

East Tyrone Upgrade

Preliminary Preferred Options Report

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Table of contents

Table of contents	3
List of Figures.....	4
List of tables.....	5
Executive summary	6
1. Introduction.....	9
2. NIE Networks RP7 33kV reinforcement provision.....	10
3. Longlist of options.....	12
3.1. Option 1: Status Quo	12
3.2. Option 2: Transfer Cookstown Cement Works to Tremoge (£9.93m)	12
3.3. Option 3: 33kV circuits between Tremoge and Dungannon (£6.28-£7.64m)	14
3.4. Option 4: New 110/33kV substation at Tamnamore (£16.39m).....	16
3.5. Option 5: Third transformer (standby mode) at Dungannon Main (£8.09m).....	18
3.6. Option 6: Second 110/33 kV substation at Dungannon Main	21
3.7. Option 7: New 110/33kV BSP in Cookstown (£24.22m- £29.34m).....	25
4. Shortlisting.....	30
4.1. Capital cost	30
4.2. Technical and deliverability.....	31
5. Appraisal of shortlist	36
5.1. Economic performance	36
5.2. Environmental impact	38
6. Conclusions.....	39
Appendix A. Capital costs of the options.....	40
Appendix B. Revenue costs due to lost load during transformers maintenance	57

List of Figures

Figure 1: SLD of 110kV mesh and transformers at Dungannon Main	9
Figure 2: Circuits highlighted in blue with expected shortfall	10
Figure 3: Reconfiguration of the 33 kV network in RP7 plan.....	11
Figure 4 : Option 2 – 33 kV circuits coming from DUN to Cookstown Cement Works that will be rearranged.....	13
Figure 5 : Option 2 – Location of substations and route of the new 33 kV circuits	13
Figure 6 : Option 2 – 33kV configuration of Tremoge and Cookstown Cement Works	14
Figure 7 : Sub-option 3.a – SLD with double cable 33 kV circuits between Tremoge and Dungannon	15
Figure 8 : Sub-option 3a – Location of substations and new 33 kV circuits.....	15
Figure 9 : Option 4 – SLD of the feeders' arrangements in Tamnamore and Dungannon BSPs	17
Figure 10 : Option 5 – 110kV SLD of Dungannon with third power transformer	19
Figure 11 : Option 5 – SLD of Dungannon for the 33 kV DBBs with the third power transformer	19
Figure 12 : Study area for the expansion of the substation footprint	20
Figure 13 - 33kV undergrounding required (proposed cable purple dashed)	20
Figure 14 : Sub-option 6.a – SLD of 110kV works	22
Figure 15 : Sub-option 6.a – SLD of DUN A and DUN B substations.....	22
Figure 16 : Sub-option 6.b – Single line diagram of DUN A and DUN B 110kV works	24
Figure 17 : Sub-option 6.b – Single line diagram of DUN A and DUN B.....	25
Figure 18 : Sub-option 7.a – Connection from 110 kV spare bays in Dungannon substation	26
Figure 19 : Sub-option 7.a – 33 kV arrangement of the network for the new 110/33 kV BSP in Cookstown	27
Figure 20 : Sub-option 7.b – Connection from a marshalling station in the Tremoge - Dungannon 110 kV circuit.....	28
Figure 21 : Sub-option 7.c – Connection from Tremoge cluster at 110 kV	28
Figure 19 : Typical demand profile by the transformers on a maintenance day	59
Figure 21 : Load shedding during the transformers maintenance	60
Figure 22 : Revenue costs due to transformers maintenance according to the year	61

List of tables

Table 1 : Summary of capital costs per option	30
Table 2 : Comparison of the longlist of option	35
Table 3 : Shortlisted options	35
Table 4 : NPV of the shortlisted options	37
Table 5 : Option 2 – Capital costs for distribution works	41
Table 6 : Sub-option 3.a – Capital costs for distribution works	42
Table 7 : Sub-option 3.b – Capital costs for distribution works	43
Table 8 : Option 4 – Capital costs for distribution works	44
Table 9 : Option 4 – Capital costs for transmission works.....	45
Table 10 : Option 5 – Capital costs for distribution works.....	46
Table 11 : Option 5 – Capital costs for transmission works	47
Table 12 : Sub-option 6.a – Capital costs for distribution works.....	48
Table 13 : Sub-option 6.a – Capital costs for transmission works	49
Table 14 : Sub-option 6.b – Capital costs for distribution works.....	50
Table 15 : Sub-option 6.b – Capital costs for transmission works	51
Table 18 : Sub-option 7.a – Capital costs for distribution work.....	52
Table 19 : Sub-option 7.a – Capital costs for transmission works	53
Table 20 : Option 7.b – Capital costs for distribution works.....	54
Table 21 : Option 7.b – Capital costs for transmission works	55
Table 22 : Sub-option 7.c – Capital costs for distribution works	56
Table 23 : Sub-option 7.c – Capital costs for transmission work	56

Executive summary

Dungannon Main 110/33kV Bulk Supply Point (BSP) supplies the Dungannon and Cookstown areas of County Tyrone. The peak demand at this substation under an N-1 contingency is now above the nominal rating of the transformers during the winter peak in the winter months. The most recent demand forecast for Dungannon Main, done in 2022-23, shows that Dungannon Main had a peak demand of 95 MW. The analysis done as part of the Needs assessment showed that, based on the demand profile the transformers had a rating of 100 MVA. However, the forecast demand based on uptake of low carbon technologies indicates that this will be exceeded in the coming years.

It has been also identified by NIE Networks that there is the need to reinforce the 33 kV network around Cookstown. NIE Networks included provision for this in their RP7 submission.

Because Dungannon Main has both transmission and distribution apparatus, the Needs assessment checked compliance of this substation against the security of supply standards in place for both transmission and distribution. This assessment concluded that for the N-1 contingency the site could be made compliant as a short-term measure through post fault transfer of demand on the distribution system as well as a load shedding scheme to prevent transformer overload. However, this would not be a long-term solution and a reinforcement would be progressed in parallel with such a scheme. In addition, for an N-1-1 scenario (i.e., loss of both transformers) then the recommended one third of demand could not be satisfied, as there isn't sufficient capacity on the 33kV system to resupply from neighbouring bulk supply points.

To address the need a project was included in the Transmission Development Plan Northern Ireland (TDPNI) 2020-2029, updated in the TDPNI 2021-2030 and also included in the draft TDPNI 2023-2032. The project falls under the category of "Load Related and Security of Supply" projects.

NIE Networks and SONI have jointly assessed the different options to address the issues identified in the Need Case.

The options proposed to accomplish the objectives of this project are the following:

Option 1: Status Quo

The Status Quo option is based on keeping Dungannon Main as is. It would require a derogation from the security of supply standards.

Option 2: Install 33kV cables to transfer Cookstown Cement Works 33kV switchboard demand onto Tremoge (£9.93m)

Option 3: Install 33kV circuits between Tremoge and Dungannon substations along with an auto-transfer scheme:

- **Sub-option 3a:** Build two 33 kV underground cable circuits (£7.64m)
- **Sub-option 3b:** Build two single 33 kV OHL circuits (£6.28m)

Option 4: Build a bulk supply point in Tamnamore and divert 33kV circuits from Dungannon to Tamnamore (£16.39m)

Option 5: Install a third transformer in Dungannon Main (£8.09m)

Option 6: Establish a second 110/33 kV substation at Dungannon Main

- **Sub-option 6a:** Phased approach with only one transformer initially (£7.49m)
- **Sub-option 6b:** Fully build second 110/33 kV BSP at Dungannon Main (£10.51m)

Option 7: Build a new 110/33kV BSP in Cookstown

- **Sub-option 7a:** Connect from Dungannon 110/33 kV substation (£24.22m)
- **Sub-option 7b:** Connect from the Dungannon – Tremoge 110 kV circuits through a new marshalling substation (£29.34m)
- **Sub-option 7c:** Connect from Tremoge 110/33 kV cluster substation (£26.00m)

From the above longlist, options 1, 4, 6b, 7a and 7b were shortlisted. To identify the preliminary preferred option, the further lifecycle cost analysis was conducted and option 6b was selected as the preliminary preferred option. This option addresses the scope of this project by ensuring that demand is transferred from the existing substation onto the new substation which will have sufficient capacity under single circuit outage. This option also ensures that in a maintenance trip contingency, resupply of significantly more than the 1/3 recommended by ENA ER P2/6 will be available. Option 6b would require the 33 kV reinforcement of the Distribution Network in the area of Cookstown to be delivered by NIEN after this project as set out in the NIEN RP7 plan.

1. Introduction

Dungannon Main is a 110/33kV substation to the north of Dungannon town in County Tyrone. The configuration of the substation is shown in Figure 1. The bulk supply point supplies over 33,000 consumers in Dungannon, Cookstown, Coalisland and the surrounding villages. The area is also known for its agriculture, construction material suppliers and food production industries.

Demand has been increasing in the Dungannon and Cookstown areas and peaked at 95 MW in 2022/23 against a firm capacity of approximately 100 MVA, based on modelling the thermal characteristics of the transformer and demand profile. NIE Networks, in the last ten years, constructed a new 33kV circuit from Creagh Main 110/33kV bulk supply point to Coagh West 33/11kV substation, situated to the north of Cookstown. This allowed the transfer of about 13 MW of demand from Dungannon Main to Creagh Main 110/33 kV substation, providing demand relief in the medium term. However, the Need report confirms that solutions need to be in progress to ensure that Dungannon Main will continue to comply with security standards.

NIE Networks have made provision in their RP7 plan to reinforce the 33 kV circuits from Dungannon Main to Cookstown. However, this distribution project will be included in the assessment of options.

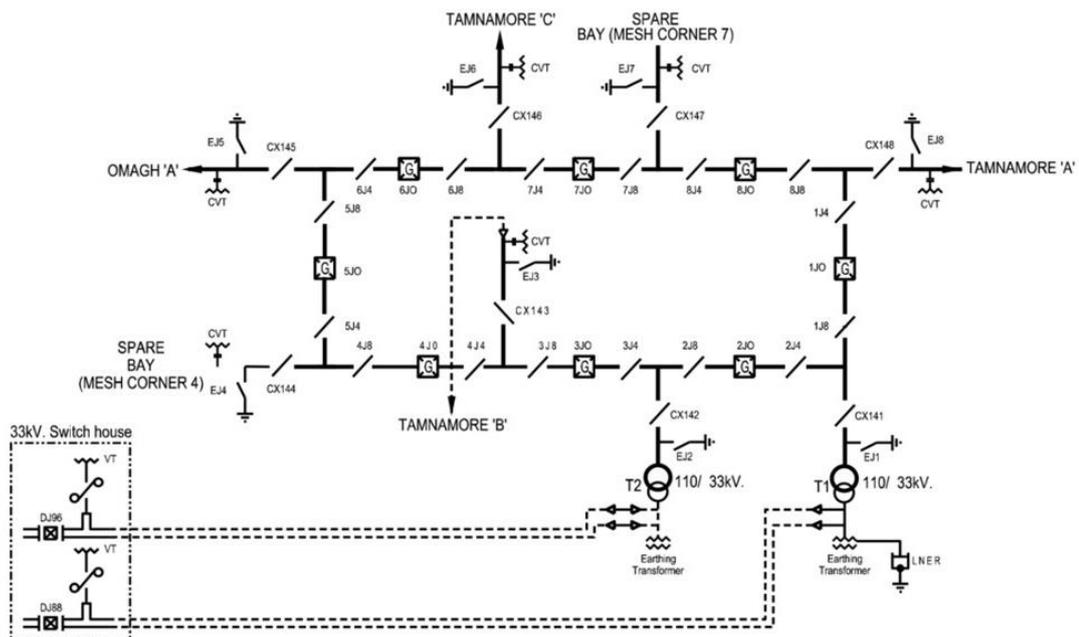


Figure 1: SLD of 110kV mesh and transformers at Dungannon Main

2.NIE Networks RP7 33kV reinforcement provision

NIE Networks has identified a shortfall in capacity of the 33 kV system to Cookstown South 33/11 kV substation, see Figure 2.

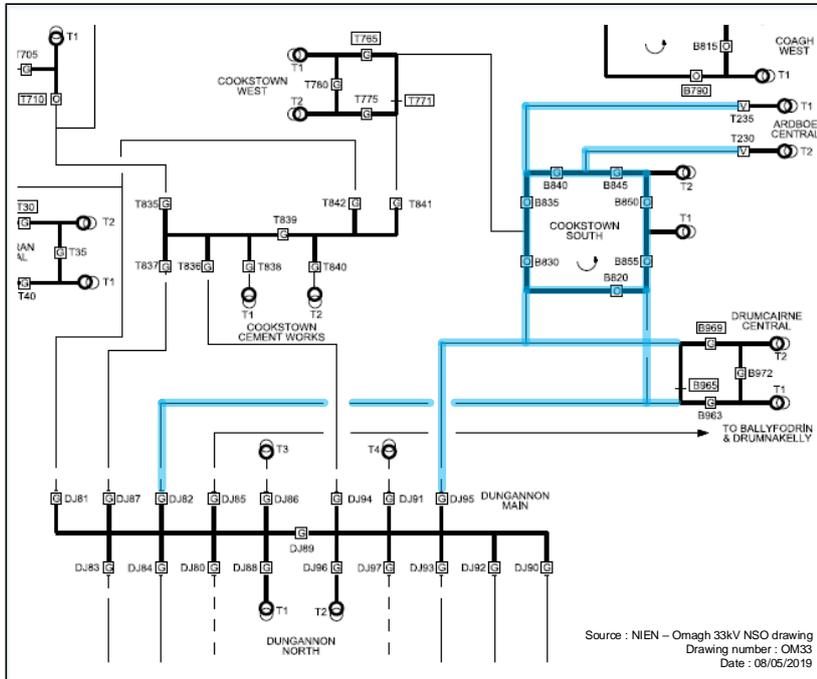


Figure 2: Circuits highlighted in blue with expected shortfall

NIE Networks has included a 33kV reinforcement project in its RP7 Primary Network program to address this shortfall. This consists of constructing a new seven panel 33 kV switchboard at Dungannon Main to enable provision of two spare bays. To do this the Moy Park and Killyman circuits would be diverted to the new 33kV switchboard, and the panels released would be used to provide two interconnecting cables between the old board and the new. New circuits based on overhead lines approximately 27km would then be established from Dungannon Main to allow splitting the existing Cookstown South, Ardboe Central and Drumcairne Central circuits see Figure 3. The work also required a new 5 panel 33 kV switchboard at Ardboe and an extension 33 kV switchboard with at least 6 panels at Dungannon Main. The total cost expected for these works are £3.47m. NIE Networks plan to deliver this by 2028.

The outline project to reinforce the 33 kV network in Cookstown, however is included where appropriate in the options appraisal. This project would not be required for the options that involve Cookstown being reinforced at 110kV. It would also be impacted by options at Dungannon Main were the work overlaps.

3. Longlist of options

The technical solutions proposed to address the issues identified in the Need Case will be presented in the longlist of options.

3.1. Option 1: Status Quo

By 2026, the demand at Dungannon Main 110/33 kV substation is expected to exceed the firm capacity, depending on the uptake of low carbon technologies. There is ability to transfer a sufficient level of demand on the 33kV and 11kV system to neighbouring bulk supply points after the loss of a transformer. That allows the site to remain compliant with the TSSPS.

Under a forced outage, such as failure of an existing transformer, it is possible that there might need to be load shedding to prevent an overload. However, a transformer failure is very rare, and this scenario is unlikely. However, if additional capacity is not provided in the future, it may become increasingly challenging to obtain an outage to carry out transformer maintenance, which is necessary for system reliability. The long-term cost of this option can be estimated based on value of lost load and the assumption that a) maintenance cannot be neglected and b) if capacity is not available to maintain supplies during the outage, then there will be unserved energy to facilitate it.

If transmission reinforcement of the Cookstown demand block is not undertaken, then it will still be necessary for NIE Networks to reinforce Cookstown South as envisaged in its RP7 Primary Network program. These revenue costs are detailed in appendix B.

3.2. Option 2: Transfer Cookstown Cement Works to Tremoge (£9.93m)

This option is based on transferring Cookstown Cements Works onto the Tremoge cluster. Cookstown Cement Works is a high voltage customer connected as per Figure 4.

The work would involve laying 17km of 33kV cables from Tremoge to a new 33kV switchboard close to Cookstown Cement Works, see Figure 5. A new configuration would be established, see Figure 6

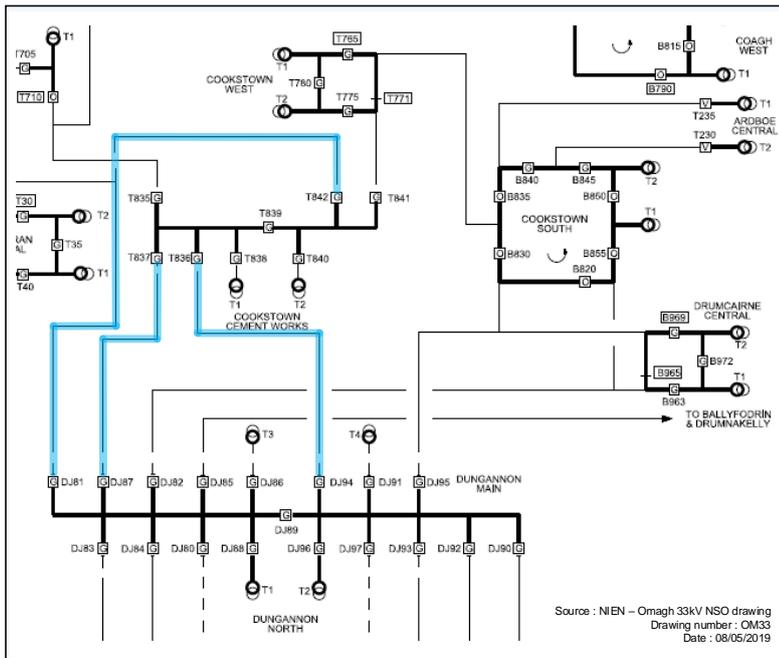


Figure 4 : Option 2 – 33 kV circuits coming from DUN to Cookstown Cement Works that will be rearranged



Figure 5 : Option 2 – Location of substations and route of the new 33 kV circuits

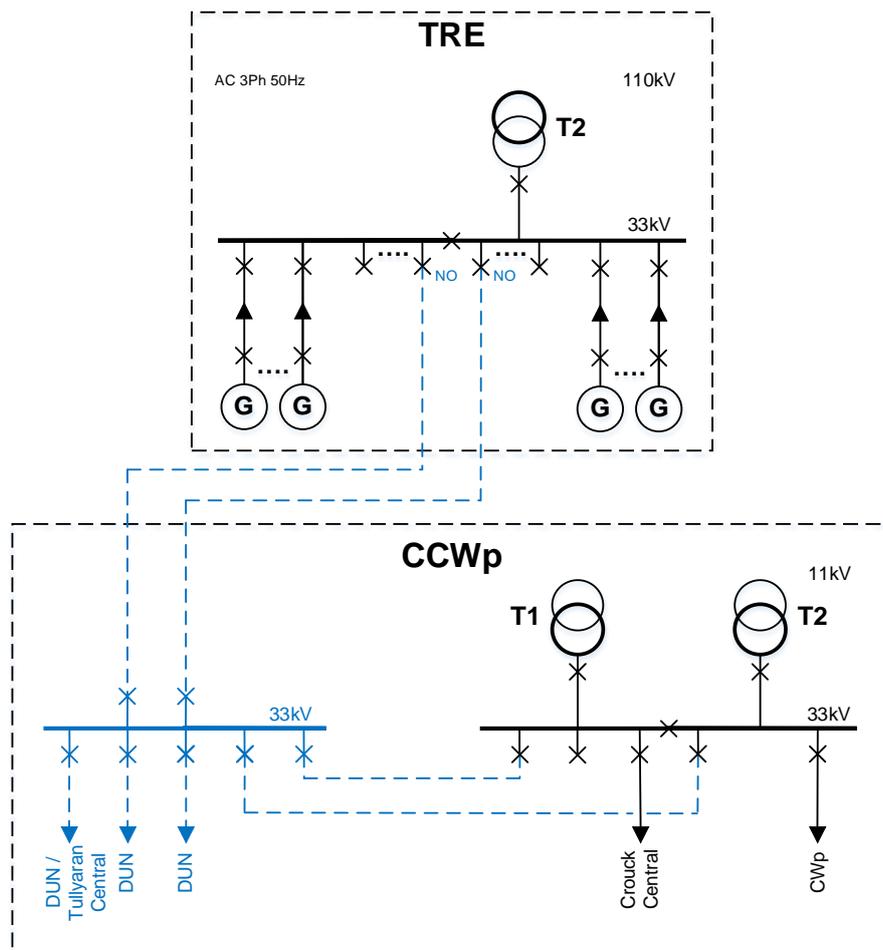


Figure 6 : Option 2 – 33kV configuration of Tremoge and Cookstown Cement Works

There are two ways of operating this arrangement:

- 1) Tremoge circuits would be normally open, and only closed under an N-1 or N-1-1 scenarios at Dungannon Main (transferring Cookstown Cement Works to Tremoge).
- 2) Cookstown Cement Works PS would be transferred on a system normal basis to Tremoge.

3.3. Option 3: 33kV circuits between Tremoge and Dungannon (£6.28-£7.64m)

This option is based on installing two 33kV standby circuits (normally open) that would transfer demand to Tremoge cluster substation during the loss of a transformer at Dungannon Main. There are two sub-options, the circuits would be based on a) underground cable and b) overhead lines.

3.3.1. Sub-option 3a: Build two 33kV underground cable circuits (£7.64m)

This option includes the following work:

- a) Install 2x 33 kV panels at Dungannon.

b) Install 19.5 km of 2x 33 kV underground circuits between Tremoge and Dungannon.

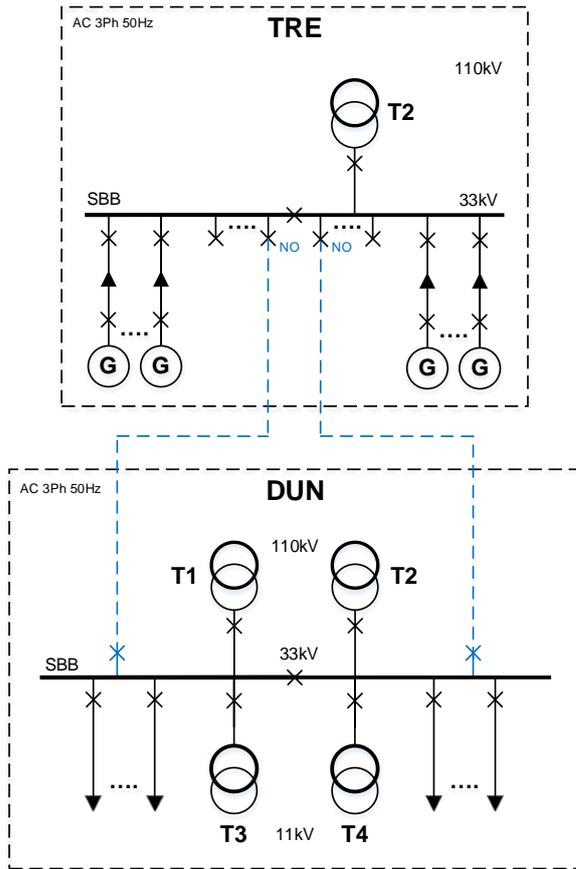


Figure 7 : Sub-option 3.a – SLD with double cable 33 kV circuits between Tremoge and Dungannon

Figure 7 above shows the SLD with the double cable 33 kV circuits between Tremoge and Dungannon. The circuits would be normally open, and only closed under a N-1 or N-1-1 contingency at Dungannon. Figure 8 shows the location of substations and an indicative route of the new 33 kV cable circuits.



Figure 8 : Sub-option 3a – Location of substations and new 33 kV circuits

The steps to resupply demand at Dungannon would be as follows:

- 1) Tx 1 or Tx 2 forced out of service.
- 2) Temporary overload of Tx 1 or Tx 2 (within 150% emergency half hour rating).
- 3) Offload wind at Tremoge (necessary to prevent wind generation overloading 33 kV circuits during parallel), expected to take around 20 minutes.
- 4) 33 kV circuit on the same side of the 33kV switchboard as the faulted transformer would be closed, establishing a parallel between Tremoge and Dungannon.
- 5) Automation scheme would open circuit breakers on 33kV system to establish open points including the bus-section switch.

This option requires about 20 minutes to ramp down the wind farms at Tremoge and reconfigure the 33 kV system to transfer demand from Dungannon over to Tremoge. In theory this would have the potential to ensure N-1 and N-1-1 compliance although this may be questionable depending on the time to run down the windfarms.

3.3.2. Sub-option 3b: Build two single 33 kV OHL circuits (£6.28m)

A variant to the double 33 kV cable between Tremoge and Dungannon is two single 33 kV OHL circuits. Option 3b will have a SLD very similar to the one presented in Figure 7.

- a) Install two single 33 kV overhead lines circuit (approx. 20.7 km each) between Tremoge and Dungannon.
- b) Install 2x250m of 33 kV underground cable near the substations.

As in sub-option 3a, also involves a complex automation scheme and the need to manually ramp down the wind generation at Tremoge.

3.4. Option 4: New 110/33kV substation at Tamnamore (£16.39m)

This option is based on establishing a new BSP at Tamnamore and turning in several 33 kV circuits currently supplied from Dungannon into the new Tamnamore bulk supply point with new 33kV normally open positions. This solution would comply with the security of supply standards for the N-1 and N-1-1 scenarios and would also satisfy ER P2/5 recommendation under an N-1-1 (more than 1/3 of GD)

This option comprises the following activities:

- a) Secure approximately 6 acres of land immediately to the north of Tamnamore substation to extend the 110 kV substation.
- b) Divert the existing Tamnamore – Dungannon B circuit via new underground cable.
- c) Extend the existing 110 kV double busbar as required, install two new 110/33 kV transformers a 33 kV switchboard.

d) Establish new 33kV overhead lines to connect in the following:

- 1x circuit towards Killyman Central 33/11kV.
 - 1x circuit towards Moy Park 33/11kV.
 - 2x circuits towards Drumcairne Central 33/11kV, and then towards Arboe Central 33/11kV.
 - 1x circuit to connect to the Ballyfodrin Central 33/11kV and Drumnakelly 110/33kV.
- About 35km of Jaguar 33 kV OHL circuits are estimated to be required to deliver this solution.

The cost of the transmission and distribution elements are estimated to be £9.46m and £6.93m respectively. Figure 9 presents an indicative 33kV SLD of the diversions into Tamnamore.

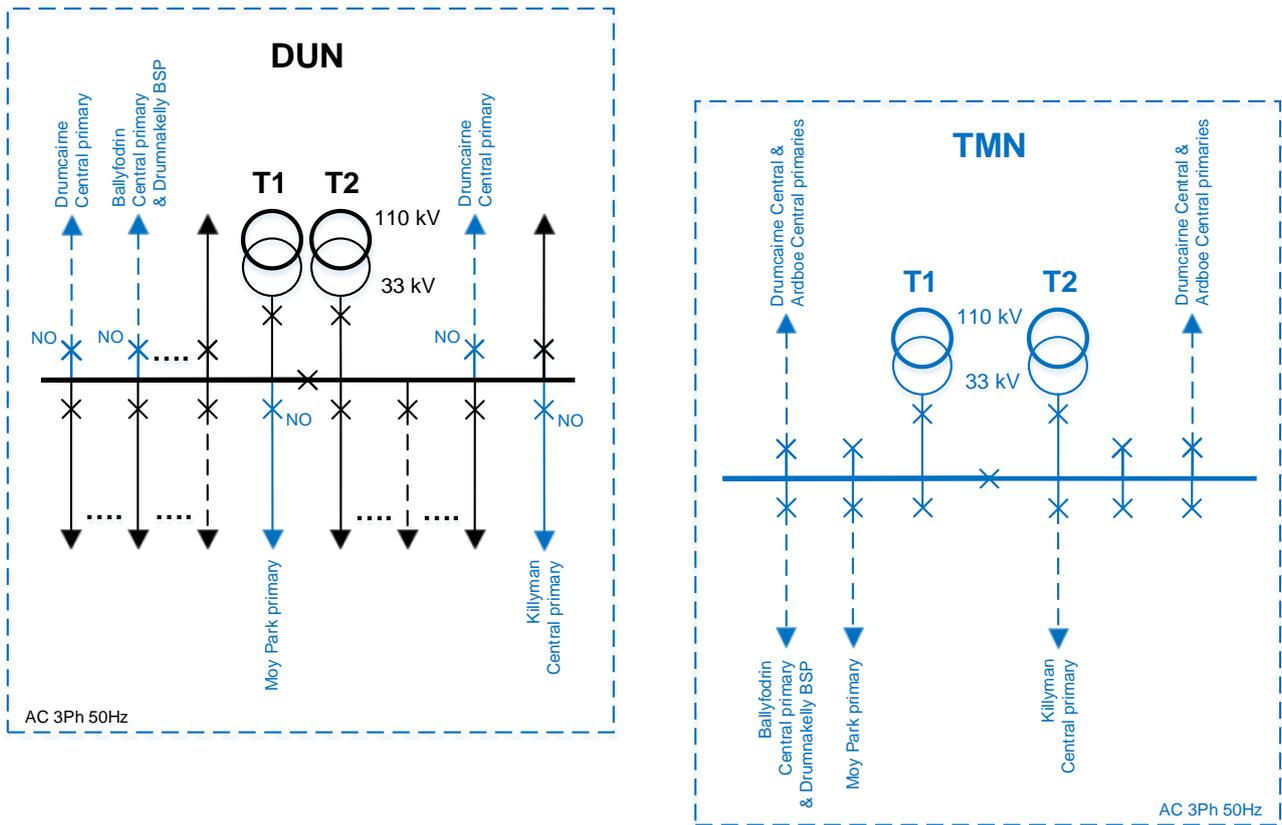


Figure 9 : Option 4 – SLD of the feeders' arrangements in Tamnamore and Dungannon BSes

3.5. Option 5: Third transformer (standby mode) at Dungannon Main (£8.09m)

This option is based on installing a third transformer at Dungannon Main, with 110kV and 33kV arrangements per Figure 10 and Figure 11. In this arrangement the 3rd transformer would operate normally energised from the 110kV side but offloaded. This is to avoid an excessive fault level on the 33kV switchboard. This would be an unconventional approach and is only currently used in legacy Belfast 33/6.6kV substations.

To achieve this it would be necessary to extend the substation by 0.8 acres to the southwest of the substation, carry out necessary pre-enabling including diverting an access road to a proposed battery as well as undergrounding four existing 33kV overhead lines, install a new replacement 33kV switchboard designed to operate with a standby transformer, divert all 33kV circuits and install a third 110/33kV transformer to operate in standby mode.

To extend the compound it would be necessary to purchase land in the approximate area as shown in Figure 12 and underground four 33kV overhead lines that enter to the southwest of the substation, see Figure 13.

The option would include the following work:

- a) Purchase additional land and extend compound as required, including diversion of existing access road to a battery site;
- b) Carry out undergrounding of 33kV overhead lines entering the southwest of the substation;
- c) Extend compound to southwest;
- d) Replace existing 33kV switchboard with new unit with additional functionality to operate 3rd transformer in standby mode;
- e) Divert all existing 33kV feeders including existing 110/33kV transformers to new 33kV switchboard;
- f) Install a new 110/33kV transformer connected to mesh corner 4 and
- g) Install a fast-acting automation scheme to ensure that, during a forced outage of one existing transformer the third transformer is automatically connected.

With this option the N-1 and N-1-1 scenarios are addressed in terms of security of supply compliance.

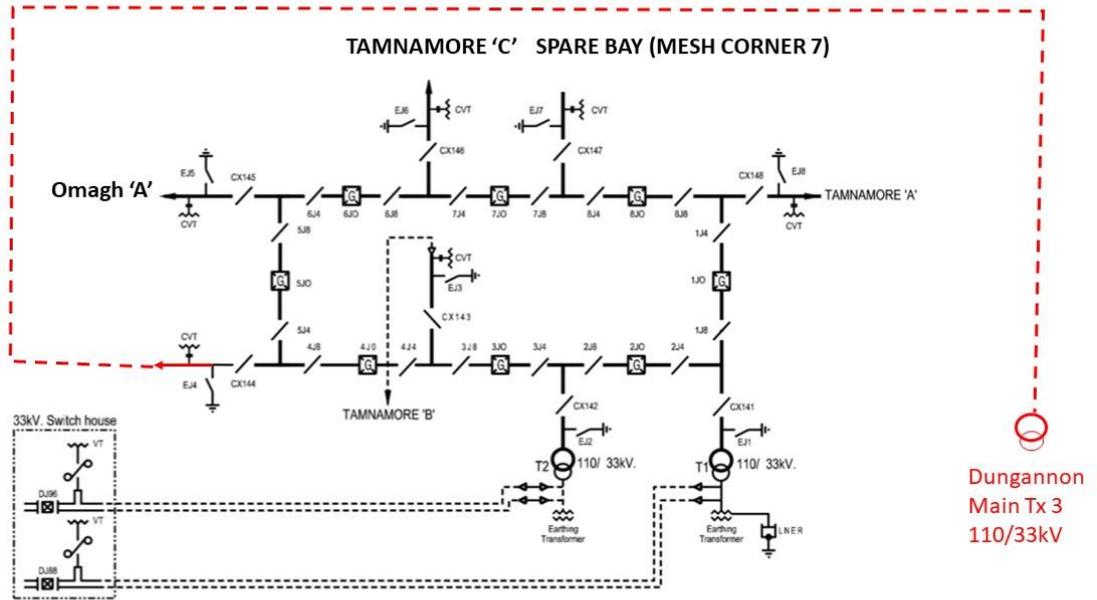


Figure 10 : Option 5 – 110kV SLD of Dungannon with third power transformer

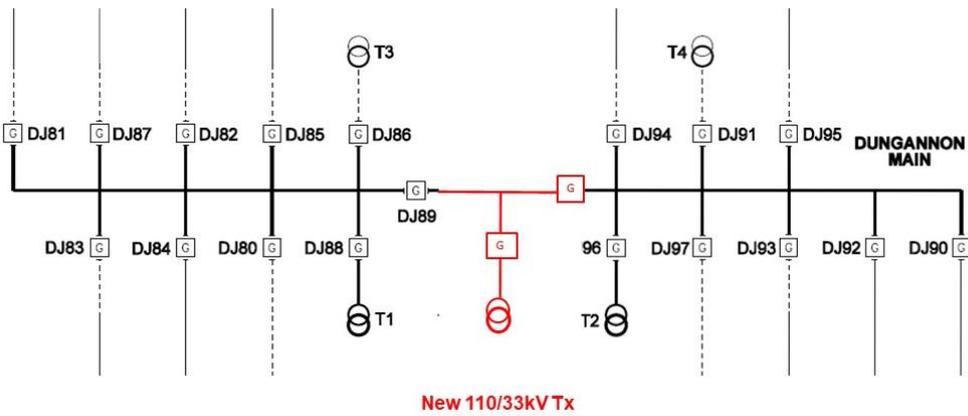


Figure 11 : Option 5 – SLD of Dungannon for the 33 kV DBBs with the third power transformer



Figure 12 : Study area for the expansion of the substation footprint



Figure 13 - 33kV undergrounding required (proposed cable purple dashed)

This option is estimated to cost £4.78m and 3.74m for transmission and distribution elements respectively.

This option does not address the capacity limitations identified in the 33 kV network in Cookstown, so a proportion of the NIEN RP7 Primary Network Program would be delivered separately. However, as a new 33kV switchboard would be established as part of this project, two additional bays as needed would be included. Therefore, there would be no need for a new six panel 33kV switchboard envisaged in the NIE Networks RP7 plan, reducing the cost of the RP7 plan from £3.47m to approx. £2.72m.

3.6. Option 6: Second 110/33 kV substation at Dungannon Main

This option is based on establishing a second 110/33kV substation at Dungannon Main. For this solution there are two sub-options: a) phased approach with only one transformer initially, b) fully build second 110/33 kV BSP at Dungannon Main. The second substation would be established like Option 5, by initially carrying out 33kV undergrounding and then an extension of the compound to the southwest.

This option does not address the capacity limitations identified in the 33 kV network from Dungannon to Cookstown, so the overhead line costs of the NIEN RP7 Primary Network Program would be required to be delivered separately to this option. As a new 33kV switchboard would be established as part of this project, two additional bays as needed would be included. There would be no need for the six panel 33kV switchboard envisaged in the NIE Networks RP7 plan, reducing the cost of the RP7 plan from £3.47m to approx. £2.72m. The delivery timeline however would be the same as the main project, i.e. by 2029.

3.6.1. Sub-option 6a: Phased approach with only one transformer initially (£7.49m)

This sub-option would involve installing a third 110/33kV transformer and 33kV switchboard. It would include the transfer of the Moy Park and Killyman Central 33/11 kV circuits to the new 33 kV switchboard and two interconnecting cables between the switchboards.

Initially, with this option the new transformer would be used in standby mode, with the new switchboard initially supplied from the existing via two interconnecting 33kV underground cable circuits. Figure 14 shows SLD of the 110kV works with the single transformer. Figure 15 below presents the SLD for the 33kV works.

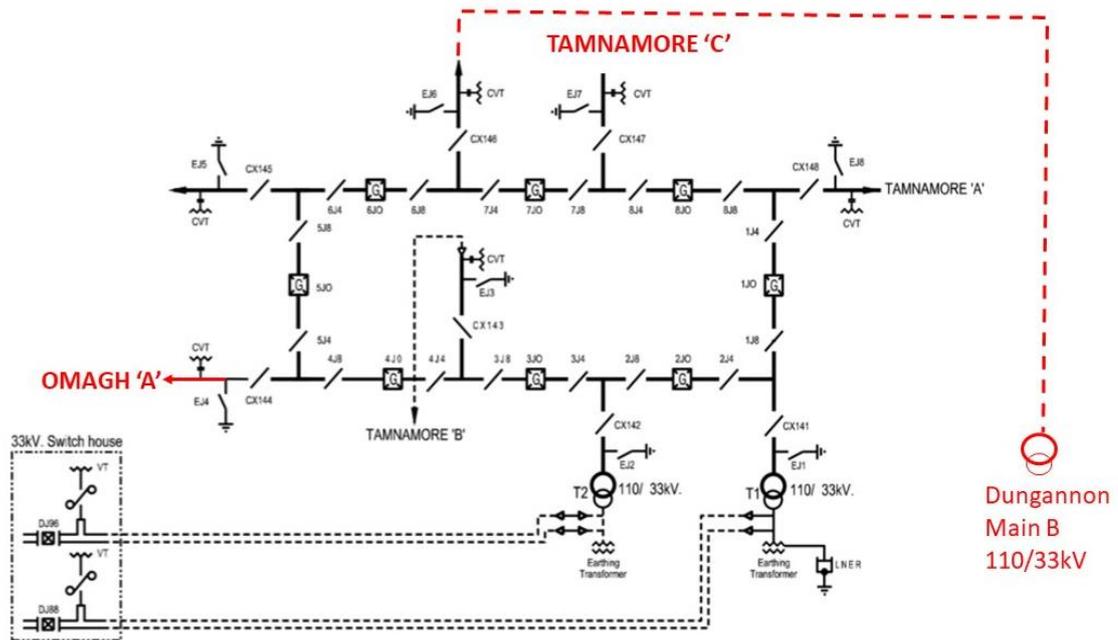


Figure 14 : Sub-option 6.a – SLD of 110kV works

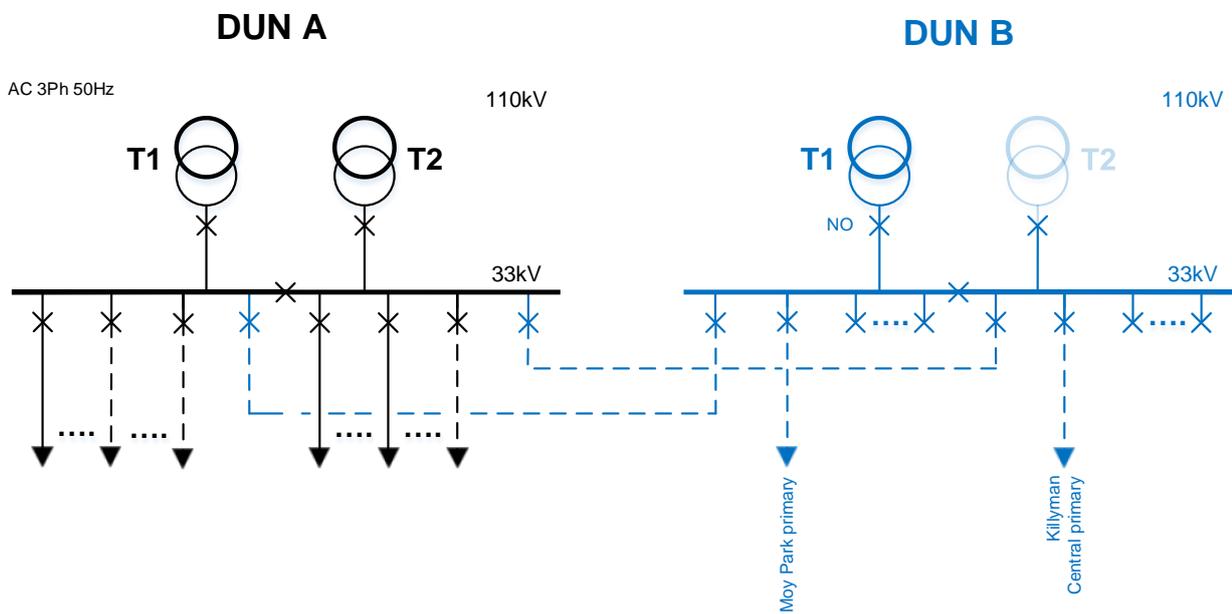


Figure 15 : Sub-option 6.a – SLD of DUN A and DUN B substations

Option 6.a comprises the following work:

- a) Underground 33kV circuits entering southwest of substation.
- b) Purchase land to southwest and expand compound, pre-enabling of that land.
- c) Divert existing Omagh A 110 kV circuit to spare bay in mesh corner 4.
- d) Install a new 110/33 kV transformer and connect to former Omagh A 110 kV bay.

- e) Install a new 33kV switchboard and divert Moypark and Killyman 33 kV circuits.
- f) Install new 33 kV interconnecting cables between the two 33 kV switchboards.

The cost of the above works is for transmission and distribution elements are £4.79m and £3.44m respectively.

3.6.2. Sub-option 6b: New 110/33 kV BSP at Dungannon Main (£10.51m)

This option is as per sub-option 6a with the second transformer installed from the outset. The substation would operate as a separate bulk supply point, located on the same site. Figure 16 shows an SLD of the 110kV works. Figure 17 presents the 33 kV SLD of DUN A and DUN B including the transfer of Ardboe and Drumcairne 33/11kV substations as part of the NIE Networks RP7 plan. This option will include the following work:

- a) Purchase land to expand the substation to the southwest, 110/33 kV substation pre-enabling of that land, and diversion of OHL and 33kV underground circuits in the area of the substation expansion.
- b) Relocate Omagh A 110 kV circuit to spare bay in mesh corner 4.
- c) Relocate Tamnamore C 110 kV circuit to spare bay in mesh corner 7.
- d) Install two new 110/33 kV transformers and connected to the former Omagh A and Tamnamore C feeder bays.
- e) Establish a new 33 kV switchboard and divert Moy Park and Killyman Central.
- f) Install new 33 kV interconnecting cables between the two 33 kV switchboards.

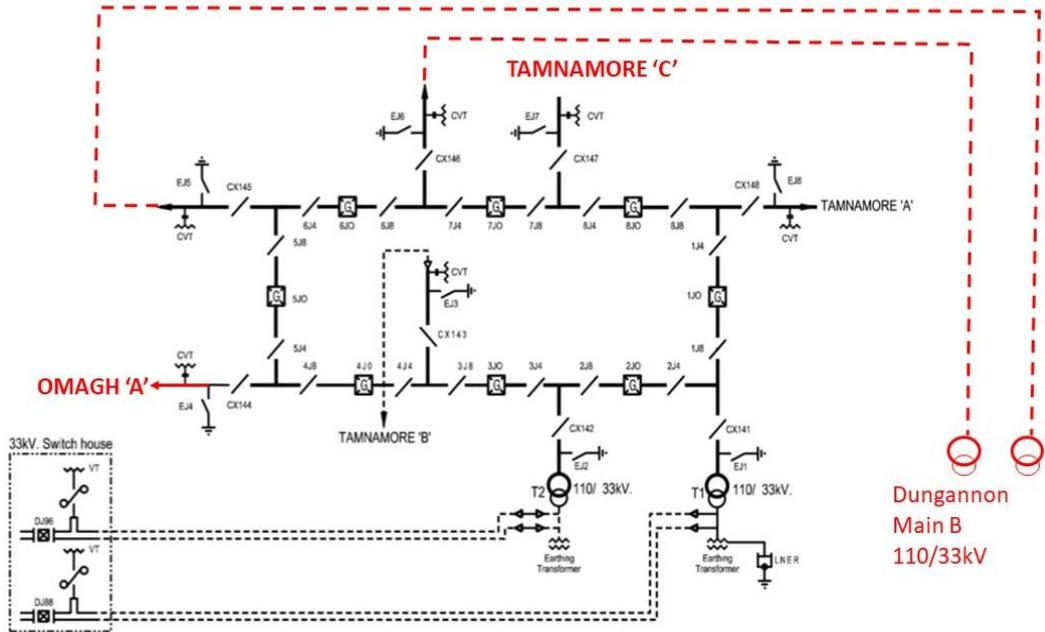


Figure 16 : Sub-option 6.b – Single line diagram of DUN A and DUN B 110kV works

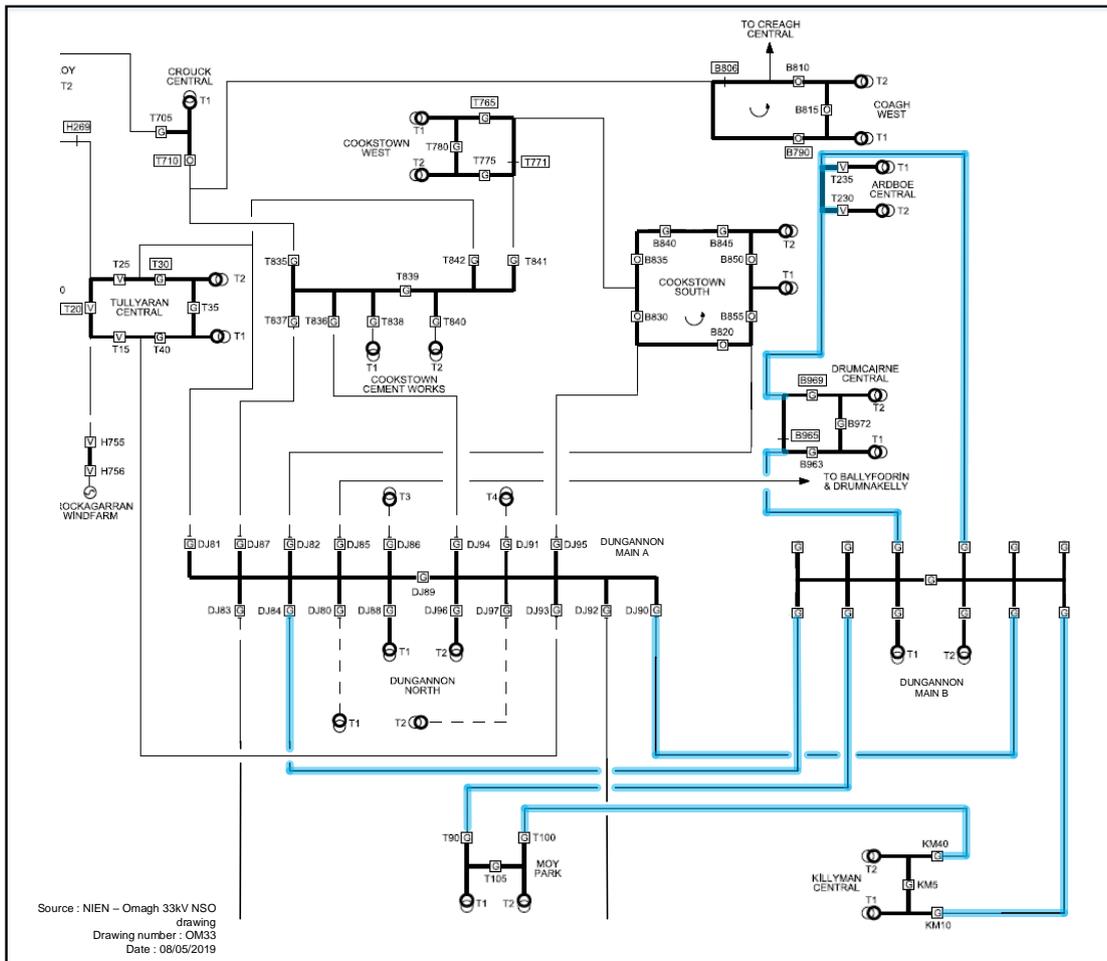


Figure 17 : Sub-option 6.b – Single line diagram of DUN A and DUN B

The transmission and distributions costs of the above works are estimated at £7.33m and £3.18m respectively. Construction is estimated to take place by 2028 and 2029.

The NIE Networks RP7 plan to reinforce Drumcairne and Ardboe would also be done in parallel with similar timeline. It is estimated at a cost of £2.72m, a reduced sum allowing for the fact that a new 33kV switchboard for the distribution project would not be required. Again, as in Option 5 this would be slightly lower cost as this option would include sufficient spare 33kV panels in the new larger 33kV switchboard and would not require the new 6 panel switchboard envisaged by NIE Networks.

3.7. Option 7: New 110/33kV BSP in Cookstown (£24.22m-£29.34m)

This option is based on establishing a new BSP in the southern outskirts of Cookstown. There are several sub-options for the 110 kV works: Sub-option 7a) connect from Dungannon Main 110 kV mesh, Sub-option 7b) connect from the Dungannon – Tremoge 110 kV circuits through

a new marshalling substation, and Sub-option 7c) connect from Tremoge 110/33 kV cluster substation. This option would also address separately the 33 kV capacity issues to Cookstown therefore changing the original NIE Networks RP7 plan.

3.7.1. Sub-option 7a: Connect from Dungannon 110/33 kV substation (£24.22m)

In this sub-option the new 110/33 kV substation would be connected via two new 110 kV single circuits to the existing 110 kV mesh at Dungannon Main. Figure 18 below shows the possible location of the new substation and route of the 110 kV lines.

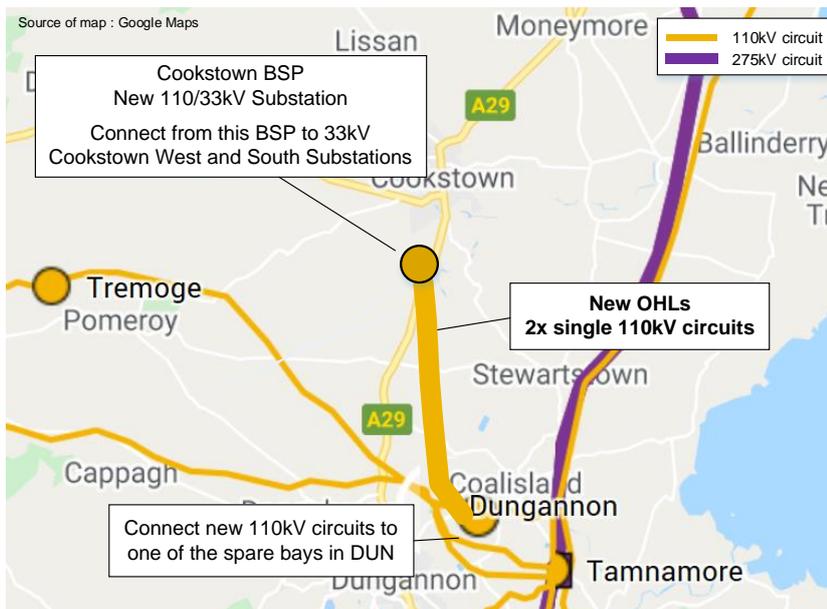


Figure 18 : Sub-option 7.a – Connection from 110 kV spare bays in Dungannon substation

Below are the activities necessary to deliver this option:

- Procure site and pre-enabling.
- Build a new BSP in Cookstown.
- Install approx. 11.6 km of two single circuit 110 kV overhead lines (Trident) between Dungannon and the new BSP with cable sections at both ends (4 x 500m).
- Reconfigure the 33 kV network in Cookstown area. This works will split the Cookstown South, Ardboe Central and Drumcairne Central circuits connecting them directly from the Cookstown BSP (£3.52m).

This solution would transfer load the load in Cookstown from Dungannon Main to the new Cookstown BSP in Cookstown thus relieving the capacity issue at Dungannon and offering excellent resupply in the event of a N-1-1 scenario using the 33 kV circuits as per Figure 19.

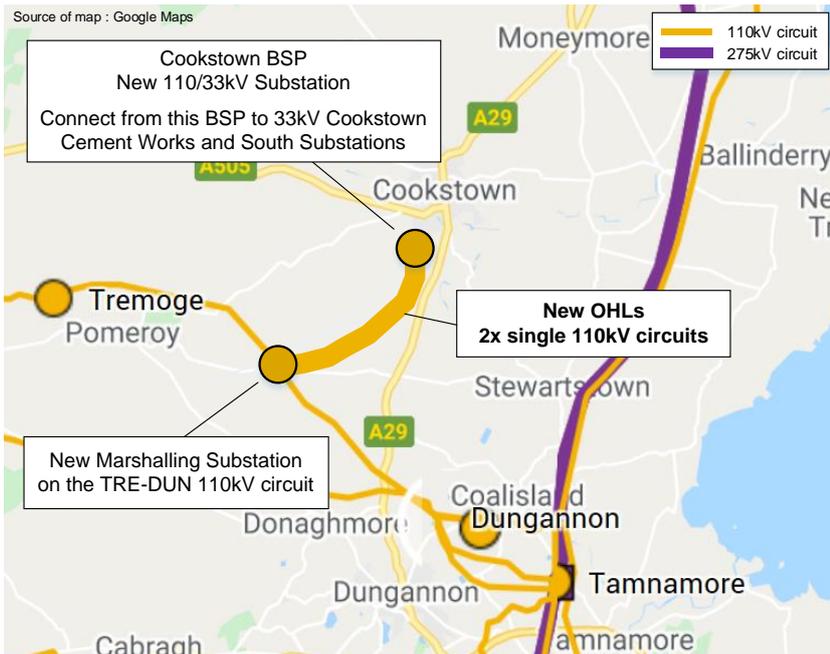


Figure 20 : Sub-option 7.b – Connection from a marshalling station in the Tremoge - Dungannon 110 kV circuit

3.7.3. Sub-option 7c: Connect from Tremoge 110/33 kV cluster substation (£26.00m)

Figure 21 below presents sub-option 7c to build a new 110/33 kV BSP in Cookstown and connect it through two single 110 kV OHL circuits coming from Tremoge 110/33 kV cluster.

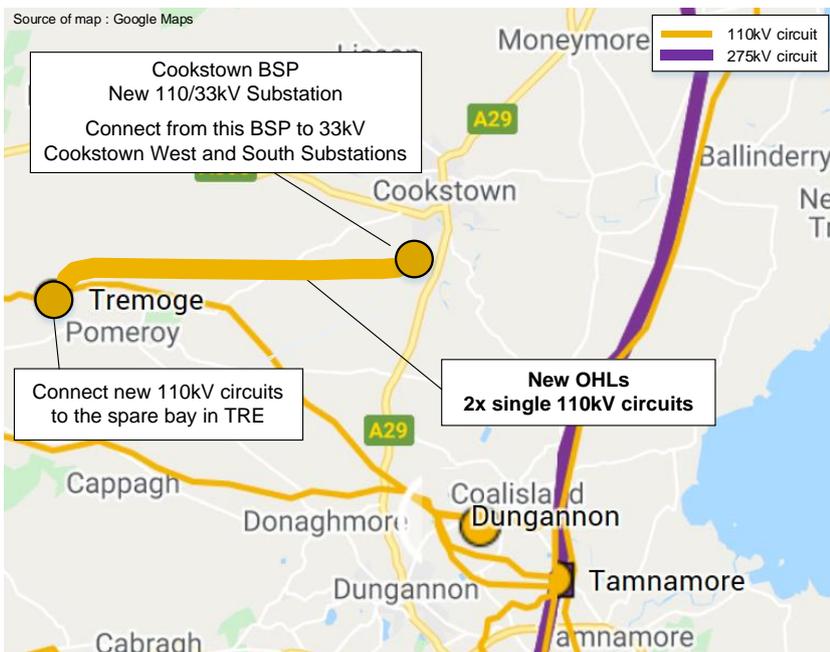


Figure 21 : Sub-option 7.c – Connection from Tremoge cluster at 110 kV

The following work would be necessary to deliver this option:

- a) Build a new BSP in Cookstown.
- b) Establish two 110kV bays at Tremoge.
- c) Install 15.9 km of two single circuit 110 kV OHL (Trident) between Tremoge and the new BSP with cable sections at both ends (4 x 500m).
- d) Reconfigure the 33 kV network in Cookstown area. This works will split the Cookstown South, Ardboe Central and Drumcairne Central circuits connecting them directly from the Cookstown BSP (£3.52m including 10% contingency).

4.Shortlisting

The options framework is a tool which provides an approach to rationalise the longlist of options.

The framework will rank options according to the sequence of criteria below:

1. Capital costs.
2. Technical performance (High-level assessment).
3. Deliverability.

4.1. Capital cost

Table 1 below presents the capital costs per options.

Item description	2	3a	3b	4	5	6a	6b	7a	7b	7c
Distribution Works (£m)	9.93	7.64	6.28	6.93	3.98	3.1	3.18	3.52	3.52	3.52
Transmission Works (£m)	0.00	0.00	0.00	9.46	4.11	4.4	7.33	20.70	25.82	22.48
Total (£m)	9.93	7.64	6.28	16.39	8.09	7.50	10.51	24.22	29.34	26.00

Table 1 : Summary of capital costs per option

The works to reinforce the 33 kV network proposed by NIEN as part of their RP7 programme are not captured in the capital cost of the options.

The main observations from the costs are as follows:

- Option 1 does not present any capital costs, so it is not identified in table 1.
- Option 2 is very expensive distribution solution at £9.93m that only transfers approximately 10 MVA away from Dungannon Main. It would therefore have a very short scheme life requiring further reinforcement within a very short period.
- The Option 3 variants establish standby 33kV connections from Tremoge to Dungannon. These are about the same cost as Options 5 and 6a. The option 3 variants are unconventional and narrow solution and do not offer the continuity of supply or further development potential of 6a.
- Option 4 is a new bulk supply point at Tamnamore and at £16.39m is £8-10m cheaper than the Cookstown bulk supply point options.

- Option 5 is a very expensive means of establishing a standby 3rd transformer type solution.
- Option 6a is a step towards establishing a new bulk supply point at Dungannon and only marginally more expensive than Option 5 standby transformer approach.
- The Cookstown options are by far the most expensive at £24-29m as they involve significant 110kV circuit build.

4.2. Technical and deliverability

4.2.1. Option 1: Status Quo

The do-nothing option is required to be taken through to the short list, offering a reference for comparison with the other shortlisted options. Technically this option would result in a breach of the Transmission System Security and Planning Standards and the Distribution System Security and Planning Standards. This is because there would not be sufficient capacity to supply the demand in an N-1 contingency, i.e. forced outage of a transformer. Eventually it would result in difficulties obtaining outages for transformer maintenance.

4.2.2. Option 2: Transfer Cookstown Cement Works demand onto Tremoge

This option would result in the transfer of a modest 10 MVA Cookstown Cement Works from Dungannon to Tremoge. This would give a few years demand relief similar to the transfer of Coagh West. This option would have a relatively short scheme life which given its high cost of £9.93m performs poorly compared to other options. Moreover, the deliverability of this option is challenging due to the very long 33kV cable route and the associated traffic disruption. For these reasons this option is not shortlisted.

4.2.3. Option 3: Install 33kV circuits in standby mode between Tremoge and Dungannon along with an auto-transfer scheme.

The normal means of reinforcing the transmission and distribution system is to expand and augment with additional circuits and plant and then sectionalise the distribution system. The equipment continues to operate in a similar way. This is a broader approach but one that allows for further expansion. The approach in Option 3 is in a narrow way targeted to address the resupply issue in the planning standards and is therefore not a normal augmentation.

Similar to Option 2 this involves a very long cable route between Tremoge and Dungannon of about 18 km which would be extremely challenging to deliver given the narrow roads and potential disruption. In addition, it is the existing switchboard at Dungannon along with the duration of the required outage makes this option difficult to implement. In conclusion it has poor deliverability.

This option is also technically inferior. Tremoge is a cluster site therefore it would be necessary to manually ramp down renewable generation at Tremoge before any 33kV parallel with Dungannon could be attempted. This is to prevent the very strong generation source at Tremoge directly feeding demand at Dungannon and overloading the 33kV overhead line. Whilst this run back is being carried out through normal control room procedures, there would be a short-term overload of the remaining in-service transformer and 33kV switchgear at Dungannon. Whilst the transformer, which has significant thermal inertia, would have an emergency rating this does not apply to the 33kV switchgear. It is likely therefore that demand would need to be disconnected as part of the transfer.

In summary this option attempts to address the need but would entail a temporary loss of supply during any changeover. More importantly however it could not be further developed and could not shortlisted.

4.2.4. Option 4: New bulk supply point in Tamnamore (£16.39m)

In theory this option provides additional resilience to HILP events. However, it is quite uncommon for a transmission to distribution interface substation to be developed at a grid supply point, with exceptions being Coolkeeragh (for historical reasons) and Kells cluster (more recent). There are some practical disadvantages to this. A 110/33kV distribution substation will have to be designed with appropriate 110kV and 33kV overhead line routes and/or cable easements. Usually however a standard 110/33kV substation will have relatively few 110kV circuits so access is manageable.

It becomes more problematic trying to integrate a new 110/33kV substation within the grounds of an existing grid supply point. The grid supply point purpose is to supply many 110/33kV substations and could have ten or more 110kV overhead line and/or cables already. Introducing 33kV cables into this mix can cause safety and derating issues which are difficult to manage out. Ultimately this complicates and possibly stifles the future development of the grid supply point.

From a delivery perspective, achievement of the required 32.5 km of 33 kV overhead circuits would be challenging and would be expected to lead to delays which as time progresses could be a risk to supply. An additional challenge to the timely delivery of this solution is the need to extend the compound at Tamnamore. Whilst there is an intention to purchase land to the north of the substation, subject to TNPP approval, for the purposes of the Mid Tyrone project, delays in purchasing this land adds more risk. However, the option is still considered suitable for shortlisting.

4.2.5. Option 5: Third transformer (standby mode) at Dungannon Main

This option would involve operating the third transformer in standby mode with connections to a new 33kV switchboard. This is implemented in 33/6.6 kV substations in Belfast where the switchboards were designed and installed with two bus-section switches and three incomers. This type of scheme would be difficult to retrofit at Dungannon. It would involve replacing the 33kV switchboard with a type designed for this purpose with 33kV undergrounding and compound extension required. It is a similar amount of work as that required for Option 6 with an inferior technical standard at the end of it. This option is almost as expensive as Option 6 but is of a lower technical standard and is therefore not shortlisted.

4.2.6. Option 6: Second 110/33 kV substation at Dungannon Main

Option 6a is a phased approach which only allows a single transformer to be installed. This would need to be operated in standby mode as well similar to Option 5. However, the design is capable of being developed with the installation of a second transformer, provided a 110kV bay is available at that time. However, there is a risk that a connection application could result in the bay being used for something else, therefore preventing this option from being further developed.

Options 6b is preferred as it allows both transformers to be installed from the outset whilst there are spare bays to do so and also allows demand to be transferred permanently with the second transformer. This would relieve demand on the two existing transformers rather than acting in standby mode.

The options are deliverable as two spare bays exist on the 110 kV mesh and there is space around the site to extend the compound. The only disadvantage of this option compared to the Tamnamore extension is the theoretical higher risk under a HILP scenario. However, any additional risk is difficult to quantify as HILP risks also exist in other parts of the transmission system and are of higher impact. This can also be addressed by additional mitigating measures in the design.

The timeline for delivery is expected to be 2029 given the need for compound extension. However, this is expected to be many years sooner than any of the Cookstown options and probably sooner than the Tamnamore option given the extent of new 33kV circuits.

Based on the above arguments, options 6b is shortlisted.

4.2.7. Option 7: New 110/33kV BSP in Cookstown

Technically these options are superior to all other options as they would involve the construction of a new 110/33 kV substation at Cookstown which is a significant load centre with growing demand, and also relieving Dungannon Main. It would also avoid the need to

reinforce the Drumcairne and Ardboe 33kV circuits from Dungannon Main that NIE Networks had set out in their RP7 plan.

However, the cost of these options are four times that of option 6a because they involve the development of 110 kV overhead line to connect the new substation. In addition, these options all involve much greater degree of complexity. They all involve the construction of at least one new substation in a green field site with the additional site selection and land procurement complexities. Option 7b also involves construction of a marshalling substation in addition to the new 110/33kV. Technically these are better options but in addition to the additional cost are of much greater complexity meaning the risk of delays are much higher.

Given the pace of demand growth expected at Dungannon Main it is more likely that capacity would be exhausted before they would be constructed. In the event of delays then the costs of demand curtailment (VOLL) could be added as per Option 1 Do Nothing.

It is useful to shortlist at least one of the options to study the life cycle costs which would include the avoidance of the NIE Networks planned 33 kV reinforcement from Dungannon to Cookstown. Sub-option 7a is the cheapest and is therefore shortlisted.

Table 2 below presents a comparison of the longlist of options. A five-colour scheme is used to demonstrate the comparison of options.



Option	Description	Technical	Deliverability	Cost
1	Status Quo ()		n/a	n/a
2	Transfer Cookstown Cement Works demand onto Tremoge (£9.93m)	Dark Blue	Light Blue	Green
3.a	33 kV underground cable circuits between Tremoge and Dungannon (£7.64m)	Light Blue	Light Blue	Yellow
3.b	Two 33 kV OHL circuits between Tremoge and Dungannon (£6.28m)	Light Blue	Green	Yellow
4	Bulk supply point in Tamnamore (£16.39m)	Light Green	Green	Light Blue
5	Third power transformer in Dungannon Main (£8.09m)	Light Blue	Light Green	Light Green
6.a	Second 110/33 kV substation at Dungannon Main (one transformer) (£7.49m)	Light Blue	Light Green	Light Green
6.b	Second 110/33 kV substation at Dungannon Main (£10.51m)	Light Green	Light Green	Green
7.a	New 110/33 kV BSP in Cookstown, lines from Dungannon (£24.22m)	Yellow	Light Blue	Dark Blue
7.b	New 110/33 kV BSP in Cookstown – marshalling s/s the Dungannon – Tremoge (£29.34m)	Yellow	Dark Blue	Dark Blue
7.c	New 110/33kV BSP in Cookstown – Connect from Tremoge) (£26.00)	Yellow	Light Blue	Dark Blue

Table 2 : Comparison of the longlist of option

Table 3 shows the shortlisted options.

Option	Description
1	Status Quo
4	Tamnamore 110/33kV and divert 33 kV circuits from Dungannon to Tamnamore (£16.39m)
6b	Establish a second 110/33 kV substation at Dungannon Main – Fully build second 110/33 kV BSP at Dungannon Main (£10.51m)
7.a	Build a new 110/33 kV BSP in Cookstown – Connect from Dungannon 110/33 kV substation (£24.22m)

Table 3 : Shortlisted options

5.Appraisal of shortlist

The options framework for the identification of the preliminary preferred solution will be based on the criteria already considered as well as the following:

1. Economic performance.
2. Environmental impact.

5.1. Economic performance

The economic performance assessment will be based on the Net Present Value (NPV) for an assessment period of 40 years¹. The NPV uses a discount rate of 3.5%.

Appendix B includes calculations for Option 1 Do Nothing. This is based on the eventual need for a shutdown of demand to facilitate transformer maintenance at Dungannon. These costs will be included in option 1 during the lifecycle. The other options avoid the need for shutdowns to facilitate maintenance as they are N-1 compliant.

The impacts of the HILP events captured in this assessment are detailed in appendix **Error! Reference source not found.**

As referred in section **Error! Reference source not found.**, the impact of the distribution project will be captured to understand which of the shortlisted options has the smallest overall net present cost. This is done by adding the capital costs necessary to deliver the distribution project specific to each option. In the next section these costs are presented based on studies conducted by NIEN for their RP7 proposal to the UR.

5.1.1. Capital costs and delivery timeline

Option 1: Status Quo

The NIE Networks RP7 distribution plan is included.

Option 4: Bulk supply point in Tamnamore

The delivery timeline for the transmission works is estimated to span between 2028 and 2029 with the distribution elements completing a year later. These costs replace those planned by NIE Networks in their RP7 Primary Network Program.

Option 6b: Second 110/33 kV BSP at Dungannon Main

¹ This period is the lifespan of many transmission and distribution assets, which means that is assumed that after 40 years, assets are written off and replaced by new ones.

The cost of the work planned by NIEN will be reduced as the second switchboard (see Figure **Error! Reference source not found.**) will be available as part of the capital cost of Option 6b. In this option Ardboe Central, Drumcairne Central, Moy Park and Killyman Central primaries will be diverted to the new BSP.

Option 7a: Build a new 110/33 kV BSP in Cookstown

Option 7a includes in its proposed solution the rearrangement of the 33 kV network in Cookstown and would replace the NIEN RP7 plan. The capital costs for the distribution works presented in Table 1 reflects the investment that is estimated to be necessary. The reconfiguration of the 33 kV distribution network to be delivered under this option is presented in Figure 19.

The expected deliverability period for option 7a is 8 years.

The works required to deliver the 33 kV reinforcement in Cookstown under Option 7b is identical to option 7a. Therefore, the Costs and deliverability of 7b are the same as option 7.a.

5.1.2. Lifecycle costs

The revenue costs associated with these options are the following:

- Operation and Maintenance (O&M) costs. The O&M costs associated to the reinforcement of the 33 kV network will be captured in the economical assessment.
- HILP associated costs, as per appendix B and assuming no investment in fire prevention will be considered, e.g., halon fire-fighting system for the control rooms in Dungannon Main.
- For Option 1 the demand will exceed capacity. During N-1 conditions it would be necessary to disconnect demand to avoid overload of transformer. The costs of load shedding are developed in appendix B.

5.1.3. NPV

Table 4 presents the NPV of each shortlisted option.

1	4	6.b	7.a
279.80	16.77	11.81	22.34

Table 4 : NPV of the shortlisted options

The NPV results above refer to Net Present Costs (NPCs). So, a higher NPV means higher costs for the life cycle of the project.

In Option 1 Do Nothing it is likely that transformer maintenance could be facilitated by the prior transfer of demand to neighbouring bulk supply points. This complicates the outage process but is a viable approach. However, depending on demand growth this would eventually become ineffective. At that point transformer maintenance outage would require an element of demand disconnection. This would incur lifecycle costs due to the disruption caused by the disconnection of supplies during these maintenance periods, assessed as value of lost load. This cost is reflected in the NPV for Option 1.

Tamnamore is more expensive than Option 6b and has a higher NPV. With the Tamnamore option the block of demand is supplied from two separate sites. So, in theory it should be more resilient than Option 6b to HILP events. However, it is assumed that the additional risk that exists with Option 6b would be addressed and mitigated with additional security measures at Dungannon Main and/or suitable fixed fire-fighting system in the planned new substations control room at Dungannon if deemed necessary. Therefore, no account has been given to any increased risk as it will be mitigated. Although difficult to quantify financially and include in an NPV, the Tamnamore option, which could have multiple 33kV and 110kV cables in close proximity would result in congestion of cable assets entering the substation. This would have consequences which are difficult to quantify in financial terms.

Sub-option 7a is the solution that presents the worst performance in the CBA, excluding option 1. The reasons for this are the high capital costs. However, there is also a risk with this option that the length of time to deliver it would result in a lack of capacity emerging at Dungannon Main there being a risk to supplies, similar to Option 1.

5.2. Environmental impact

At this stage, the preliminary preferred solution continues to be sub-option 6b, particularly due to its deliverability.

Sub-option 6b will require an extension of the existing compound to the south of Dungannon Main. Due to this extension, the road access of the future battery storage unit will be diverted, however the entrance planned by the battery developer will remain as planned.

6. Conclusions

The shortlisted options would all address the issues identified in the Need Case (if the Status Quo option is excluded).

The Cookstown options, whilst technically superior are extremely expensive and could not be built on time.

The Tamnamore option is slightly more expensive but is not ideal to develop a 110/33kV substation on the same site as a 275/110kV grid supply point due competition for cable routes, uncoordinated developments and potential derating at cable crossing points.

In terms of capital costs, the least cost shortlisted solution is sub-option 6.b with a cost of £10.51m. It will deliver a fully equipped second BSP adjacent to the existing Dungannon site diverting demand from the existing transformers allowing security of supply for an N-1 and also providing additional resilience in the case of an N-1-1. This solution can be delivered in the shortest timescale, due to the expectation that demand could exceed firm capacity in a relatively short period of time. In conclusion, sub-option 6.b is the preliminary preferred option.

This project also provides a new 33kV switchboard at Dungannon which lays the foundations for NIEN to deliver its RP7 reinforcement and re-arrangement of the 33 kV network in Cookstown area. As part of sub-option 6.b, the re-arrangement of Moy Park and Killyman Central primaries will be delivered, and later through the RP7 program there will be a re-arrangement of the 33 kV networks in Cookstown and from Dungannon towards Drumcairne Central and Ardboe Central primaries.

The environmental impact of the extension has been assessed and no major issues are identified.

Appendix A. Capital costs of the options

The Transmission System Operator and Distribution Network Operator development costs are excluded from the figures presented below.

Ap A.1. Option 1

During the life cycle of this project, under the NIEN RP7 Primary Network Program, OHL and underground 33 kV circuits towards Moy Park and Killyman Central primaries in the south of Dungannon along with Drumcairne Central and Ardboe Central primaries in Cookstown will be re-arranged.

Ap A.2. Option 2

Transfer Cookstown Cement Works demand onto Tremoge.

No transmission works will be required for this option.

Distribution Works	
Item description	Total [£m]
Site procurements and agreements	
Purchase of site for new 33kV s/b at Cookstown Cement Works	0.10
Substation works (Cookstown Cement Works Primary)	
Pre-enabling works for proposed new 33kV switchboard	1.46
33kV indoor switchboard, 16 panel board installed in 20 panel switch house as per recent cluster designs. Includes cable jointing and rearrangements	1.72
Substation works (TRE)	
33kV panels	0.00
Cable works	
33 kV 630 mm ² underground cable dual circuit, between TRE and CCWp.	5.15
Re-routing 33kV cables coming from DUN to CCWp	0.61
Subtotal	9.03
10% contingency	0.90
Total	9.93

Table 5 : Option 2 – Capital costs for distribution works

Ap A.3. Option 3

Install 33kV circuits between Tremoge and Dungannon substations along with an auto-transfer scheme.

No transmission works will be required for this option.

Ap A.3.1. Sub-option 3.a

Build two 33kV underground cable circuits.

Distribution Works	
Item description	Total [£m]
Substation works (DUN)	
33 kV switchboard single panel extension, including jointing (assuming no switch house works)	0.28
Automation scheme to all 33/11kV substation to break parallel and ensure demand transferred to TRE	0.75
OHL & Cable works	
33 kV 630 mm ² underground cable dual circuit, between TRE and DUN	5.91
Subtotal	6.94
10% contingency	0.69
Total	7.64

Table 6 : Sub-option 3.a – Capital costs for distribution works

Ap A.3.2. Sub-option 3.b

Build two single 33 kV OHL circuits.

Distribution Works	
Item description	Total [£m]
Substation works (DUN)	
33 kV switchboard single panel extension, including jointing (assuming no switch house works)	0.28
Automation scheme to all 33/11kV substation to break parallel and ensure demand transferred to TRE	0.75
OHL & Cable works	
Single 33kV 200mm ² OHL (Jaguar) circuit between TRE and DUN.	4.38
33 kV underground cable dual circuit, to be installed near TRE and DUN	0.30
Subtotal	5.71
10% contingency	0.57
Total	6.28

Table 7 : Sub-option 3.b – Capital costs for distribution works

Ap A.4. Option 4

Build a bulk supply point in Tamnamore and divert 33kV circuits from Dungannon to Tamnamore.

Distribution Works	
Item description	Total [£m]
Site procurements and agreements	
Procure land nearby TMN substation to extend the footprint	0.37
Substation works (TMN)	
33kV switch house with a standard switchboard	1.72
OHL & Cable works	
Single 33kV 200mm ² ACSR OHL circuit (Jaguar) to connect TMN BSP to Killyman Central primary, Moy Park primary, the circuit towards Ballyforin Central primary / Drumnakelly BSP. 2x single circuits from TMN BSP to Drumcairne Central primary, and from there to Arboe Central 1 single circuit.	3.44
33 kV single core unarmoured copper 240mm ² underground cable to be installed near TMN and each of the primary to avoid hub-and-spoke effect of OHL	0.76
Easements for the 33 kV underground circuits	0.02
Subtotal	6.3
10% contingency	0.63
Total	6.93

Table 8 : Option 4 – Capital costs for distribution works

Item description	Total [£m]
Substation works (TMN)	
110kV/33kV Substation pre-enabling	1.80
110kV/33kV 90MVA ONAF transformer with cable	3.67
110kV transformer feeder arrangements. Includes 110kV AIS DBB Bay	1.51
OHL & Cable works	
110kV single circuit wood pole Trident with 300mm ² AAAC to divert DUN B OHL circuit.	0.05
Lay 1x 1000 mm ² Al XLP cable direct in the substation compound for the DUN B circuit diversion.	1.32
Move the underground Drumkee Battery storage circuit to the new 110kV AIS feeder.	0.25
Subtotal	8.60
10% contingency	0.86
Total	9.46

Table 9 : Option 4 – Capital costs for transmission works

Ap A.5. Option 5

Install a third transformer in standby mode at Dungannon Main.

Distribution Works	
Item description	Total [£m]
Substation works (DUN)	
Replace existing 33kV switchboard by a new indoor switchboard	2.58
Automation scheme	0.25
OHL & Cable works	
Underground 33 kV circuits to facilitate new compound	0.79
Divert all 33kV circuits to new s/b	0.15
Subtotal	3.62
10% contingency	0.36
Total	3.98

Table 10 : Option 5 – Capital costs for distribution works

Transmission Works	
Item description	Total [£m]
Land purchase	
Purchase approx 0.8 acre	0.24
Preenabling (including divert access road)	1.31
Substation works (DUN)	
110/33kV 90MVA ONAF transformer with cable	1.84
Equip mesh corner 4	0.25
Revamp 110kV protections and control building	0.10
OHL & Cable works	
Subtotal	3.74
10% contingency	0.37
Total	4.11

Table 11 : Option 5 – Capital costs for transmission works

Ap A.6. Option 6

Establish a second 110/33 kV substation at Dungannon Main.

Ap A.6.1. Sub-option 6.a

Phased approach with only one transformer initially.

Distribution Works	
Item description	Total [£m]
Consents	
Easements for the 33 kV underground circuits	0.01
Substation works (DUN B)	
33kV switchhouse including 33 kV indoor switchboard	1.72
OHL & Cable works	
33 kV cable from new switchboard in DUN B to existing switchboard in DUN A	0.30
Underground 33 kV circuits to facilitate new compound	0.79
Divert 33 kV cricuits of Moy Park and Killyman Central primaries from DUN A to DUN B, inside and outside the substation, including the feeders	0.15
Subtotal	2.81
10% contingency	0.28
Total	3.10

Table 12 : Sub-option 6.a – Capital costs for distribution works

Transmission Works	
Item description	Total [£m]
Site procurements	
Procure land nearby DUN substation to extend the footprint	0.24
Pre-enabling	
Preenabling (including divert access road)	1.31
Substation works (DUN)	
110kV/33kV 90MVA ONAF transformer with cable	1.84
Equip mesh corner 4 for an OHL HV bay	0.25
Convert ex-Omagh A bay to a transformer HV bay	0.25
Revamp 110kV protections and control building	0.10
OHL & Cable works	
Change 110 kV Omagh A OHL circuit to spare bay in mesh corner 4	0.01
Subtotal	4.00
10% contingency	0.40
Total	4.40

Table 13 : Sub-option 6.a – Capital costs for transmission works

Ap A.6.2. Sub-option 6.b

Fully build a second 110/33 kV BSP at Dungannon Main.

Distribution Works	
Item description	Total [£m]
Consents	
Easements for the 33 kV underground circuits	0.01
Substation works (DUN B)	
33kV switchhouse including 12x 33 kV panels indoor switchboard	1.72
OHL & Cable works	
33 kV cable from new switchboard in DUN B to existing switchboard in DUN A	0.23
Re-arrange OHL and underground 33 kV cricuits towards Moy Park and Killyman Central primaries	0.15
Underground 33 kV circuits and OHL works related to rearrangement of circuits affected by the substataion footprint expansion	0.79
Subtotal	2.89
10% contingency	0.29
Total	3.18

Table 14 : Sub-option 6.b – Capital costs for distribution works

Transmission Works	
Item description	Total [£m]
Site procurements	
Procure land nearby DUN substation to extend the footprint	0.24
Pre-enabling	
Pre-enabling works to accommodate the new 33kV switch-house and re-arrange OHL and underground circuits	1.30
Substation works (DUN)	
110/33kV 90MVA tx (2 off)	3.67
Equip mesh corner 4 for an OHL HV bay	0.25
Convert ex-Omagh A bay to a transformer HV bay	0.25
Equip mesh corner 7 for an OHL HV bay	0.25
Convert ex-Tamnamore C bay to a transformer HV bay	0.25
Revamp 110kV protections and control building	0.10
OHL & Cable works	
Change 110 kV Omagh A OHL circuit to spare bay in mesh corner 4	0.01
110 kV cable from new transformer HV bay (ex-Omagh A bay) to the new 110/33 kV transformer in DUN B	0.33
Change 110 kV Tamnamore C OHL circuit to spare bay in mesh corner 7	0.01
Subtotal	6.66
10% contingency	0.67
Total	7.33

Table 15 : Sub-option 6.b – Capital costs for transmission works

Ap A.7. Option 7

Build a new 110/33kV BSP in Cookstown.

Ap A.7.1. Sub-option 7.a

Connect from Dungannon 110/33 kV substation.

Distribution Works	
Item description	Total [£m]
All distribution works to reconfigure the 33kV network and create a BSP in Cookstown	3.2
Subtotal	3.2
10% contingency	0.32
Total	3.52

Table 16 : Sub-option 7.a – Capital costs for distribution work

Transmission Works	
Item description	Total [£m]
Site procurements	
Procure land in the South outskirts of Cookstown to install a new BSP	0.27
Pre-enabling	
Pre-enabling 110/33	2.91
Substation works (DUN)	
Equip Dungannon mesh corner 4	0.25
Prepare ex TMN 'A' bay for one of the single 110kV circuits from Dungannon Main to the new Cookstown Main	0.25
Equip spare bay on mesh corner 7 for the second circuit from Dungannon Main to the new Cookstown Main	0.25
Substation works (new BSP in Cookstown)	
110kV control building	0.15
110/33kV 90MVA ONAF transformer, including 100m of 110kV cable (2 off)	3.67
110kV transformer feeder termination (disconnectors, earth switches, busbar)	0.50
OHL & Cable works	
110kV single circuit wood pole Trident with 300mm ² AAAC between DUN and the new BSP in Cookstown. This item will require further assessment from NIEN to define the final solution.	7.00
Move TMN 'A' 110kV cable circuit to bay in mesh corner 4	0.99
110 kV single core armoured copper 1000mm ² underground cable for each circuit, to be installed near DUN and Cookstown Main substations to avoid hub-and-spoke.	2.58
Subtotal	18.82
10% contingency	1.88
Total	20.70

Table 17 : Sub-option 7.a – Capital costs for transmission works

Ap A.7.2. Sub-option 7.b

Connect from the Dungannon – Tremoge 110 kV circuits through a new marshalling substation.

Distribution Works	
Item description	Total [£m]
All distribution works to reconfigure the 33kV network and create a BSP in Cookstown	3.2
Subtotal	3.2
10% contingency	0.32
Total	3.52

Table 18 : Option 7.b – Capital costs for distribution works

Transmission Works	
Item description	Total [£m]
Site procurements and agreements	
Procure land along DUN – TRE 110kV circuit to install a new 110kV Switching Substation	0.14
Procure land for new 110/33kV	
Substation works (new Marshalling Substation)	
110kV control building	0.15
110kV substation pre-enabling	2.91
Substation turn-in from existing line	1.
110kV AIS DBB Bay	3.79
Substation works (new BSP in Cookstown)	
110kV/33kV Substation pre-enabling	2.91
110kV control building	0.15
110kV/33kV 90MVA ONAF transformer, including 100m of 110kV cable	3.67
110kV transformer feeder terminations (disconnectors, earth switches, busbar)	0.5
OHL & Cables works	
110kV Single circuit wood pole Trident with 300mm ² AAAC between TRE and the new BSP in Cookstown. This item will require further assessment from NIEN to define the final solution.	5.67
110 kV single core armoured copper 1000mm ² underground cable for each circuit, to be installed near DUN and Cookstown Main substations to avoid hub-and-spoke.	2.58
Subtotal	23.47
10% contingency	2.35
Total	25.82

Table 19 : Option 7.b – Capital costs for transmission works

Ap A.8. Sub-option 7.c

Connect from Tremoge 110/33 kV cluster substation.

Distribution Works	
Item description	Total [£m]
All distribution works to reconfigure the 33kV network and create a BSP in Cookstown	3.2
Subtotal	3.2
10% contingency	0.32
Total	3.52

Table 20 : Sub-option 7.c – Capital costs for distribution works

Transmission Works	
Item description	Total [£m]
Site procurements and agreements	
Procure land in the South outskirts of Cookstown to install a new BSP	0.27
Substation works (TRE)	
110kV AIS DBB Bay	0.76
Substation works (new BSP in Cookstown)	
110kV/33kV Substation pre-enabling	2.91
110kV control building	0.15
110kV/33kV 90MVA ONAF transformer, including 100m of 110kV cable	3.67
110kV transformer feeder terminations (disconnectors, earth switches, busbar)	0.50
OHL & Cables works	
110kV Single circuit wood pole Trident with 300mm ² AAAC between TRE and the new BSP in Cookstown. This item will require further assessment from NIEN to define the final solution.	9.59
110 kV single core armoured copper 1000mm ² underground cable for each circuit, to be installed near DUN and Cookstown Main substations to avoid hub-and-spoke.	2.58
Subtotal	20.43
10% contingency	2.04
Total	22.48

Table 21 : Sub-option 7.c – Capital costs for transmission work

Appendix B. Revenue costs due to lost load during transformers maintenance

SONI would not advocate the disconnection of demand to maintain a 110/33kV transformer at Dungannon as it would prefer reinforcement instead. The cost benefit analysis requires that even though there is a TSSPS requirement the cost of Do Nothing should still be evaluated. However, this exercise is to show for the purposes of a net present value approach the actual cost of Option 1 Do Nothing.

This is an exercise to identify the Value of Lost Load (VoLL) during the maintenance of the transformers. A high-level approach will be used to identify the demand profile in the transformers for each day of maintenance, based on estimating the capacity absorbed through the transformers from historical data and estimating its change during the project lifecycle.

Maintenance procedures

The conditions assumed to deliver this maintenance are the following:

- The outages occur during the maintenance season from May to August.
- Each transformer is maintained every 3 years.
- Maintenance will take 5 working days. During this period, the transformer will be off during non-stop 8h each day, from 8:00 to 16:00.
- Per year only one transformer will be subject to maintenance, i.e., if one of the transformers is maintained in year x, the other transformer will be maintained on year x+1. In year x+2 no maintenance will take place, and after that the procedure will be repeated.

Value of Lost Load

Based on the Trading and Settlement Code – Policy Parameters 2018 – Decision Paper (SEM-17-071), from 14 September 2017 [4], the VoLL for the all-island in 2018 was 11,128.26 €/MWh or £9,406.81/MWh². This value will be considered the base VoLL. The exchange conversion will be 1GBP=1.183EUR.

The VoLL is updated based on the Harmonised Index of Consumer Prices (HICP). From the SEM Committee – Value of Lost Load 2015 [5], for 2015 the weighted average for the HICP was +0.83%, from 2014.

Load transference and local generation contributions

² FX conversion applied is 1GBP=1.183EUR on the 26th April 2022.

The transferable capacity through the 11 kV and 33 kV networks is assumed to be available all year and is detailed in the Need Case, section 3.5.2.

At the moment, the transferable capacity is a maximum of 31.5 MVA after 3h of the request being initiated. For the purpose of this analysis, it is considered that the request for the capacity transference will be done with sufficient time before the maintenance works are initiated, meaning that the 31.5 MVA was transferred from the BSP at the time the maintenance works were initiated.

It is assumed that the transferable capacity will reduce with time as distribution networks get more congested by the introduction of heat pumps and electrical vehicles. The rate at which the load transfer will be reduced is equal to the rate of increase in demand during the project lifecycle.

Regards to local generation, there are the contributions from Crockagarran wind farm, which has a Maximum Export Capacity (MEC) of 17.5 MW to satisfy demand. However, there is no evidence that on the scheduled maintenance days, this capacity will be available. Therefore, using a conservative approach its contributions will not be considered.

Cyclic overload ratings of the power transformers

From the assessment conducted in the Need Case, appendix B, table 19, the overload capacity of the power transformers is 3.47%.

Profile of the absorbed power profile in the transformers for each day of maintenance

This assessment used available data from the SONI Historical Information System (HIS), including data from 2021 and 2022. Both years are very similar in terms of the data available for a specific day during the summer period. Figure 22 presents the typical demand profile on a maintenance day.

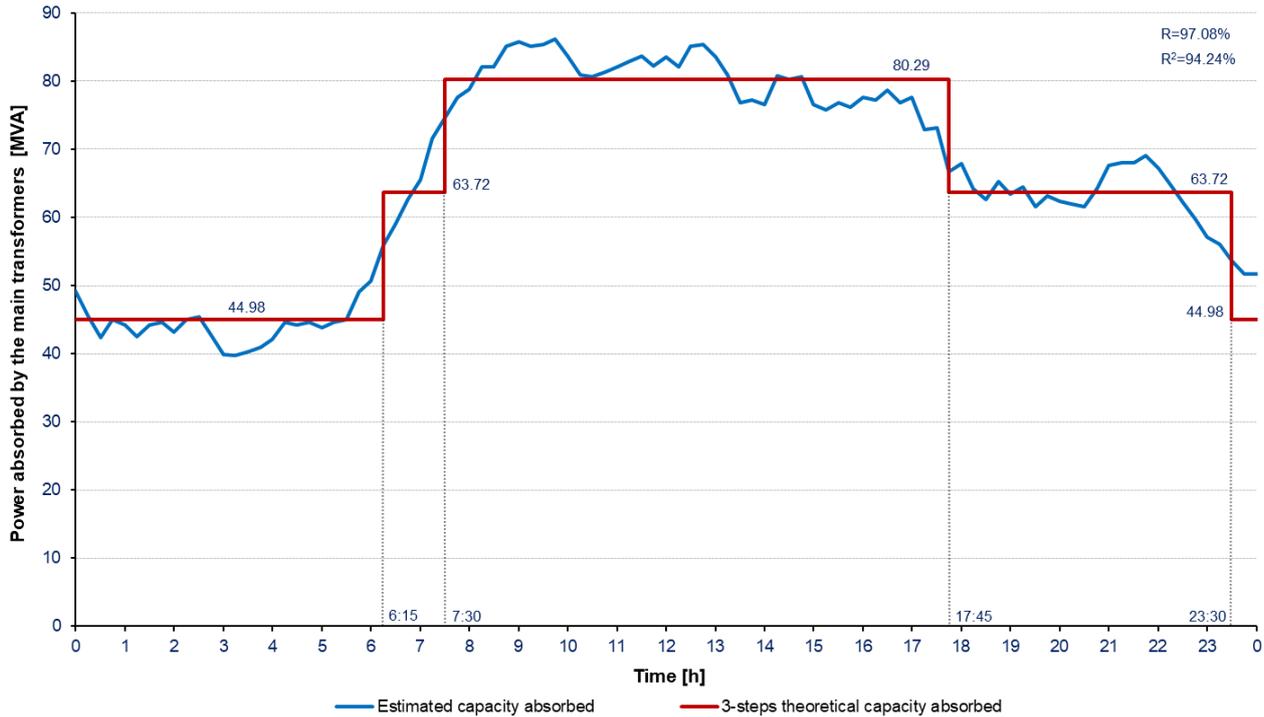


Figure 22 : Typical demand profile by the transformers on a maintenance day

In blue is a 3-steps representation³ for the purpose of calculating the lost load during maintenance works. The worst case in terms of transformer capacity usage took place on the 5th May 2021, at 9:45, with a combined power of 85.47 MVA through both transformers (metered in the secondary). This data was used in this assessment and replicated for each day of the working week during which the transformer maintenance (5 days required) is carried out.

Estimation of the absorbed power growth of the transformers

For the purpose of estimating the absorbed power growth of the transformers during the project lifecycle, information from the Tomorrow Energy Scenarios – Northern Ireland 2020 (TESNI 2020) was used and assumes that the transformers will follow the demand growth with no contribution from local generation or load transfer being considered. Using a conservative approach, the Accelerated Ambition scenario in the TESNI 2020, is used to define the demand growth.

³ The 3-steps theoretical approach has a coefficient of correlation (R) of 97.08%, and a coefficient of determination (R²) of 94.24%, which are high values, meaning that the curve is a very good representation of the estimated capacity absorbed, not only in terms of values but also its variation.

The information available in section 5 of the TESNI 2020, suggests a Total Energy Requirement (TER) growth, between 2020 and 2040, of greater than 66%, with the peak electricity demand⁴ growing by 70%. This means that both demanded energy and capacity will have a strong positive correlation, and therefore it will be assumed that the capacity absorbed through the transformers during the project lifecycle will have the same growth as the total energy requirement data from TESNI 2020, Figure 5.5⁵. After 2050 there is no data available, but assuming that the goals on the Accelerated Ambition scenario were achieved with the modest economic growth continuing up to the end of the lifecycle of this project in 2062, the growth of demand between 2050 and 2062 will be 0.26-0.27%/y, the same as between 2040 and 2050.

Load shedding due to transformers maintenance

Based on the context presented above, it will be required to carry out load shedding during the maintenance of the transformers in Dungannon Main in the year 2035.

Figure 23 presents the impact of maintenance on the transformers in terms of load shedding in Dungannon BSP. In the assumed conditions, the first year that maintenance on the transformers is going to impact the capacity of the BSP to satisfy demand is 2035.

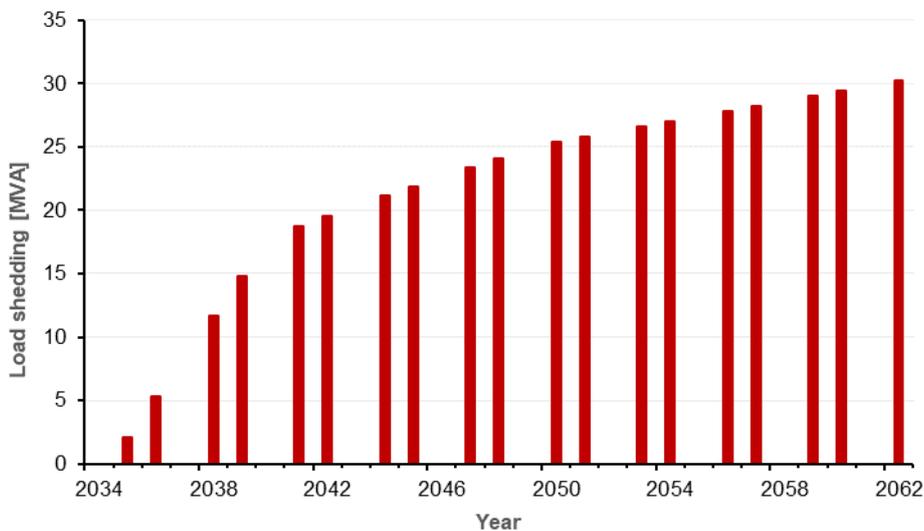


Figure 23 : Load shedding during the transformers maintenance

⁴ The peak electricity demand in Northern Ireland typically occurs on a weeknight in winter at 5pm.

⁵ This figure represents the total energy requirement, between 2020 and 2050, for the three scenarios defined in TESNI 2020.

The years when there is no load shedding, except for 2034, e.g., 2037, 2046, 2055, etc, are years with no transformer maintenance. In the end of the project, it is expected that the load shedding goes above 1/3 of the transformers' nominal capacity. The impact on the revenue costs due to the transformer's maintenance is presented in Figure 24.

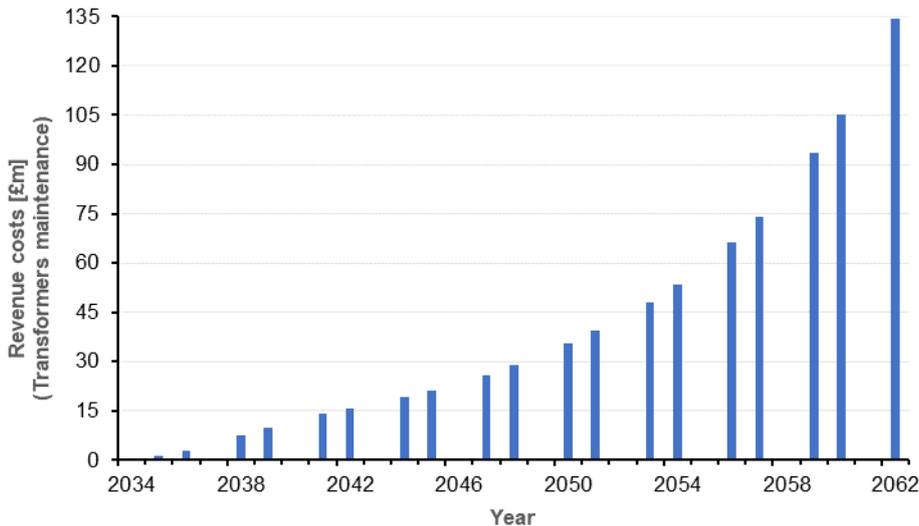


Figure 24 : Revenue costs due to transformers maintenance according to the year

The major driver for the cost growth is the VoLL. The values of the VoLL growth were already very limited, but if the VoLL value doubles, which is still below the 2015 figures, these costs in 2062 will be more than 12 times greater than the present cost estimate presented in the above figure.

These costs will be added to the CBA and are expected to have a significant impact on option 1, Status Quo. Whereas for other shortlisted options, further capacity will be added through the delivery of the projects and therefore the need for capacity to avoid load shedding will be satisfied by the proposed solutions.

