19.53** | |

Figure A1-6 - Option 4 cost estimate

# Appendix 2 - Net Present Cost Assessment and Assumptions

| Assumption | Option | | | | | | |
|---|---|---|---|---|---|---|---|
| | *1 – Do nothing* | *2a - Restring to 200 MVA only* | *2b - Restring to 250 MVA and use the existing 200 MVA cable sections* | *2c - Restring all sections to 250 MVA* | *2d - Restring to 200 MVA and construct a new OHL section on the A circuit* | *3 - New 110 kV circuit from Drumnakelly to Tamnamore* | *4 - Installation of a third interbus transformer at Tamnamore substation* |
| Capital Cost of Assets | - Asset replacement in 2035 - £12.24m | £18.44m | £23.33m | £28.0m | £14.50m | £26.05m Asset replacement in 2035 - £12.24m | £19.53m Asset replacement in 2035 - £12.24m |
| Duration of construction | - | 2 years, starting in 2027 | 2 years, starting in 2027 | 2 years, starting in 2027 | 2 years, starting in 2027 | 2 years, starting in 2028 | 2 years, starting in 2028 |
| Estimated Completion Date and Energisation | - | 2028 | 2028 | 2028 | 2028 | 2029 | 2029 |
| TSO costs | - | £3.69m | £4.67m | £5.60m | £2.90m | £5.21m | £4.11m |
| Operation and Maintenance (Based on 1.3% capital value) | - £90k after 2035 | £240k | £300k | £360k | £190k | £340k £500k after 2035 | £250k £410k after 2035 |
| Wind constraint costs | £3.64m until 2028 and £3.95m for 2029. £10.16m after 2030 | £3.64m until 2028. Then £0.83m for 2029 and £3.96m after 2030 | £3.64m until 2028. Then £0.83m for 2029 and £3.96m after 2030 | £3.64m until 2028. Then £0.80m for 2029 and £3.66m after 2030 | £3.64m until 2028. Then £0.83m for 2029 and £3.96m after 2030 | £3.64m until 2028. Then £3.95m for 2029 and £10.2m after 2030 | £3.64m until 2028. Then £3.95m for 2029 and £5.68m after 2030 |
| TOTAL NET PRESENT COST | £191.34m | £107.00m | £113.00m | £114.11m | £102.17m | £222.87m | £145.93m |