BELFAST METROPOLITAN REDEVELOPMENT PROJECT

(CARNMONEY TO CASTLEREAGH)

PRELIMINARY PREFERRED OPTIONS REPORT

January 2020

SONI

Approval SONI

Title	Version	Name	Signature	Date
Author	1	Michael McClure	PM up to 27/1/20	27/1/20
Author	1	Rónán Davison-Kernan	PM from 27/1/20	30/10/20
Reviewer	1	Raymond Smyth	Approved by email	30/10/20
Approver	1	Arthur Moynihan	Approved by email	30/10/20

Revision

Date	Version	Summary of Changes	
27/01/2021	1	Final version issued	

CONTENTS

SUMMARY

A case of need report has been prepared in relation to the Castlereagh – Eden section of the Ballylumford - Castlereagh 110 kV double circuit.

Work required along the double circuit is being considered in four sections:

- Ballylumford to Eden;
- Eden to Carnmoney;
- Carnmoney to Finaghy; and
- Finaghy to Castlereagh

The refurbishment of the Ballylumford - Eden section of the tower line, with Upas conductor, has been approved in principle by the Utility Regulator through the SONI TNPP process. This section is currently with NIE Networks for detailed design with work expected to be completed in 2022.

SONI is also preparing a Preliminary Preferred Options Report and TNPP for the Eden – Carnmoney section of the line. It is planned that that this section will also be refurbished with a number of spans undergrounded.

The double circuit was constructed in 1943 to connect Ballylumford Power Station on Islandmagee to supply several 110 kV bulk supply points operated by the Electricity Board for Northern Ireland. The circuits also formed part of the initial transmission system in Northern Ireland. Since the construction of the 275 kV network in the 1960s, the primary purpose of the double circuit is to provide a 110 kV backfeed into Castlereagh 275/110 kV grid supply point and supply Eden and Carnmoney substations.

Given its age of 77 years, the double circuit has a number of condition issues, including:

- The Steel Cored Copper (SCC) conductor on the 'B' circuit was assessed to be at end of life;
- The Cadmium Copper (CAD) conductor on the 'A' circuit was assessed to be within 10 years of service life (report dated 2016);
- Corrosion of certain sections of steelwork on towers and
- Foundation issues, including expected honeycombing and spalling as well as expected mechanical loading issues on numerous foundations.

Due to the relatively low capacity of the conductors on the double circuit and the capacity used to supply Eden and Carnmoney substations, the capacity that remains to provide a level of resupply to Castlereagh is limited to approximately 70 MVA. This is used during the summer maintenance season to facilitate necessary transformer outages. This is the only 110kV backfeed into Castlereagh substation but its capacity relative to the demand at Castlereagh is poor.

Since the tower line was constructed, the city of Belfast and other surrounding towns have expanded. As a result, sections of the tower line are now in an urban environment and traverses many residential areas. In some cases, towers have become effectively landlocked by housing. The double circuit also crosses many busy transport links, including both the M1 and M2 motorways. Access to towers to carry out major refurbishment works would be disruptive to residents and commuters.

This report focuses on the issues and solutions relating to the two sections between Carnmoney and Castlereagh. At this stage, the preliminary preferred option is to:

- Connect Tx 4 at Castlereagh;
- Establish a temporary (normally open) connection at Finaghy between the Castlereagh – Finaghy circuit and the Finaghy – Donegall circuit;
- Recover Finaghy – Carnmoney 110 kV tower line;
- Procure sites and establish GIS 110 kV switchboards at Belfast North Main and Belfast Central;
- Establish a double circuit 110 kV cable connection between Belfast North Main and
- Recover towerline from Castlereagh – Finaghy.

1 INTRODUCTION

The Electricity Board for Northern Ireland (EBNI) constructed a double circuit 110 kV tower line in 1943 between Ballylumford Power Station in Islandmagee and Rosebank Main in East Belfast (Figure 1.1). The tower line also supplied Eden, Carnmoney, and Finaghy bulk supply points along the route. This formed part of the original transmission system for Northern Ireland.

In the late 1960s the 275 kV system was constructed in Northern Ireland. As part of this project, the 110 kV double circuit was diverted into the newly constructed Castlereagh grid supply point. In the late 1990s the transmission system around Belfast was further reconfigured. As part of this project, Finaghy Main was disconnected from the tower line and connected directly via new 110 kV cables to Hannahstown 275/110 kV grid supply point. Since that work was completed, the double circuit has served to supply load at Eden Main and Carnmoney Main as well as provide a 110 kV feed to Castlereagh.

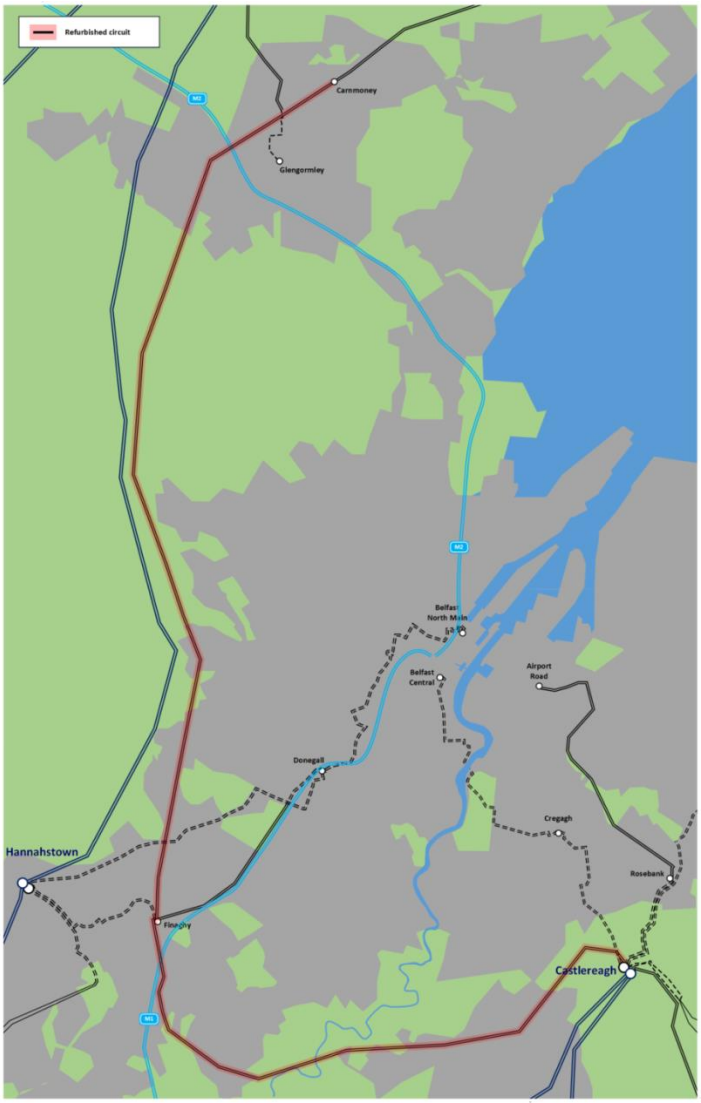


Figure 1.1: Existing 110 kV double circuit route

The tower line is now 77 years old with condition assessments progressed. An assessment in 2016 found the conductor on the 'B' circuit (composed of steel-cored copper) to be at end of life, while the conductor on the 'A' circuit (made from cadmium copper) was found to be within 10 years of end of life. Subsequent assessment (detailed below) has found degradation of towers and concrete foundations along the route. The condition of the conductor and towers, along with the low capacity of the circuits (supplying only a maximum of 70 MVA to Castlereagh during summer) mean that there is an urgent need to address the issues with the tower line.

This report is focussed on the Carnmoney – Castlereagh section of the double circuit tower line, considering it in two sections:

- Carnmoney to Finaghy; and
- Finaghy to Castlereagh.

These two sections form the most challenging portion of the route (The Ballylumford – Eden section of the double circuit is due for replacement by 2022, and Eden - Carnmoney will be discussed separately). This section is particularly challenging for the following reasons:

- A significant amount of urban development has occurred in the path of the tower line since its construction, with houses being built in very close proximity to towers - rendering some effectively landlocked;
- The line crosses several busy transport links, including the M2 and M1 motorways, and the Belfast – Lisburn railway line; and
- The line crosses the Lagan Valley Regional Park, an Area of Outstanding Natural Beauty, near Shaw's Bridge.

These access issues make refurbishment of the double circuit particularly challenging. This is considered in detail in the report.

The risk of a High Impact, Low Probability (HILP) event at Castlereagh is also considered. Such an event [redacted] and can only be mitigated [redacted] e double circuit cannot be removed without reinforcement elsewhere. In addition to this, projected load increases in Belfast city centre will necessitate reinforcement.

In this report, the feasibility of refurbishing the existing tower line is assessed, as well as alternative options which involve either the full or partial removal of the double circuit and construction of new substations and cable circuits which provide a connection between Hannahstown and Castlereagh. The results of technical, economic, deliverability and socio-economic studies are presented, and a preliminary recommendation, based on the information available at present, is made on the preferred option.

Environmental constraint mapping has been carried out on all options shortlisted in this report by RPS on behalf of SONI (see Appendix I). SONI have also engaged with NIE Networks and the Utility Regulator on this project ahead of submission of the TNPP, and will shortly be engaging with the local authorities and elected representatives affected.

2 FEASIBILITY OF REFURBISHING THE DOUBLE CIRCUIT

SONI engaged an overhead line specialist consultant, LS Transmission Consultancy Limited (LSTC[1]), to assess how a refurbishment of the double circuit could be carried out. The consultant performed a tower by tower assessment, noting the work required and any difficulties likely to be encountered in terms of stringing and foundation refurbishment. The findings for each tower were provided to SONI, showing an aerial view. This report is included as Appendix A. Tower access assessments can be seen in Appendix B.

SONI also requested LSTC to provide an independent estimate of the costs to either refurbish or recover the tower line. The scope provided by SONI included the requirement to provide cost estimates for several options which included partial refurbishment and recovery of the tower line. LSTC subcontracted this work to NorPower Overhead Line Services[2]. NorPower Overhead Line Services have extensive experience in Great Britain of the refurbishment of similar 132 kV double circuit tower lines, as documented on their website. The NorPower report is also included in Appendix A.

2.1 Tower steelwork and foundations

To gain an understanding of the scale of work required to foundations, an assessment of intrusive inspections at 8 towers, including foundations, along the Castlereagh to Finaghy section was used. This found the following issues:

- Some degree of spalling or honeycombing was present within the foundations at the majority of the assessed towers.
- Varying degrees of steelwork corrosion was observed at all towers, with some steelwork replacement necessary.

Based on these inspections it is concluded that all foundations are defective to some extent and would require intrusive inspection and/or remediation if the circuit were to be refurbished

The LSTC report finds that foundation assessment or remediation at 13 towers on the Castlereagh to Finaghy section would involve considerable disruption to landowners, including land damage in gardens and drives. A further 21 towers along the Carnmoney to Finaghy section would incur similar disruption.

For the rural areas the tower line the NorPower has assumed a raft type foundation would be installed. This is the method chosen to reinforce foundations of similar 132 kV tower lines in Great Britain.

[1] https://www.lstc.co.uk/
[2] http://norpower.co.uk/

In cases where space is limited for access with plant and removal of earth the tower foundation could, if necessary and practical, be reinforced by installing piles at each tower corner and a reinforced concrete ring beam around the base of the tower, as indicated in Figure 2.1. However, even with this less intrusive solution, equipment including a mini-pile plant and excavator would be required on site. Materials such as casings and concrete would also be required on site. In extreme cases, such as land locked sites, equipment and materials would need to be lifted over rooftops by a mobile crane into land locked sites. Contractors would also require security and welfare provision.

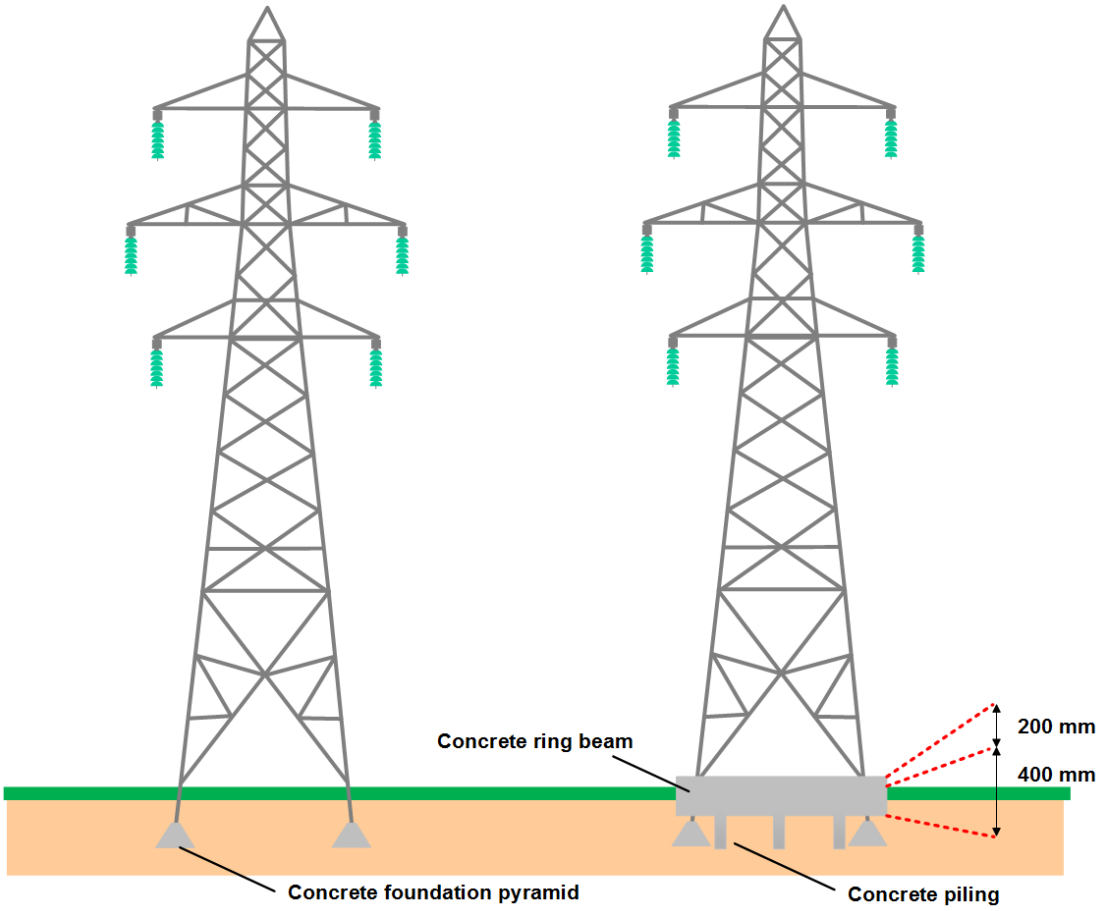


Figure 2.1: Tower foundation reinforcement

The social and environmental impact of this remediation method must also be considered.

As shown in figure 2.1, up to 20 cm of the ring beam would exist above the surface. This may have implications for planning permission and may complicate the renewal of wayleaves, or the establishment of Necessary Wayleaves and may instead, given the changes to the nature of the equipment on the land, require an easement.

Additionally, a drive-through inspection by LSTC along the Castlereagh to Finaghy section noted many towers showing signs of corrosion on individual sections. Corroded sections would be cut away and replaced with new pre-manufactured sections of steelwork. For landlocked sites these

would need to be lifted into place, by mobile crane over rooftops. Removed corroded sections would also have to be removed in a similar manner.

The environmental report in Appendix I also highlights that this line passes through the Belfast Hills, Clement Wilson Park and Lagan Meadows Sites of Local Nature Conservation Importance (SLNCI) as well as the Belvoir Area of Specific Scientific Interest (ASSI). It also passes over two salmon rivers. Access to these areas for the heavy equipment required for refurbishment would be challenging and require significant mitigation measures to prevent damage.

In conclusion there will be considerable work required to steelwork and foundations in any project to refurbish this tower line. This would lead to significant disruption and is a consideration regarding the practicality of in situ refurbishment.

2.2 Stringing issues

If it was found necessary and practical to do so, a refurbishment would include the replacement of the existing conductors with Upas (300 mm^2 AAAC). This conductor is already planned for the Ballylumford to Eden section of the double circuit which is at the detailed design stage.

Whilst NIE Networks has previously had the conductors on this circuit assessed, LSTC recommended that, as part of any detailed design works for the restring of the existing tower line, an updated condition assessment of the existing conductors would be required.

NorPower recommended that in order to minimise the risk of the existing conductor breaking during any restring, each phase of the existing conductor would initially be used to pull through a 16mm anti twist wire rope which is lighter and stronger. This rope would then be used to pull through the heavy Upas conductor. In addition scaffolding would be required at major road crossings and a cradle support system at other urban areas where scaffolding is not feasible. Stringing is considered to be complex where angle towers are surrounded by residential development and square rigging procedures would be required.

The following are the key issues identified by NorPower associated with the restringing element of a refurbishment of the tower line:

Castlereagh to Finaghy section:

- There are 14 critical road and rail crossings which would require scaffolding; and
- There are 10 spans which would have clearance infringements with a higher rated conductor (operated at 75ºC), which would need to be addressed through mitigation measures[3].

[3] This is mostly by installing weights or semi-tension sets on suspension towers to prevent excessive conductor swing under high wind. Vegetation management would also be required.

Carnmoney to Finaghy section

- There are 17 road crossings that would require scaffolding including the M2 and slip roads at Sandyknowes roundabout; and
- There are also 11 spans that would have clearance infringements with a higher rated conductor (operated at 75ºC), which would need to be addressed through mitigation measures.

The replacement of the conductor on the Castlereagh to Finaghy and Carnmoney to Finaghy sections would be very challenging regarding ensuring access, establishing scaffolding work at major road crossings and special work methods at difficult stringing positions. Restringing the tower line, whilst not impossible, would be extremely difficult.

2.3 Cost of refurbishment

Based on its tower by tower assessment, NorPower provided a detailed estimate of the total cost of refurbishing the double circuit. The costs took the following into consideration:

- An estimate of the costs of tower foundation remedial works as well as replacement of sections of tower steelwork and restringing;
- An estimate of traffic management and scaffolding costs including design for restringing over public roads;
- A cost estimate for appropriate work methods to ensure the safety of both the general public and landowners;
- An estimate of all labour and CDM costs; and
- A high level estimate of the likely cost of compensation for disruption and remediation of land damage.

A number of assumptions were used by the consultant:

- All CDM costs are based on current best practice;
- Where materials, equipment and work sites are likely to require overnight storage, an allowance for 24 hour security has been included;
- Where access routes to towers are to be established, the shortest distance was used;
- On towers where a crane would be required, its operation would restrict access to several properties at a time;
- The full refurbishment of foundations and towers in certain areas is expected to take four weeks per tower. During this time the work area would need to be delimited and secured. In the event where dwelling houses are considered inside the work area these properties would

ideally require to be vacated. For some towers, the tower legs are in four separate properties, so these properties would all be affected; and

- A daily assumed compensation cost for impacted residents has been assumed on a per-property basis.

Table 2.1 shows the cost for the refurbishment of both the Carnmoney to Finaghy and Castlereagh to Finaghy sections. The costs represent a best estimate at this stage.

Table 2.1: Estimated cost of refurbishment of Carnmoney to Castlereagh

Element	Cost (£m)
Refurbishment of Carnmoney to Finaghy section	11.2
Refurbishment of Castlereagh to Finaghy section	7.3
Total	**18.5**

3 FEASIBILITY OF DECOMMISSIONING AND REMOVING THE DOUBLE CIRCUIT

3.1 Impact of removal on the network

As discussed in the case of need, the Carnmoney to Castlereagh double circuit provides resupply to Castlereagh substation. This circuit supplies a portion of the demand at Castlereagh under transformer outage conditions and is required to allow the annual maintenance of transformers. The circuits also provide a degree of resupply in the event of a High Impact Low Probability (HILP) event such as the loss of the 275 kV infeed or transformer capacity at Castlereagh. Decommissioning the double circuit without replacement of the above functionality in some other way would be unacceptable as it would compromise security of supply.

3.2 Recovery of the circuit

Assuming that the resupply can be provided in another way the actual recovery of the circuit or sections thereof is a significant project. The recovery of the tower line would be in stages, starting with the removal of the conductor and then the towers.

To remove the conductor, a pilot 16mm anti-twist wire rope would be pulled through to maintain tension. The rope would then be lowered and removed in pieces. For major road crossings scaffolding and in some cases a cradle system would also be required to allow conductor and pilot rope to be safely recovered.

For towers that are being recovered, the process of removal would depend on the level of access. Towers with relatively easy access would be removed in larger sections using a mobile crane. Where towers are land locked the towers would be removed by crane, top down in smaller sections. If it was not possible to obtain access for a crane, the tower would be cut into smaller pieces and removed from site manually.

There would be a decision in regard to steelwork and foundation materials below ground level which would probably depend on the site and the views of the land owners. The preferred approach, particularly in sites with nearby dwellings or other buildings, would be to cut the tower legs 0.5m below ground level and reinstate the surface. The concrete stub/pyramid type foundation for each corner would be left in situ. This would ultimately involve the least disruption and damage. For towers that are accessible for plant and whereby there is unlikely to be damage to neighbouring property, the foundations could be removed and the ground reinstated; however, this would involve excavation of a significant quantity of earth.

The duration of the work to remove the double circuit from impacted residents and landowners would be much shorter than the work associated with refurbishment.

Recovery of the tower line would result in temporary disruption. However this would be significantly lower than that for refurbishment. In addition recovery of each tower would allow the respective land owners the reuse of the land vacated. Finally the removal of the towers and conductor would also allow other potential development projects in the area to proceed unimpeded. Over the long term this is likely to also be beneficial to customers as the cost of alterations would be avoided.

Removal of the tower line would require access to the same environmentally sensitive areas as for refurbishment highlighted in Appendix I. However, the works being undertaken and the heavy machinery required to do so would be significantly less onerous than for refurbishment. Removal would also remove the impact of the presence of the line (and future maintenance works) on these areas and rpvode a long-term environmental benefit.

3.3 Cost of removal

Based on its tower by tower assessment, NorPower provided a detailed estimate of the total cost to remove the tower line. The costs took the following into consideration:

- An estimate of traffic management and scaffolding costs including design for conductor removal over public roads;
- A cost estimate for appropriate work methods to ensure the safety of both the general public and landowners;
- An estimate of the costs of tower removal, including where crane hire is necessary;
- An estimate of all labour and CDM costs; and
- An estimate of the scrap value of towers.

Table 3.1 shows the costs for the removal of both the Carnmoney to Finaghy and Castlereagh to Finaghy sections. The costs represent a best estimate at this stage.

Table 3.1: Estimated cost of decommissioning and removal of Carnmoney to Castlereagh

Element	Cost (£m)
Removal of Carnmoney to Finaghy section	3.8
Removal of Castlereagh to Finaghy	2.7
Removal of elements within substation	0.1
Total	**6.6**

As shown, the removal cost is approximately one third of the price of the refurbishment work.

4 REINFORCEMENT OPTIONS

4.1 Long list of options

The previous sections have noted the considerable complexities and issues involved in refurbishing the double circuit. A long list of options has therefore been developed. These options range from refurbishment in situ, to introducing reinforcements to allow partial and complete removal. Alternative methods to ensure a 110 kV supply to Castlereagh to cater for maintenance outages and high impact low probability scenarios are also included.

The long list of 14 options, including indicative capital costs, is displayed in Table 4.1.

As part of a separate project there is a plan to install two shunt reactors on tertiary windings of interbus transformers at Castlereagh. All options which include installation of a 4th Interbus transformer at Castlereagh also include for installation of one of these shunt reactors on the tertiary winding of this transformer in order to rationalise construction works at Castlereagh. In order to allow for a fair comparison of options, all options which do not include a 4th transformer include costs for installation of a shunt reactor on one of the other transformers at Castlereagh.

Table 4.1: Long list of reinforcement options

Option	Description	Cost (£m)
1	Refurbishment of entire circuit	21
2	Install 4th IBTx and remove Carnmoney to Castlereagh double circuit	12
3a	Sailortown reinforcement	32
3a+	Sailortown reinforcement with alternate Donegall configuration	39
3b	East City Centre reinforcement	37
3c	Belfast Central reinforcement	35
4	Blacks Road reinforcement (Dunmurry Link)	25
5a	Glencairn 110 kV termination, cable to Finaghy	41
5b	Glencairn 110 kV termination, cable to Finaghy and connect in Lisburn	48
5c	Glencairn 110 kV termination, cable to BNM and Belfast Central	47
5d	Glencairn 110 kV termination, cable to Donegall and East City Centre	51
5e	Glencairn 110 kV termination, cable to Donegall and Belfast Central	51

5f	Glencairn 110 kV termination, cable to Donegall, BNM and Belfast Central	62
6	Hybrid phasing of Options 2 and 3a	36

4.2 Rationalising the long list

Each option was modelled in PSSE and found to comply with the minimum requirements of the planning standards. To reduce the length of the long list the power flow from the PSSE analysis was considered along with the capital cost for each option.

Options 5a - 5f were rejected as the resulting configuration and power flow associated with these options is very similar to option 3 and 4, however the capital costs are considerably greater.

4.3 Short list of options

Table 4.2 details the short list of eight options that will be assessed in detail to ultimately determine a preferred option.

Table 4.2: Short list of reinforcement options

Option	Description
1	Refurbishment of entire circuit
2	Connect 4th IBTx and remove Carnmoney to Castlereagh double circuit
3a	Sailortown reinforcement
3b	East City Centre reinforcement
3c	Belfast Central reinforcement
4	Blacks Road reinforcement (Dunmurry Link)
5	Hybrid phasing of Options 2 and 3a (4th IBTx at Castlereagh and Sailortown Reinforcement)

4.4 High Level Description of the shortlisted options

4.4.1 Option 1: Circuit refurbishment (£21.4m)

This option is based on refurbishing the tower line from Castlereagh to Carnmoney, see Figure 1.1, at a cost of £21.4m (See Appendix C). This would include:

- Upas conductor, giving a minimum rating of 144 MVA;
- Remedial works to all tower foundations; and
- Replacement of some sections of steel work.

4.4.2 Option 2: Connect Tx 4 and recover tower line (£11.5m)

This option is based on providing additional transformer capacity (connection of Tx 4) at Castlereagh to allow the tower line to be recovered. The estimated cost for this option is £11.5m (see Appendix C). This includes £6.55m to recover the tower line from Castlereagh to Carnmoney.

4.4.3 Option 3: Establish reinforcement through Belfast to allow tower line to be recovered (£32.2m - £36.8m)

Option 3 is based on establishing a 110 kV link between Hannahstown and Castlereagh. This would establish the necessary resupply to Castlereagh and allow the tower line to be recovered. The main option has three variants:

- Option 3a – Underground cable connection between Belfast Central Main and Belfast North Main (Sailortown link), replacement of Donegall to Belfast North Main cables
- Option 3b – Underground cable connection between Donegall and a new switching station connected into the Cregagh to Belfast Central Main circuits
- Option 3c – Underground cable connection between Donegall to new switching station at Belfast Central Main

The estimated cost for the above options is £32.2m, £36.8m and £35.5m respectively (see Appendix C).

4.4.4 Option 4: Blacks Road Reinforcement (£24.6m)

This option is based also on establishing robust interconnection between Hannahstown and Castlereagh grid supply points. In this case this is established by making use of a section of the existing Castlereagh – Finaghy tower line which would be restrung and refurbished. The option includes the following work:

- A new GIS switching substation is developed near Blacks Road and the Lisburn to Hannahstown 110 kV circuits are diverted into the new switching substation.
- The Castlereagh to Finaghy 110 kV circuits are cabled into the new switching substation.
- The Carnmoney to Finaghy section of the Ballylumford to Castlereagh 110 kV double circuit is decommissioned and removed. Most of the Castlereagh to Finaghy sections is retained and refurbished.
- This option is estimated to cost £24.6m (see Appendix C).

4.4.5 Option 5: Hybrid Phasing of 4th Interbus Transformer and Sailortown Reinforcement (£36m)

Phase 1

- Castlereagh IBTx 4 (and associated shunt reactor) would be connected and commissioned.
- A temporary (normally open) connection between the Castlereagh – Finaghy terminal tower and the Finaghy – Donegall terminal tower would be established at Finaghy Main.
- The Carnmoney to Finaghy section of the Ballylumford to Castlereagh 110 kV double circuit is decommissioned and removed. The section between Finaghy and Castlereagh would remain temporarily in service, with both circuits temporarily connected to Finaghy.

Phase 2

- New GIS substations would be developed adjacent to Belfast Central and Belfast North Main. New double circuit cable is installed between Donegall and Belfast North Main, replacing the existing cables and at the same time catering for increased demand at Giants Park.
- New double circuit cable would be installed between Belfast Central and Belfast North Main.
- Upon completion of the above GIS substation and cable works, the Finaghy – Castlereagh section of the double circuit would be removed.

This option is estimated to cost £36m.

5 ASSESSMENT OF OPTIONS

The options have been assessed according to the criteria set out in Appendix C. The appraisal of options is summarised in Table 5.1.

5.1 Option 1 – Full refurbishment

5.1.1 Electrical performance

This option retains the basic configuration that exists at present. This configuration is inherited and not optimal. As a result there is a modest level of electrical resupply to facilitate transformer maintenance at Castlereagh. Studies show it would be necessary to retain Tx 3 at Hannahstown and Tx 4 at Castlereagh into the long term. Furthermore due to expected demand growth at Giants Park it will also be necessary to replace the existing Donegall – Belfast North Main cables (rated at 75 MVA) with new cabling (rated at 144 MVA). The estimated cost of this option is £21.4m (see Appendix D).

5.1.2 Lifecycle cost of option and assumptions

The option has an estimated **Net Present Cost of £41m** (See Appendix F). The assessment includes the following assumptions:

- Replacement of Belfast North Main to Donegall 110 kV cables at year 10[4]
- Connection[5] of IBTx 4 and associated shunt reactor at year 4
- Option includes the procurement of two interbus transformers for asset replacement[6].

The tower line does require regular assessment of existing clearances as well as the impact of planning applications. Also in the case of a planned residential, or commercial developments there is also an ongoing risk, depending on the circumstances, that costs to raise or divert the line would be borne by the customer base. This sometimes includes preparation of necessary wayleaves and defending compensation claims. This entails an ongoing operational cost. This is especially the case in an urban setting. However there has been no allowance for this.

[4] To supply increased demand Giants Park
[5] address the lack of transformer capacity at Castlereagh for the N-M-T scenario

[6] This cost is avoided in other options which allow the number of transformers at Castlereagh and Hannahstown to be reduced by one per site.

5.1.3 Social, environmental and economic impact

Residents along the length of the double circuit would continue to be impacted by its presence into the long term, potentially inhibiting residential and/or commercial development in some cases. The use of Upas conductor at 75°C gives rise to a number of clearance issues requiring mitigation. There is also a risk that further developments would continue to cause clearance issues.

The 'Social Constraints' mapping in Appendix I shows that this line passes through several areas of high population density. The required refurbishment work would be very intrusive and prolonged for some residents. In the worst cases, refurbishment work for towers in built up areas is expected to take up to four weeks.

The option would retain the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). It would potentially require invasive foundation works in these areas, as well as prolonged access across sensitive terrain for significant heavy machinery. It might be necessary to obtain consent from DAERA for any works. The Carnmoney to Finaghy section of line crosses two salmon rivers. This could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids.

The security of supply to the Belfast area under a HILP event would be strengthened with the refurbished conductor providing a greater degree of 110 kV resupply to Castlereagh.

5.1.4 Deliverability

As has been stated in Section 2 the refurbishment of this tower line would be very disruptive to residents, requiring neighbouring properties to be vacated for up to four weeks per tower. In contrast, recovery of a tower could be carried out in a much shorter timescale.

A refurbishment of this line would trigger the need to assess the Rise of Earth Potential and if necessary establish mitigation measures at "often frequented towers". Along this route there are many towers considered in this category. Recovery of the towers would avoid the need to implement these mitigation measures.

It is considered that there would be a high risk of variations in any refurbishment contract due to unforeseen circumstances of working in an urban environment. This may also be the case for recovery however this should present a much lower risk.

There may be instances whereby members of the community do not allow access or refuse to vacate neighbouring premises during the refurbishment work. In contrast it is reasonable to

assume for the recovery options, land owners would be more amenable to facilitating access. Furthermore the requirement to vacate properties during the recovery works would be minimised.

This option would avoid the need to establish substations in Belfast and the associated cable works with the other options. However this is will be works on public roads and procurement of land in commercial areas and as a result is considered more deliverable than this refurbishment option.

5.1.5 Summary of option

The option provides a higher capacity into Castlereagh at 110 kV. However this is only beneficial for the HILP scenarios. The option does not avoid the need to retain Tx 3 at Hannahstown and Tx 4 at Castlereagh.

Other options, however, provide extra capacity at 110 kV and deliver additional benefits to the network in the greater Belfast area. This option does not do that.

The option avoids the disruption to traffic close to Belfast city centre seen in Options 3 and 5. However, the Belfast North Main to Donegall cables will require replacement with higher capacity cables to facilitate demand at Giants Park and load growth in the north city centre, so this potential disruption is only delayed.

This option involves the refurbishment of the double circuit tower line including works on foundations in gardens. Whilst this is considered possible, the scale of work and disruption is not considered practical.

Finally, in the longer term there would be continued problems with the tower line potentially impeding developments and/or increased development encroaching around the towers with associated issues with clearances. There would also be increased access issues, making tree cutting, maintenance and eventual decommissioning and demolition more problematic.

5.2 Option 2: Fourth interbus transformer at Castlereagh

5.2.1 Description of option

The option involves the connection of Tx 4 (and associated shunt reactor) at Castlereagh and recovery of the existing double circuit tower line. The estimated cost of this option is £11.5m (see Appendix D).

5.2.2 Electrical Performance

The recovery of the tower line removes the 110 kV resupply into Castlereagh. To ensure that there would be sufficient capacity to carry out maintenance of interbus transformers at Castlereagh it would be necessary to establish a connection of Tx 4. With this option however there would need to be four transformers at Castlereagh and three at Hannahstown on a permanent basis. This has a bearing on asset replacement needs in future (see lifecycle costs).

Crucially however this arrangement would result in the removal of all 110 kV resupply into Castlereagh substation. This would leave Castlereagh, which is the largest grid supply point in Northern Ireland, with no resilience against a High Impact Low Probability (HILP) [redacted] A 110 kV resupply offers critical benefits in terms of resilience as the infeed comes from another source unlikely to be affected simultaneously and can be operated with remote protection systems.

The lack of this capability would result in a high economic loss in such an event. This is included in the lifecycle costs and further discussed in the socio-economic appraisal below.

5.2.3 Lifecycle cost of option

The option has an estimated **Net Present Cost of £110m** (see Appendix F and G), which includes an estimate of the cost of a HILP event. This has the highest NPV cost of all of the shortlisted options.

The assumptions for the NPV are as follows:

- Replacement of the Belfast North Main to Donegall 110 kV cables at year 10;
- Procurement of two interbus transformers for asset replacement at Castlereagh and Hannahstown; and
- Estimate of Value of lost load (VOLL) due to higher HILP risk at Castlereagh (see below).

5.2.4 Deliverability

Delivery of this option would be the least onerous of the six short list options. Connection of Tx 4 would have little to no impact on landowners. The process of removing towers would be less intrusive than tower refurbishment, and take considerably less time.

5.2.5 Social, environmental and economic impact

The removal of the tower line would allow land owners to make use of and develop the land currently occupied by the towers. In addition the issues around long term access issues and maintenance would be avoided. Work to remove the towers and circuits is expected to be intrusive for some residents, but would be completed relatively quickly. This work is significantly less disruptive than refurbishment.

The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.

[redacted]

5.2.6 Summary of option appraisal

This option removes the double circuit, and provides additional capacity into Castlereagh 110 kV via the fourth interbus transformer. It is the cheapest option to deliver.

However, this option would remove the 110 kV resupply at Castlereagh, leaving the substation vulnerable to several HILP scenarios. [redacted] The option is therefore unacceptable as a long term solution and this is reflected in the lifecycle cost which includes an allowance for the HILP risk.

However, this option could provide a means to enable the early recovery of some sections of the tower line provided a temporary resupply could be retained and a longer term reinforcement programme was also in progress.

5.3 Option 3a: Sailortown link

This option (see Figure 5.1 below) establishes a cable connection between Belfast North Main and Belfast Central Main. This allows the tower line to be recovered. The estimated cost of this option is £32.2m (see Appendix D).

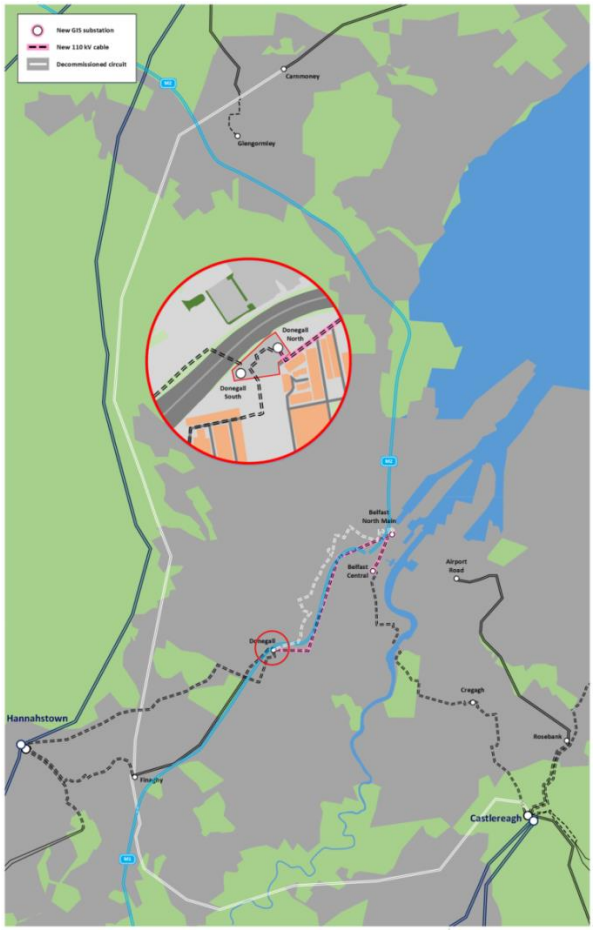


Figure 5.1: Geographic map of Option 3a

5.3.1 Electrical performance

This option would establish a robust, normally in service, interconnection between Castlereagh and Hannahstown 275/110 kV grid supply points. This would provide sufficient capacity to allow for the reduction of transformer capacity at Hannahstown from three interbus transformers to two. The option also allows the number of transformers at Castlereagh to remain as three. This would avoid the need to replace one of the older units at each of the two sites as with options 1 and 2.

As set out in the detailed results in Appendix E the connection between Belfast Central and Belfast North Main results in a greater degree of power being supplied from Hannahstown into

the city centre. This increases the loading in the Hannahstown – Donegall circuits. There are several ways in which this increase in flow can be mitigated:

- Demand could be transferred between Donegall North and Donegall South 33 kV switchboards. The Finaghy – Donegall South circuit is to be refurbished and uprated to Lynx, however this could be uprated to Upas instead.
- The flow is influenced by the impedance of the existing interbus transformers at Hannahstown, which is relatively low. These units are due for replacement in the medium term and there would be an opportunity to obtain units with higher impedance which would reduce the flow.
- Finally subject to fault level studies, it may also be possible to reduce the flow on these circuits by retaining Tx 4 at Castlereagh, which would have a similar effect.

5.3.2 Lifecycle cost of option and assumptions

The option has an estimated Net Present Cost of £49m (see Appendix F). The assumptions for the NPV are as follows:

- The replacement of the Donegall to Belfast North Main 110 kV cable circuits forms part of the main option works;
- As the option requires less 275/110kV transformers at Hannahstown and Castlereagh, the cost of replacement of the older units would be avoided;
- Increased loading on the Hannahstown – Donegall circuits would be studied with attention given to means of easing this loading, in particular the transformer impedance at Hannahstown; and
- The cost of a shunt reactor installed on Tx 3 at Castlereagh is included.

5.3.3 Deliverability and timeliness

Delivery of the substation works (GIS switchboards) will require procurement of new sites adjacent to Belfast North Main and Belfast Central. Consideration would also be given to establishing a single compound provided separation could be maintained to prevent HILP risks. It will also be necessary to achieve planning permission. This option has a lead time of approximately five years.

The option requires new cables to be laid near Belfast City Centre; depending on the routes selected, considerable traffic disruption may result. This is given greater consideration in the desk top environmental assessment.

From examination of the York Street Interchange Project Environmental Statement Non-Technical Summary there is not expected to be any significant impact on land availability at

Belfast Central and Belfast North Main provided the works are carefully phased. Furthermore the work associated with that project is unlikely to affect route availability for the Belfast Central to Belfast North Main cables.

It is expected that whilst there would be disruption associated with the removal of the conductors and towers, it would be significantly less than that associated with refurbishment of the double circuit.

Delivery of this option is expected to be achievable; however, the substation and cable works would take approximately five years to progress through pre-construction.

This may not be acceptable given the assessment that the conductor on the B circuit is at end of life. In this event, a phased delivery of the option would be preferable.

5.3.4 Social, environmental and economic impact

- The option is expected to have a long term positive social impact.
- The removal of the tower line would allow land owners to make use of and develop the land currently occupied by the towers. In addition the issues around long term access issues and maintenance would be avoided.
- Work to remove the towers and conductors is expected to be intrusive for some residents, but be completed relatively quickly.
- The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.
- The ‘Social Constraints’ mapping in Appendix I shows that the new circuits would largely be laid outside areas of high population density.
- The cable works would cause disruption to traffic; however this work will be required in any case given the expected demand growth at Giants Park and the north city centre. The work is included in this option avoiding the need for a second visit.
- As all proposed new circuits are underground cable, once the construction stage is completed they will have little long term environmental and visual impact.
- The option strengthens security of supply to the Belfast area.

5.3.5 Summary of option

This option removes the double circuit, and provides additional capacity into Castlereagh 110 kV via interconnection across Belfast city centre. It incorporates the replacement of the Donegall

North to Belfast North Main cables, and also avoids the need and cost to replace two interbus transformers.

However the option will face a lengthy delivery time, due to the work required to design and build both the new substations in Belfast and the new cables. This work would be required to be complete prior to removal of the double circuit; dependent on the condition of the conductor, this may not be feasible.

As noted in Option 2, the connection of the fourth interbus transformer at Castlereagh could allow recovery of some of the double circuit to get underway sooner. A hybrid option (option 5, set out below) combines Option 2 and 3a to incorporate the benefits of the two approaches.

5.4 Option 3b: East City Centre link

5.4.1 Description of option

This option is a variation from Option 3a and has the following elements:

- A double busbar GIS substation would be developed at Donegall marshalling the existing Hannahstown to Donegall North and Finaghy to Donegall South double circuits.
- A new 110 kV switching station (East City Centre) would be established close to the route of the existing Belfast Central to Cregagh 110 kV cable circuits, which would be diverted into the new substation.
- New double circuit cable would be installed between the new Donegall double busbar and the new switching station.
- The Carnmoney to Castlereagh section of the Ballylumford to Castlereagh 110 kV double circuit would be decommissioned and removed.
- The estimated cost for this option is £36.8m (see Appendix D).

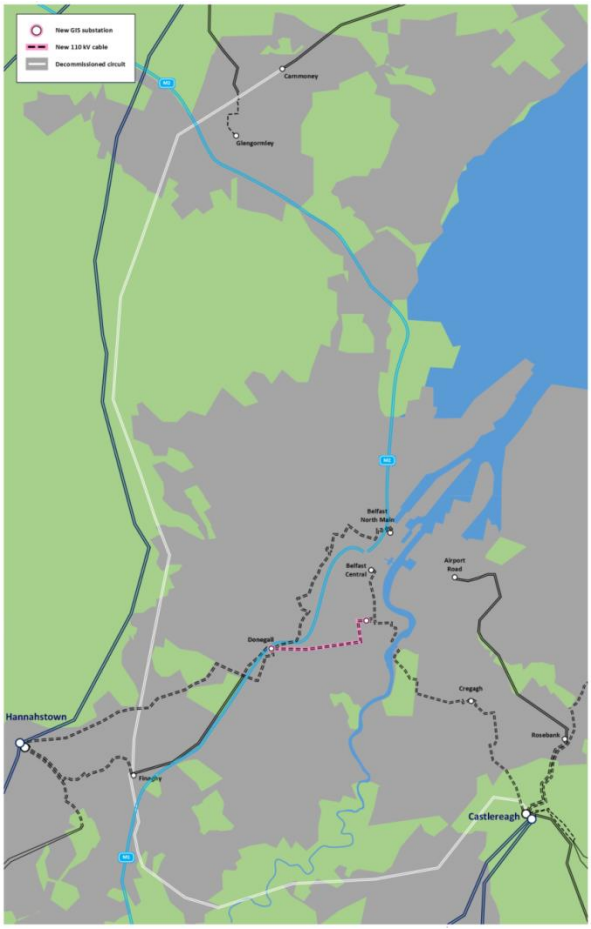


Figure 5.2: Geographic map of Option 3b

5.4.2 Electrical performance

This option is similar to Option 3a in that it established a connection between Hannahstown and Castlereagh. This allows for a reduction in the need for 275/110 kV transformer capacity at both substations.

The option provides more capacity to facilitate the increased flow from Hannahstown by marshalling four source circuits at Donegall into a new GIS switchboard. However the option does not cater for the increased demand that is expected at Giants Park and supplied from Belfast North Main. It is assumed that these circuits will need to be replaced and uprated in year 10.

Further detailed results of system studies are included in Appendix E.

5.4.3 Lifecycle cost of option and assumptions

The option has an estimated Net Present Cost of £57m (see Appendix F). This is based on the following assumptions:

- Based on expected demand increase at Giants Park, replacement of the Belfast North Main to Donegall 110 kV cables is assumed at year 10;
- As with Option 3a, the number of transformers at both Castlereagh and Hannahstown can be reduced, avoiding the cost of replacement; and
- The cost of a shunt reactor installed on Tx 3 at Castlereagh is included.

5.4.4 Deliverability

- Delivery of this option will depend on the availability of a site in the East City Centre area. This is a highly commercial area and obtaining a site may not be feasible.
- As with Options 2 and 3a it is expected that whilst there would be disruption associated with the removal of the towers, it would be significantly less than that associated with refurbishment of the double circuit.
- The new GIS substations are required to be built at Donegall and an East City Centre site.
- The option would avoid the substation works at Belfast Central and Belfast North, which depending on the timing may be impacted by the proposed York Street Interchange. Options 3 and 5 may be affected by the development.
- This option incurs similar risks to Option 3a in that it will delay the recovery of the 110 kV tower line. Additionally, the anticipated difficulty in obtaining a site in the heavily commercialised East City Centre area would potentially further delay the full recovery of the double circuit when compared to Option 3a.

- The option requires new cables to be laid on or near Donegall Pass and the Ormeau Road which sees considerable congestion; depending on the route available, considerable traffic disruption could be anticipated.
- There would be a requirement for directional drilling under the Belfast to Dublin railway.

5.4.5 Social, environmental and economic impact

- The option is expected to have a long term positive social impact.
- The removal of the tower line would allow land owners to make use of and develop the land currently occupied by the towers. In addition the issues around long term access issues and maintenance would be avoided.
- Removal work expected to be intrusive for some residents, but would be completed relatively quickly.
- The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.
- The 'Social Constraints' mapping in Appendix I shows that the new circuits would largely be laid outside areas of high population density.
- All new circuits are cable, and after the construction stage is completed will have little long term environmental and visual impacts.
- This option would entail further traffic disruption within ten years to replace the Belfast North Main to Donegall 110 kV cables. In Option 3a this work is incorporated into the project.
- This option strengthens security of supply to the Belfast area.

5.4.6 Summary of option

This option removes the existing double circuit, and provides additional capacity into Castlereagh 110 kV via interconnection across Belfast city centre. It also reduces the number of interbus transformers required at Castlereagh and Hannahstown, avoiding asset replacement of the older units. It does not include the replacement of the Donegall North to Belfast North Main cables; work which will likely be required within the next ten years.

As with Option 3a, the option will face a lengthy delivery time, due to the work required to design and build both the new substations in Belfast and the new cables. The connection of the fourth interbus transformer at Castlereagh could facilitate an earlier recovery of some of the double circuit.

This main disadvantage with this option is that obtaining a site for the East City Centre substation in this prime commercial area is not likely to feasible.

5.5 Option 3c: Central link

5.5.1 Description of option

This is the third of the three options that establishes a 110 kV cable connection between Hannahstown and Castlereagh. The work with this option includes the following items:

- New GIS substations are developed at Belfast Central and Donegall.
- New double circuit cable (rated at 144MVA per circuit) is installed between Donegall and Belfast Central.
- The Carnmoney to Castlereagh section of the Ballylumford to Castlereagh 110 kV double circuit is decommissioned and removed.
- The estimated cost for this option is £35.5m (see Appendix D).

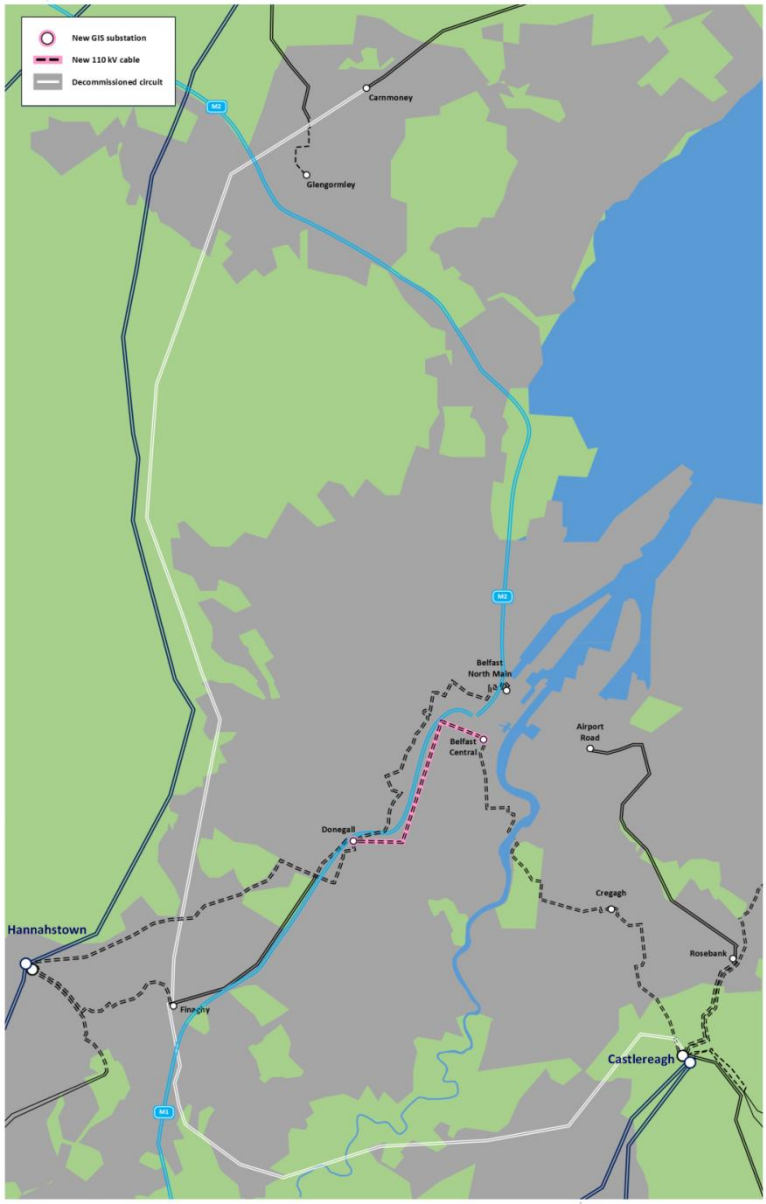


Figure 5.3: Geographic map of Option 3c

5.5.2 Electrical Performance

This option is similar to Option 3b in that it establishes a connection between Hannahstown and Castlereagh. This allows for a reduction in the need for 275/110 kV transformer capacity at both substations.

Similar to Option 3b, this option provides more capacity to facilitate the increased flow from Hannahstown by marshalling four source circuits at Donegall into a new GIS switchboard. However the option does not cater for the increased demand that is expected at Giants Park and the north city centre, supplied from Belfast North Main. It is assumed that these circuits will need to be replaced and uprated in year 10.

Further detailed results of system studies are included in Appendix E.

5.5.3 Lifecycle cost of option and assumptions

The option has an estimated Net Present Cost of £53m (see Appendix F). This is based on the following aspects:

- Based on expected demand increase at Giants Park, replacement of the Belfast North Main to Donegall 110 kV cables is assumed at year 10;
- Asset replacement costs for two interbus transformers avoided; and
- The cost of a shunt reactor installed on Tx 3 at Castlereagh is included.

5.5.4 Deliverability

- Delivery of this option is expected to be similar to Option 3a. As the option does not involve procurement of a site in a prime commercial area it is expected to be preferable to Option 3b.
- Removal of towers will encounter the challenges identified in Option 2.
- The option requires the establishment of new GIS substations adjacent to Donegall and Belfast Central Main. However both sites are located within commercial/ industrial areas and it is expected that sites could be obtained.
- It is possible that a GIS building could be established within the existing compound at Donegall, subject to outline design.
- Pending further investigation, it is unlikely that a GIS building could be established within the existing Belfast Central Main compound.
- The option requires new cables to be laid near to Belfast City Centre; depending on the route available, traffic disruption can be anticipated. This has been considered further in the desktop environmental study.

- Based on examination of the York Street Interchange Project Environmental Statement Non-Technical Statement there is not expected to be an impediment on the availability of land at Belfast Central when considering development of a GIS substation.

5.5.5 Social, environmental and economic impact

- The option is expected to have a long term positive social impact.
- The removal of the tower line would allow land owners to make use of and develop the land currently occupied by the towers. In addition the issues around long term access issues and maintenance would be avoided.
- Work to remove the conductors and towers is expected to be intrusive for some residents, but would be completed relatively quickly.
- The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.
-
- The 'Social Constraints' mapping in Appendix I shows that the new circuits would largely be laid outside areas of high population density.
- As all proposed new circuits are cable, once the construction stage is completed they would have little long term environmental and visual impacts.
- The option strengthens security of supply to the Belfast area.

5.5.6 Summary of option

This option removes the existing double circuit, and provides additional capacity into Castlereagh 110 kV via interconnection across Belfast city centre. It also frees up several interbus transformers for use for asset replacement. It does not include the replacement of the Donegall North to Belfast North Main cables; work which will likely be required within the next ten years.

As with Option 3a, the option will face a lengthy delivery time, due to the work required to design and build both the new substations in Belfast and the new cables. The temporary connection of the fourth interbus transformer at Castlereagh could facilitate an earlier recovery of some of the double circuit. This is explored in a further option (5).

By connecting Donegall to Belfast Central, Belfast Central would become a key substation, particularly if the existing Donegall to Belfast North Main cables are replaced by new cables from Belfast Central due to the much shorter distance involved. This would introduce a common mode

failure or HILP risk that would impact on both Belfast Central and Belfast North Main, placing an unacceptable risk to resilience of supplies to the central business district. For the purpose of establishing the lifecycle costs the upgrade of the cables to Belfast North Main has been assumed from Donegall to avoid any resilience issues. However this also incurs a second visit for cable works which would incur greater disruption.

5.6 Option 4: Blacks Road Reinforcement

5.6.1 Description of option

This option is based also on establishing robust interconnection between Hannahstown and Castlereagh grid supply points. In this case this is established by making use of a section of the existing Castlereagh – Finaghy tower line which would be restrung and refurbished. The option includes the following work:

- A new GIS switching substation is developed near Blacks Road and the Lisburn to Hannahstown 110 kV circuits are diverted into the new switching substation.
- The Castlereagh to Finaghy 110 kV circuits are cabled into the new switching substation.
- The Carnmoney to Finaghy section of the Ballylumford to Castlereagh 110 kV double circuit is decommissioned and removed. Most of the Castlereagh to Finaghy sections is retained and refurbished.
- This option is estimated to cost £24.6m (see Appendix D).

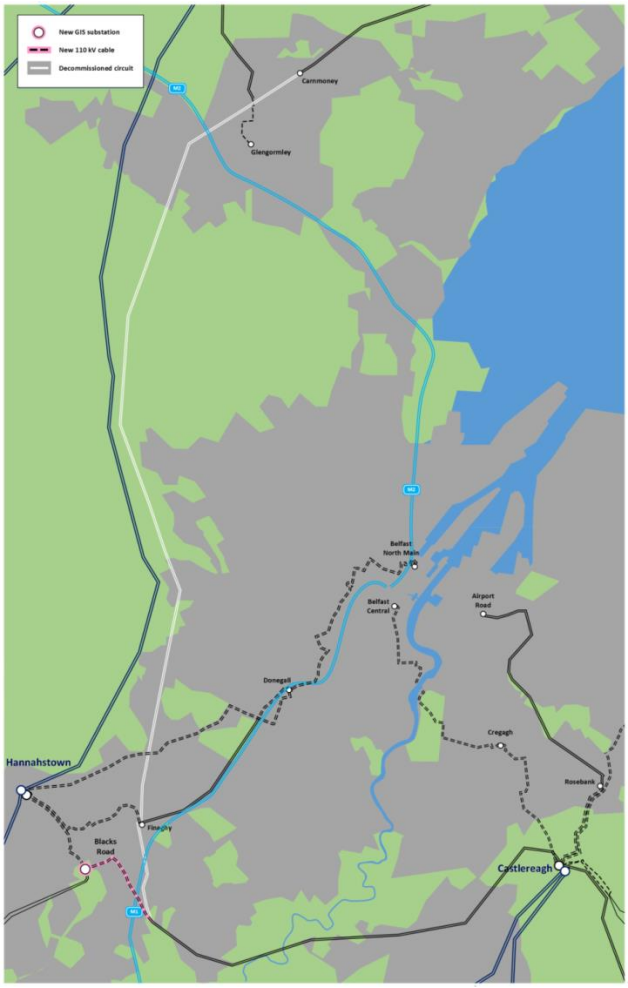


Figure 5.4: Geographic map of Option 4

5.6.2 Electrical Performance

This option would also establish a robust interconnection between Hannahstown and Castlereagh, through the new site at Blacks Road and the refurbished tower line between Blacks Road and Castlereagh. As in Options 3a-c it would also allow a reduction in the number of interbus transformers at both sites, resulting in savings in asset replacement costs, which have also been factored into the lifecycle assessment. This option does not incur the issues with heavy loading from Hannahstown that were seen with all of the Option 3 variations. However the cabling from Donegall to Belfast North Main would still need to be upgraded to cater for Giants Park and north City Centre demand.

5.6.3 Lifecycle cost of option and assumptions

The option has an estimated Net Present Cost of £45m (see Appendix G).

- Based on their condition, replacement of the Belfast North Main to Donegall 110 kV cables is assumed at year 10;
- As with Options 3a, 3b and 3c, the number of transformers at Castlereagh and Hannahstown can be reduced, avoiding asset replacement costs; and
- The cost of a shunt reactor installed on Tx 3 at Castlereagh is included.

5.6.4 Deliverability

- Delivery of option expected to be very challenging.
- Removal of towers between Blacks Road and Carnmoney will encounter the challenges identified in Option 2. However this would be to a lesser extent than the refurbishment of this very difficult section.
- Refurbishment of the tower line between Blacks Road and Castlereagh would encounter significant challenges as identified in Option 1, including difficult stringing positions and landlocked towers. See Section 3 and Appendix 3 of the LSTC Buildability Report (Appendix A).
- In order for the option to provide the maximum capacity available, Upas conductor is recommended. However there would be clearance issues associated with this conductor. This has not been investigated in detail but may include the need to raise towers with planning permission implications.
- This option requires some new cable between Blacks Road and a terminal tower close to Hunter House College. While not impacting Belfast City Centre, the cables would still have to cross a busy road junction; considerable traffic disruption can be anticipated.
- This option involves the construction of a new GIS substation at Blacks Road.

- Retention of the tower line from Castlereagh to Blacks Road is likely to reduce the scope for development, with ongoing issues with access and clearances in Four Winds and Belvoir. This is the main disadvantage with this option. In Belvoir, however, the towers are mainly located in publicly owned land with the issue of land locking not such an issue.

5.6.5 Social, environmental and economic impact

- The option will generally have a mixed impact. The option is considered strong electrically; however there would be continued issues such as bird fouling and potential to impede development.
- Residents and land owners between Blacks Road and Carnmoney will benefit from the recovery of the tower line in terms of making use of the land.
- However, residents and land owners along the route from Blacks Road to Castlereagh will continue to host the tower line and would not benefit from its removal.
- Removal work is expected to be intrusive for some residents, but be completed relatively quickly.
- Areas where towers are retained would have similar impacts identified in the Buildability Report in Appendix A.
- The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.
- The ‘Social Constraints’ mapping in Appendix I shows that the new circuits and switching station would be built within an area of relatively high population density, and that the retained and refurbished section of double circuit also passes through such areas.
- As in Options 3a-c, this option strengthens security of supply to the Belfast area.

5.6.6 Summary of option

This option provides additional capacity into Castlereagh 110 kV by retaining the double circuit from Blacks Road to Castlereagh.

The option allows for the reduction of transformers at Castlereagh and Hannahstown, saving on asset replacement costs. In addition the option does not involve the laying of cables close to the city centre. The replacement of the Donegall North to Belfast North Main cables will likely be required within the next ten years in any case.

This option would provide the best resupply to Castlereagh and thus presents the best resilience to a HILP event.

Delivery time of new infrastructure should be faster than other options; however, the connection of the fourth interbus transformer at Castlereagh may still be required to facilitate both the recovery and refurbishment aspects of the double circuit.

The main disadvantage of this option is the practicality of refurbishing the tower line from Blacks Road to Castlereagh and the ongoing maintenance and access issues. In order to obtain the rating of the conductors a number of clearance issues would need to be addressed. Some of these are to buildings and ground level and may require the lowering of ground levels or the raising of towers which would also require planning permission.

Finally, in the longer term, for the section of line between Blacks Road and Castlereagh that would be retained, there would be continued problems with the tower line potentially impeding developments and/or increased development encroaching around the towers with associated issues with clearances - see Section 3.3 of the Buildability Report. There would also be increased access issues, making tree cutting, maintenance and eventual decommissioning and demolition more problematic.

5.7 Option 5: Hybrid Phasing of 4th Interbus Transformer and Sailortown Reinforcement

5.7.1 Description of option

Phase 1

- Castlereagh IBTx 4 (and associated shunt reactor) would be connected and commissioned.
- A temporary (normally open) connection between the Castlereagh – Finaghy terminal tower and the Finaghy – Donegall terminal tower would be established at Finaghy Main.
- The Carnmoney to Finaghy section of the Ballylumford to Castlereagh 110 kV double circuit would be decommissioned and removed. The section between Finaghy and Castlereagh would remain temporarily in service, with both circuits temporarily connected to Finaghy.

Phase 2

- New GIS substations would be developed, replacing Belfast Central and Belfast North Main.
- New double circuit cable would be installed between Donegall and Belfast North Main, replacing the existing cables and at the same time catering for increased demand at Giants Park and the north city centre.
- New double circuit cable would be installed between Belfast Central and Belfast North Main.
- Upon completion of the above GIS substation and cable works, the Finaghy – Castlereagh section of the double circuit would be removed.

The estimated cost for this option is £36m (see Appendix D).

5.7.2 Lifecycle cost of option and assumptions

The option has an estimated Net Present Cost of £51m (see Appendix G).

- Similar to Option 3a, the replacement of the Donegall to Belfast North Main 110 kV cable circuits forms part of the main option works.
- This option also avoids the procurement of two interbus transformers for asset replacement, a cost which is required in Option 1 and 2.
- Resolving identified overloads on the Donegall to Hannahstown cables has been considered. Measures have been identified that can relieve loading on these circuits, including selecting a higher impedance for any new transformers at Hannahstown, transfer of demand from Donegall North to Donegall South and lastly retention of IBTx 4 at Castlereagh.

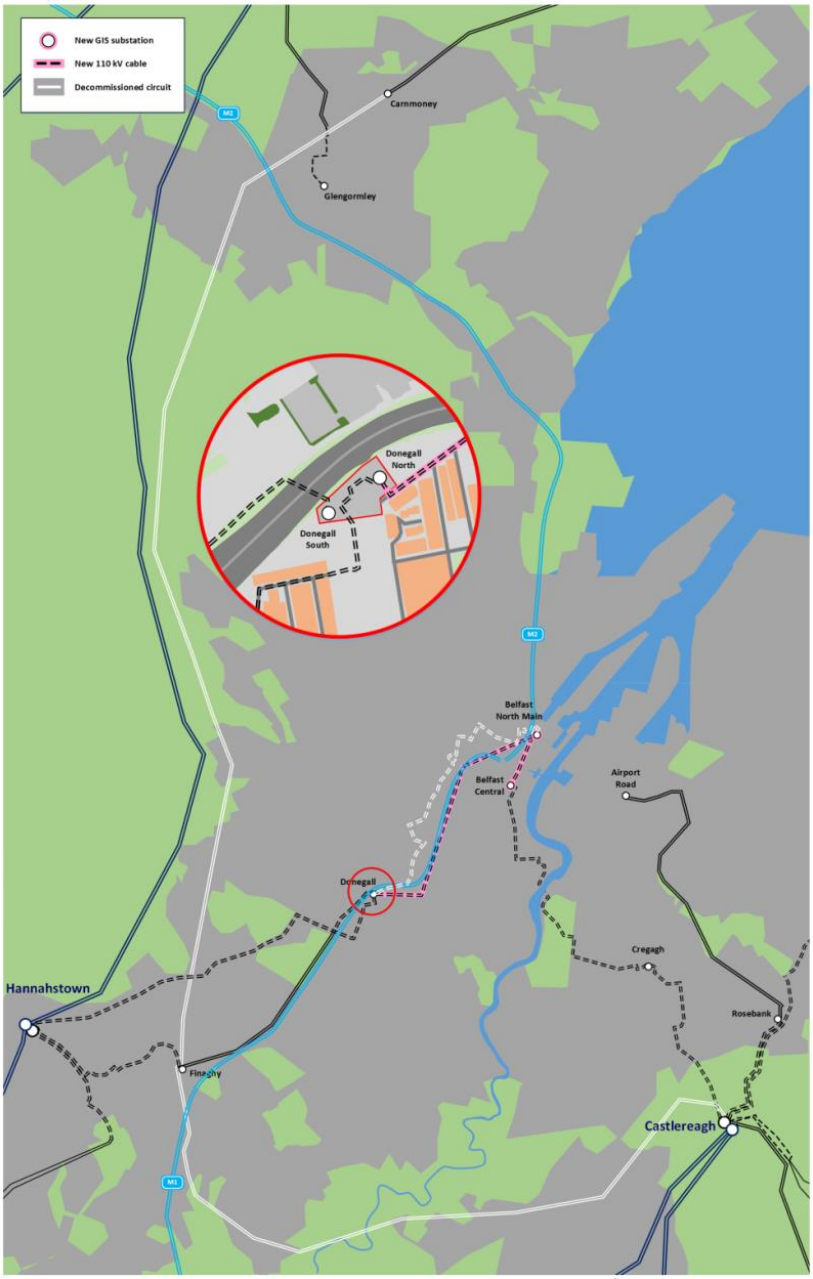


Figure 5.5: Geographic map of Option 5

5.7.3 Deliverability

- Delivery of this option is expected to be achievable. As with option 2, delivery of the first phase including the connection of IBTx 4 and the temporary connection at Finaghy will not require consents and should be straight forward.
- This option will allow the decommissioning and recovery of the 110 kV double circuit tower line from Finaghy to Carnmoney, which will avoid the complications of attempting to refurbish it.
- However, the substation and cable works associated with phase 2 (Sailortown reinforcement) would take several years to progress through pre-construction.

- The option requires new cables to be laid between Donegall and Belfast North Main and between Belfast North Main and Belfast Central Main; depending on the routes selected, considerable traffic disruption may result. This is to be further investigated in the planned desk environmental assessment.
- The York Street Interchange Project may impact on land availability at Belfast Central and route availability for the Belfast Central to Belfast North Main cables depending on the phasing of the work, however this will be further considered in detailed routing assessments.

5.7.4 Social, environmental and economic impact

- The option is expected to have a long term positive social impact.
- The removal of the tower line would allow land owners to make use of and develop the land currently occupied by the towers. The option would also ensure that clearance issues, bird fouling and other nuisance factors are removed for the entire route from Carnmoney to Castlereagh. In addition the issues around long term access issues and maintenance would be avoided.
- Work to remove the towers and circuits is expected to be intrusive for some residents, but would be completed relatively quickly.
- The option will remove the double circuit that passes through the Belfast Hills, Clement Wilson and Lagan Meadows SLNCIs and the Belvoir ASSI (within the Lagan Valley AONB). The Carnmoney to Finaghy section of line crosses two salmon rivers, this could prove to be a constraint to refurbishment works due to the legislative environmental protection for salmonids. Ensuring that any works in these areas remains environmentally sensitive would be challenging but much less onerous than refurbishment due to the lower requirement for heavy equipment and shorter duration.
- The 'Social Constraints' mapping in Appendix I shows that the new circuits would largely be laid outside areas of high population density.
- Phase 1 (Castlereagh IBTx 4) provides a level of resilience against several HILP events at Castlereagh. [redacted]
- The cable works will cause disruption to traffic relatively close the city centre. However this option allows the decommissioning of the existing Donegall North – Belfast North Main cables avoiding the need for a second visit.
- As all proposed new circuits are cable, once the construction stage is completed they will have little long term environmental and visual impacts.
- The option strengthens security of supply to the Belfast area.

5.7.5 Summary of option

This option removes the double circuit, and provides additional capacity into Castlereagh 110 kV via the fourth interbus transformer in the short-term and via interconnection across Belfast city centre longer-term. It incorporates the installation of a fourth transformer at Castlereagh and replacement of the Donegall North to Belfast North Main cables.

This option also allows all of the tower line to be recovered removing the issues with potential clearance infringements, access issues and bird fouling complaints. This option would also allow all landowners to benefit from the removal of towers from garden areas etc.

As with option 3a, the Sailortown reinforcement faces a lengthy delivery time, due to the work required to design and build both the new substations in Belfast and the new cables. As with option 2, installation of a fourth interbus transformer at Castlereagh could be achieved in a much shorter timeframe, allowing the Finaghy-Carnmoney double circuit to be removed before completion of phase 2, and Finaghy-Castlereagh to be removed following completion of phase 2.

5.8 Tabular comparison of Options

The seven options are assessed against a number of criteria. The summary of the combined performance against all of the criteria is listed in table 5.1. Each cell has been given a colour for representation purposes .

Table 5.1 – Comparison of Options

Less favourable More favourable

	1 - Refurb	2 – Tx4/recover	3a – Sailortown Link/recover	3b – East City Centre Link/recover	3c – Central Link/recover	4 – Blacks Road	5 – Hybrid phased
Technical Performance	Tower line designed for requirements of 1940s, sub-optimal configuration	Castlereagh secured for n-m-t, no increase in capacity	Significant improvement interconnection capacity. Allows reduction in number of IBTX	Significant improvement interconnection capacity. Allows reduction in number of IBTx	Significant improvement interconnection capacity. Allows reduction in number of IBTx	Significant improvement interconnection capacity. Allows reduction in number of IBTx	Improvement in interconnection capacity. Allows reduction in number of IBTx
Resilience	Similar to existing	[redacted]					
Timeliness	May not be deliverable	Would allow recovery in 2023	Cannot recover tower line until 2026	Cannot recover tower line until 2026	Cannot recover tower line until 2026	Allows phased recovery, Finaghy – Carnmoney in 2023. Issues with delivery on refurb element.	Allows phased recovery, Finaghy – Carnmoney in 2023
Cost (£m)	**£21.4m**	**£11.5m**	**£32.2m**	**£36.8m**	**£35.5m**	**£24.6m**	**£36m**
Lifecycle cost	£46m	£113m	£50m	£58m	£54m	£47m	£52m
Overall summary	Complicated delivery, may not be possible. Does not address long-term capacity issues in city centre.	Simplest to deliver but does not [redacted] or address long term capacity issues in city centre	Significant delay to recovery of tower line which is already at end of life. Provides resilience and addresses long term city centre capacity issues.	Significant delay to recovery of tower line which is already at end of life. Provides resilience. Does not address long term city centre capacity issues. Procurement of a site in city centre may be difficult.	Significant delay to recovery of tower line which is already at end of life. Provides resilience. Does not address long term city centre capacity issues.	Provides good resilience and removes majority of tower line in good time. Refurb of retained element may face significant opposition. Does not address long term city centre capacity issues.	Provides good resilience and removes majority of tower line rapidly, with the remainder (in better condition) removed later. Addresses long city centre capacity issues.

6 DECARBONISATION AND LOAD GROWTH

Under current projections, load growth in Northern Ireland is expected to be low over the next decade. However, the Department for the Economy's upcoming publication of a new Energy Strategy for Northern Ireland is expected to focus strongly on decarbonisation of the economy. Electrification of heating and transport will play a crucial role in any decarbonisation plan, and would lead to a significant increase in electricity demand beyond that currently predicted.

According to SONI's current modelling, peak load in Belfast[7] in 2025 is expected to be 420 MVA. All options assessed in this report provide sufficient capacity to meet this load under all credible contingencies. Peak demand could increase by 17- 62% by 2040 compared to this level, and by up to 19% by 2030, depending on the pace of electrification of heat and transport. For further information see scenarios being investigated by SONI[8].

One of the sensitivities in the studies described in Appendix E is a 2030 high-load scenario with approximately 12% of load growth compared to the 2025 baseline. In order to assess the resilience of the options assessed here to an increase in demand possible following a decarbonisation-focussed energy strategy, all options were compared in a study which increased peak load in Belfast by 30% compared to that currently expected in 2025. It was found in all cases that the transformers at Hannahstown were liable to overload for the loss of the Castlereagh – Hannahstown 275 kV double circuit tower line. Two of the transformers at Hannahstown are due for replacement within the next 10 years, and replacement of these transformers with units with a primary winding impedance of approximately 0.08 p.u. significantly reduces the risk of overload (in some cases removing it entirely).

Table 6.1 below gives a summary of the performance of all options in this analysis. In all cases, two transformers at Hannahstown have been replaced with units with a primary winding impedance of 0.08 p.u.

In all cases the transformers at Hannahstown will have to be replaced with higher impedance units, demand transferred from Donegall North to Donegall South, or further investment will be required in city centre circuits. Option 3a/5 presents the best alternative in this regard as it requires no additional investment in a high-load scenario.

[7] Load served by Airport Road, Belfast Central, Cregagh, Donegall, Belfast north, Finaghy, Knock and Rosebank bulk supply points

[8] See "Tomorrow's Energy Scenarios Northern Ireland" http://www.soni.ltd.uk/media/documents/TESNI-2020.pdf

Table 6.1 – Performance of options with 30% extra load

Option	Overloads seen with 30% extra load in Belfast	Critical Contingency	Further upgrades required to enable 30% load growth
1.Refurbish existing line	Both Hannahstown 275/110 kV transformers loaded at 103%	Loss of Hannahstown – Castlereagh 275 kV double circuit	Increase 275/110 kV transformer capacity at Hannahstown
	One Castlereagh – Cregagh 110 kV cable loaded at 120%	Loss of other Castlereagh – Cregagh 110 kV cable	Replace and uprate Castlereagh – Cregagh cables
2.Castlereagh IBTx4	One Castlereagh – Cregagh 110 kV cable loaded at 120%	Loss of other Castlereagh – Cregagh 110 kV cable	Replace and uprate Castlereagh – Cregagh cables
3a and 5 Sailortown Link	none	n/a	none
3b and 3c Central Link and East Central	Both Hannahstown 275/110 kV transformers loaded at 104%	Loss of Hannahstown – Castlereagh 275 kV double circuit	Increase 275/110 kV transformer capacity at Hannahstown
4. Dunmurry Link	Both Hannahstown 275/110 kV transformers loaded at 103%	Loss of Hannahstown – Castlereagh 275 kV double circuit	Increase 275/110 kV transformer capacity at Hannahstown
	One Castlereagh – Cregagh 110 kV cable loaded at 110%	Loss of other Castlereagh – Cregagh 110 kV cable	Replace and uprate Castlereagh – Cregagh cables

7 PRELIMINARY PREFERRED OPTION

This assessment is based on the information that is available at present. A desk top environmental assessment of the shortlisted options has been produced, which will be finalised in January 2021 and shared with the UR at this point. This assessment also considers some social aspects of the options. Stakeholder engagement will also be carried out with local authorities and elected representatives in the coming weeks (see section 9). Based on the information available at present SONI has made the following conclusions on the options considered. A tabular comparison of options can be seen in section 5.8 above.

Option 1 is likely to be impractical, as it requires the refurbishment of the entire circuit through many urban areas. As a result, it is likely to result in many construction challenges and significant disruption to residents. In addition, as the configuration is based on what was required in the 1940s before the establishment of the 275 kV system, the design is sub-optimal. Any future increase in load would also require further upgrade works in the city centre that would not be addressed by this option. As a result, despite the increased conductor capacity, this option does not offer a cost effective improvement in security of supply for the trip maintenance scenario. It is considered therefore that Option 1 is impractical to deliver and sub-optimal in terms of performance and is therefore rejected.

Option 4 offers a significantly improved configuration and electrical performance compared to option 1. However Option 4 is likely to face similar deliverability issues and long term nuisance factors such as bird fouling. It also partially suffers from the same access and clearance issues as option 1, due to the partial retention of the double circuit. Furthermore, while it does afford a high level of resupply to Castlereagh in the event of a high impact low probability (HILP) event, it does not address any future load growth in the city, necessitating further cabling works in the city centre should the population increase and/or there is a significant move towards electrification of heat and transport. Despite addressing some of the most critical needs in this project, option 4 does not go as far as other options to address the long-term needs of the network in the Belfast area.

Option 2 provides additional transformer capacity with the connection of IBTx 4. [redacted] In addition, it provides no additional capacity in the city centre to allow for future load growth. This option as a long term solution would be considered unacceptable and is therefore rejected.

Options 3a, 3b, and 3c are similar in that they provide robust 110 kV resupply to Castlereagh through the Belfast 110 kV network. All three options provide a significant improvement in resupply over the present day network. These options also provide enhanced capacity in the city

centre in the event of a significant increase in demand, particularly 3a which replaces the Donegall – Belfast North Main cables. These three options will all increase the fault level on the distribution system in Belfast. However, if this project does not increase network capacity in Belfast, it will be necessary to bring forward other projects which do, due to the significant demand growth anticipated in the near to medium future arising from electrification of heat and transport. These projects would also have the same impact on city centre fault levels. As such, it will be necessary to address these potential short circuit currents on the distribution system in the near future regardless of the option selected in this project.

Considering Option 3a, future load growth is likely to result in a risk of overloading the Donegall to Hannahstown cables. However several mechanisms to address this have been identified, including:

- the installation of transformers with higher impedance at Hannahstown, where the existing transformers are due for replacement ;
- transfer of demand from Donegall North to Donegall South (using the 33 kV connections between the two switchboards); and
- the retention of Tx 4 at Castlereagh.

Option 3a replaces the Belfast North Main to Donegall cables which are likely to require replacement within the next 10 years to supply additional demand at Giants Park in any case. Factoring this into a NPV calculation shows that Option 3a has a better economic performance compared to Options 3b and 3c.

Option 3b requires a new site within Belfast city centre to establish a switching station. A desktop assessment of land use in the area required suggests this may be impractical. Further the potential cable route is also considered to be problematic in terms of traffic disruption.

Option 3c has an initial capital cost marginally less that than Option 3a. However the option also requires the later replacement of the Donegall – Belfast North Main circuits leading to a higher lifecycle cost but more importantly a second visit with repeated disruption. Therefore Option 3c is considered marginally inferior to Option 3a.

Therefore, taking into account the difficulties with obtaining a new substation site associated with Option 3b, the environmental issues highlighted in Appendix I, and pending stakeholder feedback, option 3a is considered preferable. However, to enable recovery of the Carnmoney to Castlereagh double circuit to begin as soon as possible, the connection of IBTx 4 at Castlereagh should be progressed and completed (option 5). There is a separate project ongoing to install additional shunt reactors for voltage control at Castlereagh, Tamnamore and Tandragee. In conjunction with this project, the opportunity will be taken to install a 30 Mvar shunt reactor on the tertiary winding of IBTx 4.

The hybrid option 5 will allow the 110 kV double circuit to be removed in the short term while securing Castlereagh against several HILP events in the long term.

It should be noted that while option 5 will address the issues with the existing double circuit and increase network capacity in the Belfast area, it will still be necessary for NIE Networks to bring forward asset replacement projects in the RP7 regulatory period to address ageing assets, including the transformers at Cregagh, IBTx1 and 2 at Hannahstown, IBTx1 at Castlereagh, and the Finaghy – Donegall double circuit.

A phased plan of work to deliver the relevant options has been developed in is detailed in **Section 8**. Appendix H shows single line diagrams of both phases of Option 5.

8 PHASING OF WORK

A phase of work plan to implement the preferred solution (option 5) is proposed in table 8.1.

Given the possible poor condition of the conductor on the double circuit, there is a need to begin recovery of the double circuit as soon as possible. This cannot commence until the refurbishment of the Ballylumford to Eden section is complete, which is assumed to be 2022.

During the recovery of the Carnmoney to Castlereagh section, there will be a need to retain a level security of supply at Castlereagh. To deliver this, the recovery of the section will be performed in two phases:

- Recovery of Carnmoney to Finaghy, which can begin as soon as possible; and
- Recovery of Castlereagh to Finaghy, which must wait until delivery of the preferred option is complete.

Security of supply at Castlereagh will be delivered with the installation of IBTx 4 (and associated shunt reactor installation), as well as works to extend the life of IBTx 1, and the retention of the Castlereagh to Finaghy section whilst the preferred option is delivered. To allow this, this section of the double circuit will have to be connected into Finaghy substation. Delivery of both IBTx 4 and the double circuit connection into Finaghy during the Ballylumford to Eden refurbishment will allow recovery of the Carnmoney to Eden section to begin following completion of the refurbishment.

Following delivery of the city centre works, the Castlereagh to Finaghy section can then be recovered. Following this, IBTx 3 at Castlereagh can be recovered and made available for asset replacement, as well as IBTx 3 at Hannahstown if IBTx 1 and 2 have been replaced. Recovery of IBTx 3 at Castlereagh should reduce the risk of a HILP event arising from a transformer fire at Castlereagh.

Pending a preliminary preferred option for the Castlereagh to Eden section, it has been assumed that section of the double circuit will be partially refurbished, with sections in built up areas recovered and replaced with cables. The associated work has been included in table 8.1.

Table 8.1: Proposed phased plan of works

Item	2021	2022	2023	2024	2025	2026	2027
Prepare and install IBTx 4 at Castlereagh, IBTx 1 works							
Connect Castlereagh 110 kV into Finaghy*							
Remove Carnmoney to Finaghy*							
Preconstruction work for possible 2 Belfast substations	SONI	SONI	NIEN	NIEN			
Preconstruction for Belfast cable routes	SONI	SONI	NIEN	NIEN			
Belfast substation and cable works*							
Remove Castlereagh to Finaghy*							

* denotes a phase which is dependent on completion of the previous phase.

9 STAKEHOLDER ENGAGEMENT

SONI have engaged with NIE Networks throughout the development of this Options Report. NIE Networks are supportive of the conclusions reached in this report and have worked with SONI to develop the cost estimates, scoping and project timelines discussed herein.

SONI also discussed this project with the Utility Regulator at the monthly SONI-UR meeting in August 2020.

SONI will progress stakeholder engagement with the local authorities and elected representatives of areas affected by the project at an early stage. The full list of these stakeholders which SONI will contact over the coming months can be found in Appendix J.

Wider stakeholder engagement will take place as the project progresses in accordance with SONI's Grid Development Process[9].

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

Appendix A – LSTC/Norpower Reports

Buildability Report

Attached PDF file:

LSTC Reference – 49_182245_01_C Eden – Castlereagh Buildability Report.pdf

Norpower Refurbishment/Dismantling Feasibility Report

Attached PDF files:

Norpower Feasibility Study – Summary.pdf

BOQ SONI – Refurbishment of 110KV OHL.pdf

BOQ SONI – Removal of DC 110KV OHL.pdf

Appendix B - Tower Access Assessments

FINAGHY – CASTLEREAGH OVERHEAD LINE ACCESS ISSUES

The following PDF files:

55_182245_05-46_A Compressed_Part1 (Tower 1-13)

55_182245_05-46_A Compressed_Part2 (Tower 13-27)

55_182245_05-46_A Compressed_Part3 (Tower 28-38)

FINAGHY – CARNMONEY OVERHEAD LINE ACCESS ISSUES

The following PDF files:

55_182245_47-61_A Compressed (CNM – FIN Pt 1) (Tower 106b - 116)

55_182245_62-75_A Compressed (CNM – FIN Pt 2) (Tower 117-130)

55_182245_76-89_A Compressed (CNM – FIN Pt 3) (Tower 131-144)

55_182245_90-107_A Compressed (CNM – FIN Pt 4) (Tower 145-161)

Appendix C - Criteria for Assessment of Short List of Options

To help reduce the short list to a preferred option, the options were assessed against the following five criteria:

- Electrical performance;
- Longer term technical performance;
- Economic performance
- Deliverability; and
- Preliminary Environmental and Social impact.

Due to the large quantity of analysis associated with each short-listed option, a brief summary of each option's performance is presented in the main report. The analysis of technical performance is included in Appendix E.

Electrical performance

Five different considerations are included when assessing the technical performance of an option, and are as follows:

- **275 kV double circuit contingency**: the voltage performance of the network following the loss of a 275 kV double circuit is assessed against the requirements of the TSSPS;
- **Interbus transformer maintenance trip**: the performance of the network is assessed for the maintenance-trip scenario involving two IBTx at both Castlereagh and Hannahstown;
- **High Impact Low Probability events**[10]: each option will be assessed for the loss of all IBTx at Castlereagh; and
- **Belfast 110 kV network contingencies**: the thermal loading of the existing and new 110 kV networks in Belfast is assessed, for both intact and contingency scenarios.

Longer term electrical performance

- **Additional load at Belfast North Main**: to assess the longer term performance of the option, the impact of an additional 30 MVA of load at Belfast North Main will be assessed- this reflects the proposed Giants Park and data centre developments in the area; and
- **2030 Scenario A**: decarbonisation of energy to meet EU targets will impact on the future demand. The options will be assessed against one of SONI's 2030 scenarios, the medium

[10] This includes a cost for the value of lost load for a hypothetical 14 day and 1 day outage of all transformers at Castlereagh. See Appendix E for the methodology used for assessing the HILP risk at Castlereagh

scenario, to check the impact of the potential load growth on the network. **Since the time of the analysis, the scenarios have been refined and consulted upon. Scenario A is broadly in line with the 'Modest Progress' scenario.**

Economic performance

The options will be assessed for the following costs:

- **Capital cost of option**: the cost of all equipment associated with the option will be assessed. The cost of all work associated with the Carnmoney to Castlereagh double circuit will be assessed based on costs determined by LSTC; and
- **Net Present Value**: all options will be subject to an NPV calculation.

Deliverability

A high level assessment of the challenges associated with delivering the option is considered. This includes:

- **Issues relating to refurbishment**: The practical feasibility of refurbishing the Carnmoney to Castlereagh 110 kV double circuit;
- **Issues relating to removal**: The practicalities of decommissioning and removing all or sections of the Carnmoney to Castlereagh 110 kV double circuit; and
- **Issues relating to all other elements of option**: Where new circuits or substations are required, potential traffic implications are noted.

Preliminary social and environmental performance

Each option will have a high level assessment of its potential social and environmental impacts. These are detailed in Appendix I Consideration is given to:

- The impact of the option on residential and commercial areas;
- The visual impact of the option; and
- The long term benefits of the project

Further work on the social and desktop environmental impact of the options will be progressed later in the Part 1 process.

Appendix D - Option Cost Estimates

Option 1: Refurbish with Upas				
Item Description	**Unit Cost (£m)**	**No**	**£m**	**Comments**
Carnmoney - Finaghy				
Refurbishment works	7.53	1	7.53	Costs provided by LSTC / Norpower
Tower furniture works	0.15	1	0.15	Costs provided by LSTC / Norpower
Tower foundation works	3.54	1	3.54	Costs provided by LSTC / Norpower
Castlereagh - Finaghy				
Refurbishment	5.11	1	5.11	Costs provided by LSTC / Norpower
Tower furniture works	0.11	1	0.11	Costs provided by LSTC / Norpower
Tower foundation works	2.06	1	2.06	Costs provided by LSTC / Norpower
Other				
Castlereagh Tx3 shunt reactor	0.94	1	0.94	
Estimate of TAO costs			**19.45**	
Contingency			1.94	
Total			**21.39**	

Option 2: Connect Tx and recover tower line				
Item Description	**Unit cost (£m)**	**No**	**£m**	**Comments**
Tx works				
Install IBTX 4 at Castlereagh	3.00	1	3.00	Based on cable costs only, assumes use existing spare
Shunt Reactor	0.94	1	0.94	
Tower line recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy double circuit	2.34	1	2.34	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy tower foundations	0.35	1	0.35	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Estimate of TAO costs			**10.49**	
Contingency			1.05	
Total			**11.54**	

Option 3a - Sailortown link and recovery of towerline

Item Description	Rate (£m)	Quantity	£m	Comments
Site procurement				
Procure new site adjacent to Belfast Central Main	1.00	1	1.00	Based on Airport Road cost
Procure new site adjacent to Belfast North Main	0.05	1	0.05	Based on a rent to BHC
Substation works				
Site pre-enabling works	0.25	2	0.50	
New GIS station at BNM	0.68	8	5.44	Assume 8 bays- 4 circuits, 2 TX, 2 bus couplers
New GIS station at Belfast Central	0.68	8	5.44	Assume 8 bays- 4 circuits, 2 TX, 2 bus couplers
Cable works				
New cable from Donegall to Belfast North Main	1.87	4	7.49	144 MVA cable, 2 circuits of 4 km
New cable from Belfast Central to Belfast North Main	1.87	1	1.87	144 MVA cable, 2 circuits of 1 km
Towerline recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy double circuit	2.34	1	2.34	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy tower foundations	0.35	1	0.35	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Other				
Castlereagh Tx3 shunt reactor	0.94	1	0.94	
Estimate of TAO costs			**29.28**	
Contingency			**2.93**	
Total			**32.21**	

Option 3b: East City Centre link and recovery of tower line

Item Description	Unit cost (£m)	No	£m	Comments
Site procurement				
Procure new site adjacent to East Central 33/11k si	2.00	1	2.00	Estimate considering prime city centre location
Procure site adjacent to Donegall Main for GIS	0.50	1	0.50	
Substation works				
Pre-enabling civils East city centre	1.00	1	1.00	
Pre-enabling Donegall	0.50	1	0.50	
New GIS station at Donegal	0.68	14	9.52	Assume 14 bays- 8 circuits, 4 TX and 2 spare
New GIS station at East City Centre	0.68	8	5.44	Assume 8 bays- 6 circuits and 2 spare
Cable works				
New cable from Donegall to East City Centre	1.87	2.9	5.35	144 MVA cable, 2 circuits of 1.2 km
Turn in Cregagh - Belfast Central circuits	0.31	5.4	1.67	Assume 135m needed to turn in circuits, use 100m cost
Towerline recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy double circuit	2.34	1	2.34	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy tower foundations	0.35	1	0.35	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Other				
Castlereagh Tx3 shunt reactor	0.94	1	0.94	
Estimate of TAO costs			**33.48**	
Contingency			3.35	
Total			**36.82**	

Option 3c: Donegal to Belfast Central and recovery of tower line				
Item Description	**Unit Cost (£m)**	**Quantity**	**£m**	**Comments**
Site procurement				
Procure new site adjacent to Belfast Central Main	2.00	1	2.00	Estimate considering prime city centre locati
Procure site adjacent to Donegall Main for GIS	0.50	1	0.50	
Substation works				
Pre-enabling civils East city centre	1.00	1	1.00	
Pre-enabling Donegall	0.50	1	0.50	
New GIS station at Donegall	0.68	14	9.52	Assume 14 bays- 8 circuits, 4 TX and 2 spare
New GIS station at Belfast Central	0.68	8	5.44	Assume 8 bays- 6 circuits and 2 spare
Cable works				
New cable from Donegall to Belfast Central	1.87	3.1	5.80	144 MVA cable, 2 circuits of 1.2 km
Towerline recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy double circuit	2.34	1	2.34	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy tower foundations	0.35	1	0.35	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Other				
Castlereagh Tx3 shunt reactor	0.94	1	0.94	
Estimate of TAO costs			**32.25**	
Contingency			3.23	
Total			**35.48**	

Option 4: New 110kV node at Blacks Road, uprate remainder of Castlereagh to Finaghy to

Item Description	Unit cost (£m)	Quantity	£m	Comments
Site procurement				
Procure site at Blacks Road for GIS	0.50	1	0.50	
Substation works				
Pre-enabling	0.50	1	0.50	
New GIS station at Blacks Road	0.68	8	5.44	Assume 8 bays- 6 circuits and 2 spare
Tower works				
New terminal tower at Hunters House	0.20	1	0.20	144 MVA cable, 2 circuits of 4 km
Cable works				
New cables from Hunters House to Blacks Road	1.87	1.7	3.18	144 MVA cable, 2 circuits of 1 km
Turn in Hannahstown to Lisburn circuit into Blacks Road	0.62	2	1.23	
Tower line refurbishment				
Refurbishment works Castlereagh to Hunterhouse	4.57	1	4.57	Costs provided by LSTC / Norpower
Towerline recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Finaghy to Hunterhouse double circuit	0.78	1	0.78	Costs provided by LSTC / Norpower
Remove Finaghy to Hunterhouse tower foundations	0.08	1	0.08	Costs provided by LSTC / Norpower
Tower furniture works Castlereagh to Hunterhouse	0.09	1	0.09	Costs provided by LSTC / Norpower
Tower foundation works Castlereagh to Hunterhouse	0.99	1	0.99	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Other				
Castlereagh Tx3 shunt reactor	0.94	1	0.94	
Estimate of TAO costs			22.37	
Contingency			2.24	
Total			**24.60**	

Option 5: Install Tx 4, Temporary retention of FIN - CAS, Sailortown Link

Item Description	Unit Cost	Quantity	£m	Comments
Castlereagh Tx works				
Install IBTX 4 at Castlereagh	3.00	1	3.00	Based on cable costs only, assumes use existing spare
Shunt Reactor	0.94	1	0.94	
Refurbishment of IBTx 1 at Castlereagh	0.20	1	0.20	To allow life extension to completion of project
Temporary Finaghy works				
Span from Castlereagh terminal tower to Donegall te	0.20	1	0.20	Estimate
Site procurement				
Procure new site adjacent to Belfast Central Main	1.00	1	1.00	Based on Airport Road cost
Procure new site adjacent to Belfast North Main	0.05	1	0.05	Based on a rent to BHC
Substation works				
Site pre-enabling works	0.25	2	0.50	
New GIS station at BNM	0.68	8	5.44	Assume 8 bays- 4 circuits, 2 TX, 2 bus couplers
New GIS station at Belfast Central	0.68	8	5.44	Assume 8 bays- 4 circuits, 2 TX, 2 bus couplers
Cable works				
New cable from Donegall to Belfast North Main	1.87	4	7.49	144 MVA cable, 2 circuits of 4 km
New cable from Belfast Central to Belfast North Main	1.87	1	1.87	144 MVA cable, 2 circuits of 1 km
Towerline recovery				
Remove Carnmoney to Finaghy double circuit	3.31	1	3.31	Costs provided by LSTC / Norpower
Remove Carnmoney to Finaghy tower foundations	0.46	1	0.46	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy double circuit	2.34	1	2.34	Costs provided by LSTC / Norpower
Remove Castlereagh to Finaghy tower foundations	0.35	1	0.35	Costs provided by LSTC / Norpower
Remove span over Finaghy substation	0.10	1	0.10	Costs provided by LSTC / Norpower
Subtotal			**32.68**	
Contingency			3.27	
Grand total			**35.95**	

Appendix E – Technical Performance of Options

Option 1 – Refurbishment of circuit

For all analysis associated with this option, it is assumed the Ballylumford to Eden and Eden to Carnmoney sections of the double circuit are uprated with Upas conductor.

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.0% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.99 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformer is loaded to 99% in autumn and 92% in summer, thus driving the need for connection of IBTx 4 at Castlereagh.
- The Carnmoney to Castlereagh 110 kV double circuit uprated with upas conductor would provide up to 133 MVA of resupply to Castlereagh, compared to the current day 70 MVA.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations on the transmission network provided that that the third transformer is available to cover the maintenance outage of one of the other two.
- Without the third transformer, the Lisburn to Tandragee 110 kV circuits will be subject to overloading. For this option it will be necessary to retain IBTx 3 at Hannahstown.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The network continues to operate in the configuration used today.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- Marginal overloading of the cables between Belfast North Main and Donegall occurs under contingency conditions.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Summary of network analysis:

Table E.1: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	64	83	78
Finaghy to Hannahstown 'A'	144	52	53	72
Belfast North Main to Donegall 'A'	82	65	101	73
Finaghy to Donegall 'A'	86	50	50	68
Castlereagh to Cregagh 'A'	145	84	84	88
Belfast Central to Cregagh 'A'	144	39	39	36
Carnmoney to Castlereagh 'A'	166	39	40	43

Option 2 – Fourth Interbus Transformer

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.5% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.97 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformers are loaded to 78% in autumn and 68% in summer.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations on the transmission network provided that that the third transformer is available to cover the maintenance outage of one of the other two.
- Without the third transformer, the Lisburn to Tandragee 110 kV circuits will be subject to overloading.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The network continues to operate in the radial configuration used today.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- Marginal overloading of the cables between Belfast North Main and Donegall occurs under contingency conditions.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

[11] https://www.uregni.gov.uk/sites/uregni/files/media-files/2017-07-04%20RP6%20FD%20Main%20Report%20%28002%29.pdf page 267

Summary of network analysis:

Table E.2: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	64	83	78
Finaghy to Hannahstown 'A'	144	53	53	72
Belfast North Main to Donegall 'A'	82	64	101	74
Finaghy to Donegall 'A'	86	50	50	68
Castlereagh to Cregagh 'A'	145	84	84	88
Belfast Central to Cregagh 'A'	144	39	39	36

Option 3a – Sailortown Link

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.4% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.97 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformer is loaded to 71% in autumn and 64% in summer.
- No overloads or voltage violations are observed on the transmission network.
- The need for IBTx 4 at Castlereagh is deferred and the unit can be released for asset replacement.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The interconnection between Belfast North Main and Belfast Central Main results in the demand of Belfast Central Main mainly being supplied under normal (intact) conditions from Hannahstown.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.
- The 110 kV cables between Donegall and Hannahstown would be almost fully loaded under N-1 conditions.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- New load results in 107% loading of the cables between Hannahstown and Donegall under contingency conditions.
- Mitigation would likely require a new double busbar arrangement at Donegall to marshal Donegall North and South at 110 kV. This would allow the Hannahstown to Finaghy to Donegall circuits to operate in parallel.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- The increase in demand results in 113% loading of the cables between Hannahstown and Donegall under contingency conditions.
- Mitigating overloads in future scenarios would require a double busbar arrangement at Donegall.

Summary of network analysis:

Table E.3: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	97	107	113
Finaghy to Hannahstown 'A'	144	52	52	72
Belfast North Main to Donegall 'A'	144	75	86	81
Finaghy to Donegall 'A'	86	67	67	91
Castlereagh to Cregagh 'A'	145	40	49	42
Belfast Central to Belfast North Main 'A'	144	40	31	43
Belfast Central to Cregagh 'A'	144	22	28	26

Option 3b – East City Centre Link

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.3% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.98 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformer is loaded to 70% in autumn and 62% in summer.
- The need for IBTx 4 at Castlereagh is deferred and the unit can be released for asset replacement.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- Similar to Option 3a, the interconnection between Belfast North Main and East City Centre results in the demand of Belfast Central Main mainly being supplied from Hannahstown under intact network conditions.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.
- The Donegall North to Hannahstown cable circuits would be heavily loaded under N-1 conditions, but not to the extent of Option 3a.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- New load results in marginal overloading of the cables between Belfast North Main and Donegall under contingency conditions.

- Mitigation would require new cables between Donegall and Belfast North Main. This will be required in any case as these cables are also in poor condition.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Summary of network analysis:

Table E.4: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	81	88	98
Finaghy to Hannahstown 'A'	144	37	39	46
Belfast North Main to Donegall 'A'	144	65	101	73
Finaghy to Donegall 'A'	86	43	47	51
Castlereagh to Cregagh 'A'	145	39	47	40
Belfast Central to East City Centre 'A'	144	39	39	34
Cregagh to East City Centre 'A'	144	22	25	27
Donegall to East City Centre 'A'	144	42	33	44

Option 3c – Central Link

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.3% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.98 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformer is loaded to 70% in autumn and 62% in summer.
- The need to establish IBTx 4 at Castlereagh is deferred indefinitely.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The interconnection between Donegall and Belfast Central results in the demand of Belfast Central Main mainly being supplied from Hannahstown.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.
- The Donegall to Hannahstown cables would be heavily loaded under N-1 conditions, but not to the extent of Option 3.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- New load results in marginal overloading of the cables between Belfast North Main and Donegall under contingency conditions.
- Mitigation would require new cables between Donegall and Belfast North Main. This will be required in any case as these cables are also in poor condition.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Summary of network analysis:

Table D.5: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	81	88	98
Finaghy to Hannahstown 'A'	144	37	39	46
Belfast North Main to Donegall 'A'	144	64	101	72
Finaghy to Donegall 'A'	86	43	47	51
Castlereagh to Cregagh 'A'	145	39	47	40
Belfast Central to Cregagh 'A'	144	22	24	26
Belfast Central to Donegall 'A'	144	41	33	44

Option 4 – Blacks Road Reinforcement (Dunmurry Link)

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.4% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.98 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformer is loaded to 77% in autumn and 68% in summer.
- The need to establish IBTx 4 at Castlereagh is deferred indefinitely.
- No overloads or voltage violations are observed on the transmission network.
- Up to 162 MVA of power is provided to Castlereagh from Hannahstown via the new switching substation

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The network effectively operates in a similar manner to today's configuration, but with 110 kV supply to Castlereagh now supplied from Hannahstown rather than Ballylumford.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- New load results in marginal overloading of the cables between Belfast North Main and Donegall under contingency conditions.
- Mitigation would require new cables between Donegall and Belfast North Main.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Summary of network analysis:

Table E.6: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	64	83	78
Finaghy to Hannahstown 'A'	144	52	53	72
Belfast North Main to Donegall 'A'	144	65	101	74
Finaghy to Donegall 'A'	86	50	50	68
Castlereagh to Cregagh 'A'	145	84	84	88
Hannahstown to Blacks Road 'A'	144	61	48	47
Castlereagh to Blacks Road 'A'	144	29	23	31
Lisburn to Blacks Road 'A'	103	25	20	29

Option 5: Hybrid Phasing of 4th Interbus Transformer and Sailortown Reinforcement

Phase 1 – Castlereagh IBTX 2 installed, Castlereagh – Finaghy retained

For the loss of a 275 kV double circuit:

- A maximum voltage step of 3.2% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.98 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformers are loaded to 50% in autumn and 49% in summer.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The network continues to operate in the radial configuration used today.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- Marginal overloading of the cables between Belfast North Main and Donegall occurs under contingency conditions.

Network analysis 3- with demand scaled to 2030 scenario A:

Not carried out as phase 2 would be in place by 2030.

Summary of network analysis:

Table E.7: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	64	83	n/a
Finaghy to Hannahstown 'A'	144	62	53	n/a
Belfast North Main to Donegall 'A'	144	65	101	n/a
Finaghy to Donegall 'A'	86	50	50	n/a
Castlereagh to Cregagh 'A'	145	84	84	n/a
Finaghy – Castlereagh 'B'	86	60	45	n/a
Belfast Central to Cregagh 'A'	144	39	39	n/a

Phase 2 – Sailortown reinforcement

For the loss of a 275 kV double circuit:

- A maximum voltage step of 2.7% is observed in the Belfast area.
- The lowest post fault steady state voltage in the Belfast area is 0.96 p.u.
- Voltages are well within the requirements set out in the TSSPS.

For the N-M-T loss of transformers at Castlereagh:

- The remaining transformers are loaded to 52% in autumn and 47% in summer.
- No overloads or voltage violations are observed on the transmission network.

For the N-M-T loss of transformers at Hannahstown:

- No overloads or voltage violations are observed on the transmission network.
- The third transformer is no longer required to cover the N-M-T event of other two transformers, and could be released for asset replacement.

For a HILP event at Castlereagh:

Network analysis 1- 2025 assessment:

- The network continues to operate in the radial configuration used today.
- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 2- with an additional 30 MVA load at Belfast North Main:

- There are no voltage violations or overloads on the network for an N-1 contingency scenario.

Network analysis 3- with demand scaled to 2030 scenario A:

- There is heavier loading on some 110 kV circuits in Belfast.
- Mitigating overloads in future scenarios would require a double busbar arrangement at Donegall.

Summary of network analysis:

Table E.8: Summary of flows on Belfast 110 kV network

Circuit	Rate (MVA)	Overload (% of rating)		
		analysis 1	analysis 2	analysis 3
Donegall to Hannahstown 'A'	158	65	71	86
Finaghy to Hannahstown 'A'	144	31	33	72
Hannahstown to Lisburn 'A'	103	31	26	24
Belfast North Main to Donegall 'A'	144	49	59	52
Finaghy to Donegall 'A'	86	33	37	92
Castlereagh to Cregagh 'A'	145	64	74	69
Belfast North Main to Belfast Central 'A'	86	14	7	13
Belfast Central to Cregagh 'A'	144	41	51	42

Appendix G – Net Present Cost Assessments

Assumptions

Option / Assumption	1	2	3a	3b	3c	4	5
Capital costs of new assets, duration of associated works	£3m, year 0 (1 year)	£3m, year 0 (1 year)	£24.63m, years 5-7 (3 years)	£29.25m, years 6-8 (3 years)	£27.9m, years 6-8 (3 years)	£15.62m, years 2-4 (3 years)	£27.72m, year 0 (Tx 4 and Finaghy, £3.71 m) and 6-7 (city centre works, £23.98m)
Double circuit condition	Refurbished in years 1-2, £20.35m	Recovered in years 1-2, £6.54m	Recovered in years 8-9, £6.54m	Recovered in years 9-10, £6.54m	Recovered in years 8-9, £6.54m	Hunter House – Castlereagh refurb in years 3-4 (£4.58m) Carnmoney – Hunter House recovered in years 4-5(£5.82m)	Carnmoney – Finaghy recovered in years 1-2 (£4.1m), Finaghy – Castlereagh recovered year 8 (£3.06m)
HILP risk at Castlereagh	[redacted]						

Assumption / Option	1	2	3a	3b	3c	4	5
HILP annualised cost	[redacted]						
Operational cost	£200k/year for 5 years (34 towers, £30k each)	0	0	0	0	£78k/year for 5 years (13 towers, £30k each)	0
Belfast North main cables	Replaced in years 10-11, £8.24m	Replaced in years 10-11, £8.24m	n/a	Replaced in years 10-11, £8.24m	Replaced in years 10-11, £8.24m	Replaced in years 10-11, £8.24m	n/a
Asset replacement	2 IBTx procured in year 8, £7m	2 IBTx procured in year 8, £7m					
TOTAL NET PRESENT COST	**£41m**	**£110m**	**£49m**	**£57m**	**£53m**	**£45m**	**£51m**

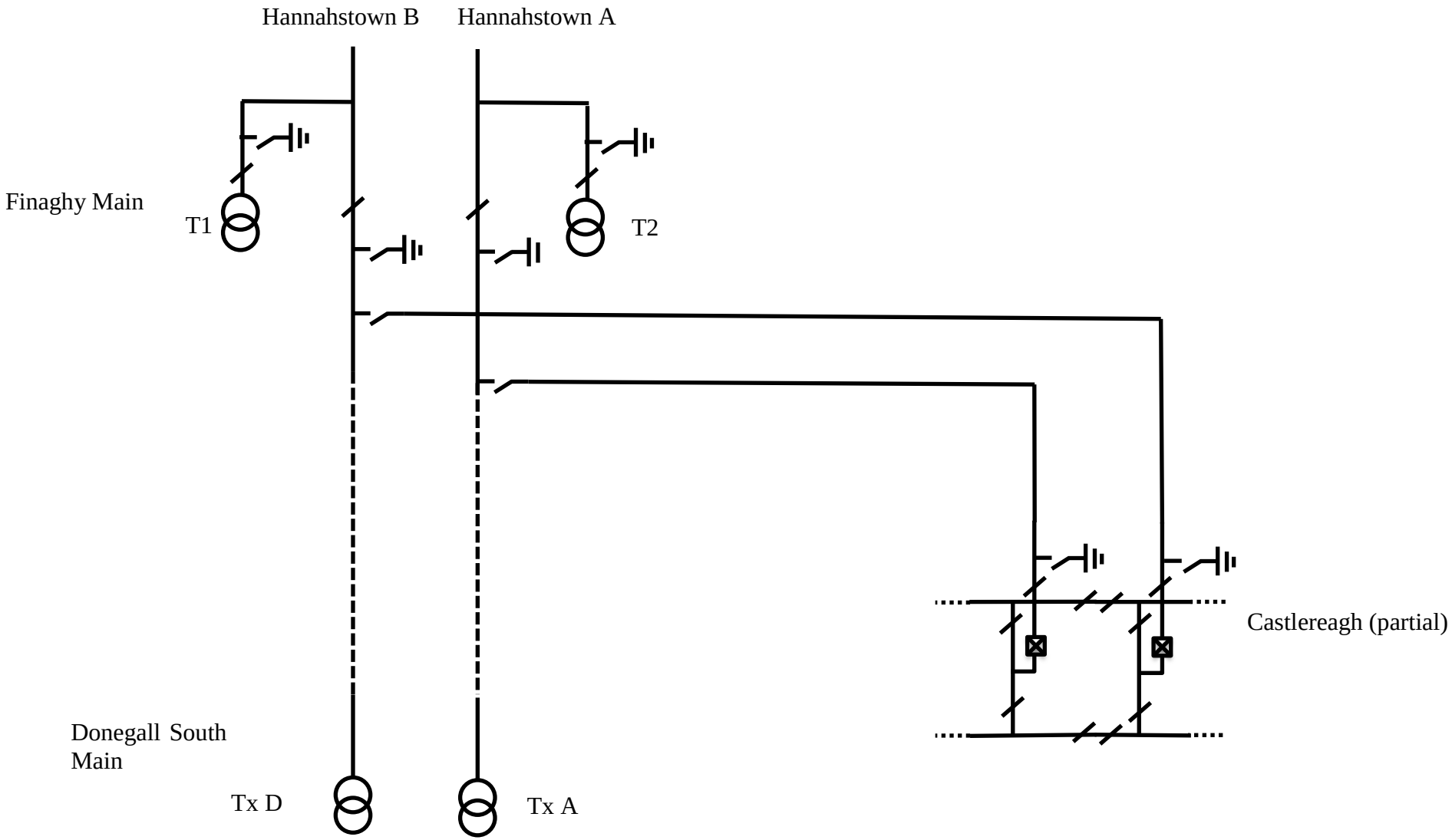
Assessments

See attached document:

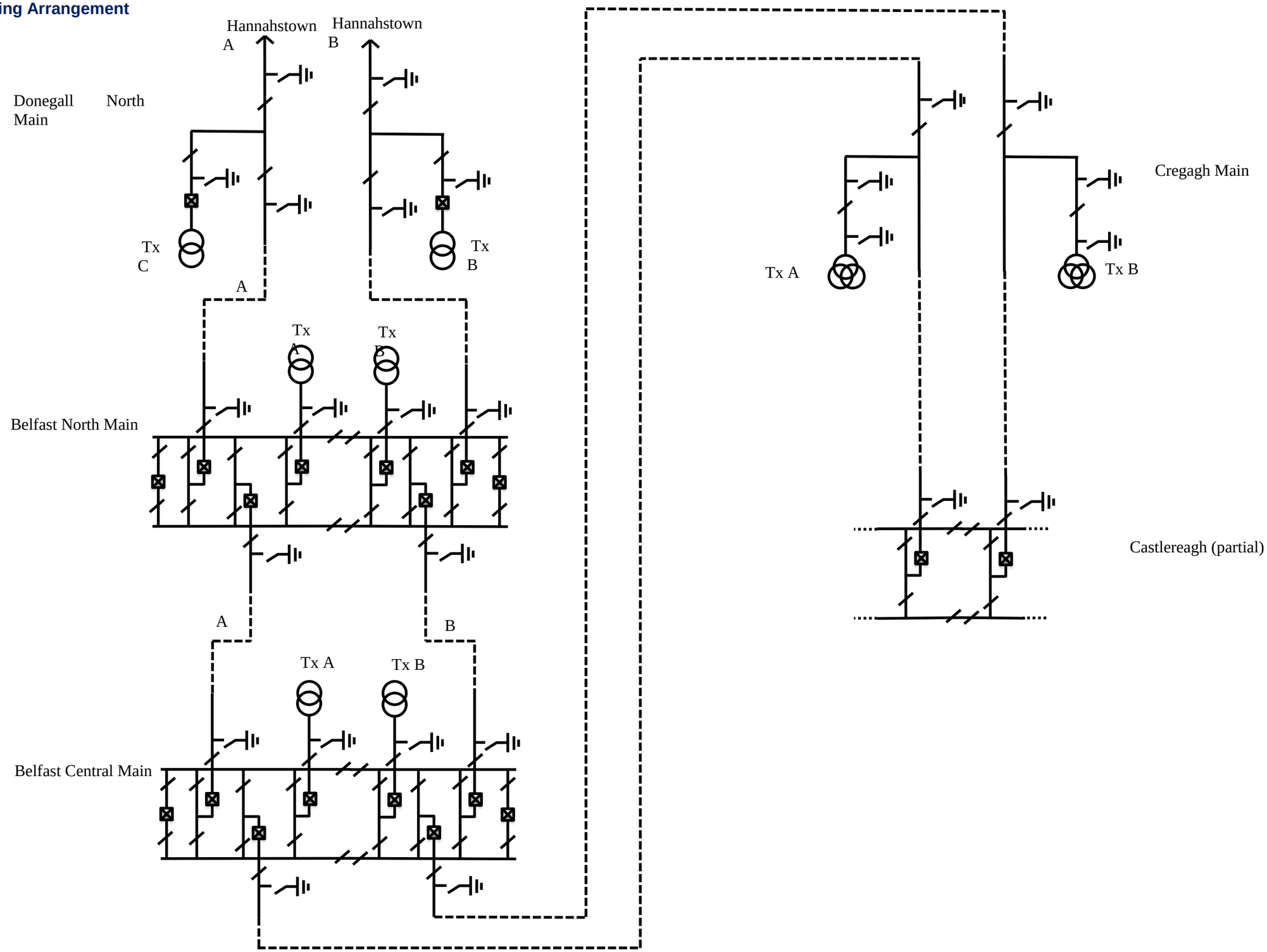
Carnmoney Castlereagh NPV.xlsx

Appendix H – Single Line Diagrams for Option 5

Phase 1 – Finaghy – Castlereagh arrangement



Phase 2 – Enduring Arrangement



Appendix I – Environmental Desktop Report

See attached documents:

RPS NI2248 SONI Carnmoney – Castlereagh Environmental Constraints Report.pdf

RPS NI2248 SONI Castlereagh – Carnmoney Environmental Constraints.pdf

Appendix J – Stakeholder List

Background

This list collates the main stakeholders that SONI will engage with during Part 1 of grid development project 'Belfast Metropolitan Redevelopment Project'. In accordance with SONI's Grid Development for Northern Ireland 3 Part Process this stakeholder engagement with be commence during Part 1 of project development.

This key stakeholder list has been prepared to detail SONI's intended external engagement in relation to Belfast Metropolitan Redevelopment Project during Part 1.

The project area encompasses 4 different council areas and 5 different Parliamentary Constituencies. The project team aim to engage with each council area on separate basis at this stage of the project.

A full stakeholder report will be compromised once engagement has been completed.

Parliamentary Constituencies	**Council areas**
East Antrim	Mid and East Antrim
South Antrim	Antrim and Newtownabbey
West Belfast	Belfast
South Belfast	Lisburn and Castlereagh
East Belfast	

Stakeholder list - Councils

Mid and East Antrim	
Anne Donaghy	Chief Executive
Paul Duffy	Head of Planning
Antrim and Newtownabbey Borough Council	
Jacqui Dixon	Chief Executive
John Linden	Head of Planning
Belfast City Council	
Suzanne Wylie	Chief Executive
Aidan Thatcher	Head of Planning
Lisburn and Castlereagh City Council	
David Burns	Chief Executive
Heather Moore	Director of Environmental Services

Stakeholder list – Parliamentary

Stakeholder	Party	Constituency
MP		
Sammy Wilson	DUP	East Antrim
Paul Girvan	DUP	South Antrim
Paul Maskey	Sinn Féin	West Belfast
Claire Hanna	SDLP	South Belfast
Gavin Robinson	DUP	East Belfast

MLA

East Antrim	
Roy Beggs	UUP
Mr Stewart Dickson	Alliance
Gordon Lyons	DUP
John Stewart	UUP
David Hilditch	DUP
South Antrim	
Steve Aiken	UUP
John Blair	Alliance
Pam Cameron	DUP
Trevor Clarke	DUP
Declan Kearney	Sinn Féin
West Belfast	
Gerry Carroll	PBP
Órlaithí Flynn	Sinn Féin
Alex Maskey	Sinn Féin
Fra McCann	Sinn Féin
Pat Sheehan	Sinn Féin
South Belfast	
Clare Bailey	Green Party
Paula Bradshaw	Alliance Party
Deirdre Hargey	Sinn Féin
Matthew O'Toole	SDLP
Clare Bailey	Green Party
East Belfast	

Andy Allen	UUP
Joanne Bunting	DUP
Naomi Long	Alliance Party
Chris Lyttle	Alliance Party
Robin Newton	DUP