Capital Project 966

Feasibility Assessment - Cross Connection at Maynooth Substation

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EirGrid

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Executive Summary

Capital Project 966 (CP 966) is a proposed development that will help transfer electricity from the west of Ireland and distribute it within the network in Meath, Kildare and Dublin to help meet the growing demand for electricity in that area. This growth is due to increased economic activity and the planned connection of new data centres in the region. CP 966 aims to strengthen the transmission network between Dunstown substation in Kildare and Woodland substation in Meath - and suggests a number of technical solutions to do so.

The connection options being considered by EirGrid are:

- Option 1: Up-voltage of the existing 220 kV overhead line (Gorman - Maynooth – Dunstown) to a 400 kV overhead line,
- Option 2: New 400 kV overhead line option; and
- Option 3: New Underground Cable options (220 kV or 400 kV).

To facilitate the three options, there will be a number of additional technical requirements at Woodland, Maynooth and Dunstown substations:

i. An extension to Woodland substation,
ii. An extension to Dunstown substation,
iii. A 400kV bay in Woodland substation,
iv. Development within the existing Woodland Substation (ring configuration);
v. A 400kV bay in Dunstown Substation,
vi. Turn in of Gorman - Maynooth 220kV circuit into Woodland Substation; and
vii. Linking Woodland - Maynooth and Dunstown - Maynooth OHL circuits at Maynooth substation.

This report considers the feasibility of item vii; possible solutions to link the Dunstown – Maynooth and Gorman – Maynooth sections of OHL close to Maynooth 220kV substation where these circuits converge.

Meetings and teleconferences have been held between the Client and Consultants to share information and to determine the scope of the study. The overall study area was jointly identified to the west of Dublin during the month of October 2019 and a team of specialists visited the study area during the month of November 2019 to survey the environment from publicly accessible areas.

This technical report identifies four possible solutions:

A. A connection of the two circuits using OHL between new towers positioned on the line of each existing alignment to ensure the standard use of existing and new structure positions,
B. A connection of the two circuits using OHL between new towers positioned off-line of each existing alignment of the two circuits, that would re-use other existing towers and may as a consequence minimise the outage implications of construction work or offer an economic efficiency,
C. A connection of the two circuits using a section of underground cable between new terminal towers,
D. A connection of the two circuits at Maynooth substation from existing terminal tower positions.

EirGrid may wish to consider combinations of options A and B to satisfy site conditions.

The report considers the technical content, construction sequence and the advantages of each solution and offers the outcome of the feasibility assessment in accordance with EirGrid criteria as presented in table 1 using the following scale to illustrate each criterion parameter:

More significant/difficult/risk Less significant/difficult/risk

Assessment Criteria	A. Online towers	B. Offline towers	C. Cable connection	D. Substation connection
Technical Performance				
Economic Performance				
Deliverability				
Environmental				
Socio-economic				
Combined Performance				

Table 1. Feasibility Assessment for Connections in proximity to Maynooth Substation

The report concludes that overall, the best performing technical option will be an OHL based solution as this is considered economically advantageous and technically less complex, however it is presently unclear whether option A or option B has a clear advantage. Option A will provide new assets in accordance with the functional specification, while option B offers some economic efficiencies but could leave the Transmission Asset Owner (TAO) with assets that are not entirely in accordance with the functional specification or requiring site-specific maintenance procedures. The determining factor could be the outage implications of the proposed up-voltage works as this will establish whether there are any construction programme or operational implications and consequently any economic advantages that can be gained that are not presently evident.

The cable option is considered more complex and expensive than either of the alternative OHL options due to the additional land, materials and components required, but may offer EirGrid flexibility for achieving the connection, while the substation option is considered more expensive than any of the alternative options and technically the most complex but does potentially allow EirGrid to manage the works entirely within the boundary of the existing substation.

Land not presently occupied by the TAO will be required for all but the substation option and therefore agreements may be required with landownerships not currently occupied with TAO assets.

As land use in the study area appears to be largely agricultural, there are no obvious clearance issues associated with the OHL options, however clearances will need to be confirmed in accordance with EirGrid functional specification.

Overall, the environmental constraints in the study area are considered low impact/risk for the OHL based options and medium impact/risk for the cable option. All options are considered to have a low social impact.

The study area contains a road network which should make delivery of construction materials and plant reasonably straightforward for all options, however temporary roads will be required to each construction site other than within Maynooth substation.

1. Introduction

1.1 What is Capital Project 966?

Capital Project 966 is a proposed development that will help transfer electricity to the east of the country and distribute it within the network in Meath, Kildare and Dublin.

The project will help meet the growing demand for electricity in the east. This growth is due to increased economic activity and the planned connection of new data centers in the region.

A significant number of Ireland's electricity generators are located in the south and south west. This is where many wind farms and some modern, conventional generators are located. This power needs to be transported to where it is needed.

The power is mainly transported cross-country on the two existing 400 kV lines from the Moneypoint station in Clare to the Dunstown substation in Kildare and Woodland substation in Meath. Transporting large amounts of electricity on these 400 kV lines could cause problems that would affect the security of electricity supply throughout Ireland, particularly if one of the lines is lost unexpectedly.

To solve this emerging issue, we need to strengthen the electricity network between Dunstown and Woodland to avoid capacity and voltage problems.

Capital Project 966 aims to strengthen the transmission network between Dunstown and Woodland substations. and suggests a number of technical solutions to do so.

1.2 Framework for Grid Development Explained

EirGrid follow a six-step approach when they develop and implement the best performing solution option to any identified transmission network problem. This six-step approach is described in the document 'Have Your Say' published on EirGrid's website [1]. The six steps are shown on a high-level in Figure 1. Each step has a distinct purpose with defined deliverables and represents a lifecycle of a development from conception through to implementation and energisation.

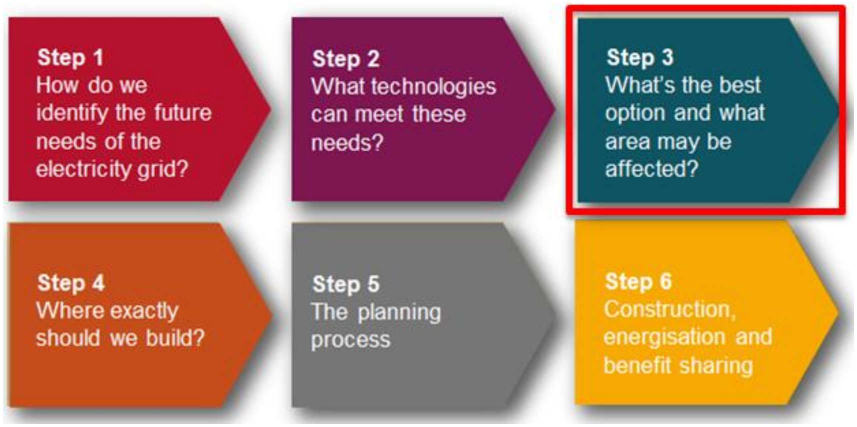


Figure 1.1 : EirGrid's six-Step Framework for Grid Development

Capital Project 966 is in Step 3 of the above process. The aim of Step 3 is to identify a best performing solution option to the need identified. There are four remaining technical viable options to be investigated in Step 3. All

[1] http://www.eirgridgroup.com/the-grid/have-your-say/

options create a connection between Woodland and Dunstown substations and have common reinforcements associated in relation to voltage support devices and 110 kV uprates. The main four options are:

- Up-voltage existing 220 kV circuits to 400 kV to create new Dunstown – Woodland 400 kV overhead line (OHL);
- A new 400 kV overhead line,
- A new 220 kV underground cable,
- A new 400 kV underground cable.

Common reinforcements to all four options (outcome of Step 2, may change in Step 3):

- Uprating of the Bracklone – Portlaoise 110 kV overhead line
- Dynamic reactive support device in greater Dublin area rated at approximately ±250 Mvar

These options will be evaluated against five criteria: technical, economic, environmental, deliverability and socio-economic and each criterion incorporates a number of sub-criteria. It shall be noted that the overall assessment is carried out by EirGrid, but certain aspects are investigated and assessed by various consultants and their assessment will feed into the overall assessment.

1.3 Aims and Context of the OHL Report

To deliver the up-voltage option noted in section 1.2 above, EirGrid will need to connect the existing Dunstown – Maynooth (2) 220 kV circuit with the Gorman – Maynooth 220kV circuit in the vicinity of Maynooth substation.

EirGrid (the Client) has engaged Jacobs to assess the technical feasibility of options to achieve this connection within the study area. This report considers the factors identified in both the Environmental Constraints Report (reference 321084AE-REP-002) and the Social Impact Assessment Scoping Report (reference 321084AE-REP-003). These constraints impact on the availability of route corridors, access for construction and both circuit and third-party operations (horizontal and vertical clearances). A preliminary bill of quantities has been completed in order to give an insight into the overall economic impact of the different options. The findings will feed into EirGrid's overall evaluation of the four remaining options.

1.4 Description of criteria used to assess the options

This report uses the following criteria to assess each connection option:

- Technical

As part of technical feasibility assessment, connection options were developed in accordance with relevant EirGrid design standards to indicate a proposed solution. Constructability and health and safety implications for operation and maintenance activities through the achievement of appropriate electrical clearances have been considered.

- Environmental

As part of environmental feasibility, only the impact arising from any new connection infrastructure has been identified and examined. For a broader environmental assessment, please refer to report 321084AE-REP-002 – Environmental Constraints Report.

- Deliverability

As part of deliverability assessment, existing access roadways and operational/maintenance assessments were made to ensure that the solution can be safely constructed, maintained and operated.

- Economic

An approximate bill of quantities (items, units, lengths etc.) has been provided.

- Socio-economic

Socio-economic assessment has been included based upon a summary of findings produced in report 321084AE-REP-003 – Social Impact Assessment Scoping Report.

1.5 Scale used to assess each criteria

The effect on each criteria parameter is presented along a range from “more significant”/”more difficult”/“more risk” to “less significant”/”less difficult”/“less risk”. The following scale is used to illustrate each criteria parameter:

More significant/difficult/risk Less significant/difficult/risk

In the text this scale is quantified by text for example mid-level/moderate (Dark Green), low-moderate (Green), low (Cream), high-moderate (Blue) or high (Dark Blue).

1.6 Relationship to other technical documents

Parallel to this report, Cable Feasibility, Environmental and a Social Impact studies are being prepared to investigate the impact of proposed solutions on the study area.

Please read in conjunction with the following reports:

- 321084AE-REP-001 - CP 966 Cable Route Feasibility Report
- 321084AE-REP-002 - CP966 Environmental Constraints report
- 321084AE-REP-003 – CP 966 Social Impact Assessment Scoping Report; and
- 321084AE-REP-004, 006, 007 and 011 – CP 966 Technical Requirements Feasibility Reports

2. The Project

One option that EirGrid is investigating is to create a new 400kV circuit connecting Dunstown and Woodland which will necessitate connecting together the existing Dunstown – Maynooth (2) 220 kV circuit with the Gorman – Maynooth 220kV circuit in the vicinity of Maynooth substation and upgrading the new circuit to operate at 400kV. EirGrid has requested an optimum methodology for carrying out the connection between the two existing circuits at Maynooth. The study assumes that any modifications required at Maynooth substation will be carried out in conjunction with the proposed up-voltage works planned for these circuits.

2.1 Existing Arrangements

The approach of the two existing OHLs to Maynooth substation comprises separate sections of 220kV single circuit OHL between Dunstown – Maynooth and Maynooth – Gorman as presented in Figure 2.1.

Figure 2.1. Existing 220kV Circuits from Gorman and Dunstown into Maynooth 220kV Substation

2.2 Required System Ratings

The study for this option is presented on the basis that the upvoltaging work on existing sections of OHL towards Woodland and Dunstown will utilise a conductor system that can be met by the EirGrid functional specification for 400kV towers and which will be used on any reconfiguration of OHL around Maynooth.

2.3 Outline Options Considered

The study has considered that the primary technology for achieving a reconfiguration of existing OHL routes will be by use of new OHL support structures but that EirGrid may wish to consider the re-use of existing structures to better understand whether there are any opportunities to be gained from such alternatives. As such, two OHL options are considered along with one based upon cable technology and one based upon configuring a 400kV connection within the existing Maynooth substation.

A. A connection of the two circuits using OHL between new towers positioned on the line of each existing alignment to ensure the standard use of existing and new structure positions,

B. A connection of the two circuits using OHL between new towers positioned off-line of each existing alignment of the two circuits, that would re-use other existing towers and may as a consequence minimise the outage implications of construction work or offer an economic efficiency,

C. A connection of the two circuits using a section of underground cable between new terminal towers,

D. A connection of the two circuits at Maynooth substation from existing terminal tower positions.

EirGrid may wish to consider combinations of options A and B to satisfy site conditions.

2.4 Basis of the Design Approach

2.4.1 Study Area

The study has sought to identify a relatively broad area within which the connection could be made. The merits of various option have then been assessed against the specified EirGrid criteria; the objective being to determine the relative strengths and weaknesses of these options. This has entailed seeking to avoid constraints identified wherever possible and developing the most direct routes where all other factors remain equal.

The study area is presented in figure 2.2

Figure 2.2. Study area in proximity to Maynooth 220kV Substation

2.4.2 Environmental Considerations

Section 5 of the Jacobs Environmental Report 321084AE-REP-002 considers the various environmental constraints associated with the OHL up-voltage option including the OHL into Maynooth substation. The conclusions of this and additional narrative specific to the Maynooth options are presented below and in table 2.1:

2.4.2.1 Biodiversity

The Rye Water Valley SAC/pNHA and the Carton Demesne Ancient and Long-established Woodland lie approximately 6km to the north east of Maynooth substation. The Royal Canal pNHA also runs through the centre of Maynooth. The Lyreen_020 is over sailed twice by the existing 220kV OHLs proposed for the up-voltage works, as they approach Maynooth substation from the west: first by the Dunstown-Maynooth line; and then, approximately 750m downstream, the Woodland-Maynooth OHL.

The most significant effects on biodiversity would be during construction for all options. Option C, the underground cable, presents the greatest risk of the four options, as the topsoil strip has the potential to create a significant amount of silty water runoff which could affect the Lyrteen_020. Note, however that at this point, the Lyreen_020 is 6km upstream of the Rye Valley SAC and is currently in poor condition. It is 'At Risk' but would have a medium sensitivity, given its distance from the SAC. Hence a moderate risk is identified for Option C. Option C may also necessitate the permanent loss of hedgerows over the cable. OHL options A and D have slightly higher risk than OHL Option B as two or three new towers are proposed, however the difference in risk is not sufficient to move them up to a higher risk category in the colour coding.

2.4.2.2 Soils and Water

Groundwater vulnerability at the Maynooth substation site is High, however there is no vulnerable groundwater identified in the land to the west of the substation where works would take place for all options. There are a number of potential effects on surface water during construction of an OHL or cable options; there would be none during operation of the OHLs; although there may some as a result of the cable operation, which is discussed below.

Without mitigation, there is the potential for significant impacts to the affecting surface water receptors during the construction phase of the proposed project. The most significant effects on soils and water would be during construction for all options. Option C, the underground cable presents the greatest risk of the four options, as the topsoil strip has the potential to create a significant amount of silty water runoff which could affect the Lyrteen_020. Note, however that at this point, the Lyreen_020 is 6km upstream of the Rye Valley SAC and is currently in poor condition. It is 'At Risk' but would have a medium sensitivity, given its distance from the SAC. Hence, as for biodiversity, a moderate risk is identified for cable option C. OHL options A and D have slightly higher risk than OHL option B as two or three new towers are proposed, however the difference in risk is not sufficient to move them up to a higher risk category in the colour coding.

2.4.2.3 Planning Policy and Land Use

The lands immediately surrounding Maynooth are predominantly arable agricultural land to the north, east and south. There is an area of heterogeneous agricultural land to the west and south west and large areas of pastures in the wider area. There are no forestry or peat/bogs present. The Regional R436 runs directly adjacent to Maynooth substation to the east.

There are no active planning applications or development lands in the vicinity of the proposed works, for any of the options.

There would be no significant risks to land use or planning and development from OHL options A, B and D. The proposed permanent land take is less or the same as the current situation; there would be a larger temporary land take during construction, but this is not expected to pose a significant risk to land use in the area. For cable option C, the risk is considered to be low to moderate; this would be during construction for the most part but also recognises that there would be restrictions on the use of the land going forwards with the cable present in the land

Agricultural land will be affected by the working clearances available beneath any new or modified OHL.

2.4.2.4 Landscape and Views

The substation is within the Northern Lowlands LCA and is highly compatible with major powerlines infrastructure. There are no protected views or prospects within 2km of the Maynooth substation. There is a designated scenic route, Views to Lyons Hill, Liffey Valley and Oughterard 2.5km to the south of Maynooth substation and a number of scenic views 3km north in Maynooth town including Mullen Bridge and Bond Bridge.

Options A, B and C would all result in the dismantling of parts of the existing OHLs into Maynooth substation and this would be a benefit to local residents. OHL option D would most likely result in new towers of increased height, although here may be fewer than at present; as such this is considered to be low to moderate risk to visual receptors. Impacts on the landscape are anticipated to be low as this landscape has been identified as highly compatible for major OHLs.

2.4.2.5 Cultural Heritage

There are a small number of RMP sites to the west and north of Maynooth substation. There is an enclosure identified to the west of the substation; as a result, there may also be a risk of unrecorded or undiscovered heritage assets, including unknown archaeology, within this area. There is a round tower on the L5207 immediately north of the area under consideration for the reconfiguration. Undesignated heritage assets include historic springs and historic water pumps at various locations within a 2km radius from Maynooth substation.

There are few historic assets in the area which could be affected by any of the options. OHL options A and B would have a low risk of effects on cultural heritage in construction and operation. Cable option C may have an effect on unknown archaeological assets during construction and introduces new structures in the area during operation. OHL option D would have a low to moderate risk during operation only as a result of new larger towers in the area.

2.4.2.6 Assessment of Options Connections into Maynooth

More significant/difficult/risk   Less significant/difficult/risk

Constraint	Option A - Online towers	Option B - Offline towers	Option C - Cable connection	Option D - Substation connection
Biodiversity				
Soil & Water				
Planning policy & Land Use				
Landscape & Visual				
Cultural Heritage				
Combined Performance				

Table 2.1 : Constraints Risk Assessment for New Connections into Maynooth Substation

The environmental assessment indicates that overall, the OHL based options are considered to be most favourable in environmental terms having lowest impact in all categories other than landscape and visual where the cable option C is favoured. Removal of OHL sections towards Maynooth substation make options A and B more favourable.

2.4.3 Socio-economic considerations

Jacobs Strategic Social Impact Assessment Scoping Report 32108AE-REP-003 considers various socio-economic impact associated with the OHL up-voltage option including the OHL into Maynooth substation. The conclusions of this and additional narrative specific to the Maynooth options are presented below and in table 2.2:

2.4.3.1 Amenity and Health

Maynooth substation lies within Small Area SA2017_087084005 (www.cso.ie). This area has a population 482, all of whom live in a house or bungalow.

In terms of amenity effects, these occur when there are two or more significant ‘nuisance’ effects on communities. These nuisance effects are generally taken to be visual impacts, traffic, noise and air quality. They are most likely to combine to create an amenity effect during the construction phase of any project.

There are few residential properties in the vicinity of Maynooth substation and those that are present are in linear settlements. There would be a neutral effect on visual receptors as a result of options a, B and C and a low effect from Option D. There is a regional road close to the substation, which would facilitate construction materials to the substation thereby limiting potential effects on amenity as a result of traffic impacts; there could be minor effects from noise and dust during construction but these are unlikely to be significant as the works would affect few residential properties and would be located primarily in fields to the rear of local properties.

During operation, there would be no traffic or air quality issues associated with the new equipment. Visual impacts are not significant, in fact for Options A and B there would be a betterment as a result of a reduction in OHLs. There would be no additional noise from the reconfigured OHL; it is likely there would be a reduction in any noise effects.

There would be no significant adverse effects on amenity from any of the options; there is likely to be an improvement to amenity under Options A and B and possibly C, although option C would be less so as it introduces Sealing End Compounds.

2.4.3.2 Economy

The percentage of people unemployed is low at 4%; there is a spread of industries within which people work, with most in Professional services, Commerce and Trade, Agriculture, Forestry and Fishing or Construction. None of the options poses a significant risk or benefit to the local economy. It is likely that workers and supplies would be procured from outside of the local area; there may be slight benefits form increased workers spending in the local supply chain, for example in pubs, restaurant and B&Bs, but it is not anticipated that this would be large enough to be significant in the local area.

The lands immediately surrounding Maynooth are predominantly arable agricultural land to the north, east and south. There is an area of heterogeneous agricultural land to the west and south west and large areas of pastures in the wider area. There is no forestry or peat/bogs present.

The land required to facilitate the reconfiguration under any options is not considered to be enough to have an economic impact on the landowner or local farming community. Additional land required for construction compounds is also unlikely to cause a significant impact.

There are no tourist sites nearby and the local roads are not likely to be used by tourists on route to attractions as there are none near the substation.

As a result, effects on the economy from the proposed works, under any option, are likely to be neutral.

2.4.3.3 Traffic & Transport

The regional road R436 runs directly adjacent to Maynooth substation to the east and access is from this road. As in other parts of the SAOI, the majority of people in the area travel to school or work by car and take less than 45 minutes to get to school or work, indicating relatively local schools and places of employment. However, the proximity of the substation to the regional road network means there is unlikely to be any significant effects on the local road network from the delivery of construction materials and workers to the site. This would be the case for all the options.

2.4.3.4 Utilities

There are unlikely to be any significant issues relating to utilities within the footprint of the substation, aside from managing the existing substation layout. Also, there are unlikely to be many unknown third-party utilities in the land surrounding the substation, but this would be surveyed prior to construction. For any other proposed project, the most significant constraints would be the existing OHLs entering Maynooth substation, however since these are the subject of the study thee are not considered a constraint.

As a result, the effects on third party utilities are likely to be neutral.

2.4.3.5 Assessment of Socio-economic criteria

More significant/difficult/risk Less significant/difficult/risk

Constraint	Option A - Online towers	Option B - Offline towers	Option C - Cable connection	Option D - Substation connection
Amenity & Health				
Economy				
Traffic & Transport				
Utilities				
Combined Performance				

Table 2.2 : Constraints Risk Assessment for New Connections into Maynooth Substation

Overall, the proposed reconfiguration under any option has a low social impact.

2.4.4 Information Gathering

The following features, which have been noted from the Jacobs Environmental and Social Impact Assessment reports, may impact upon the corridor space available for any one proposed connection.

- Individual dwellings
- Native woodland

- Monuments and sites of architectural heritage
- A locally important aquifer (across the entire study area)

An extract of this data is presented in Figure 2.3:

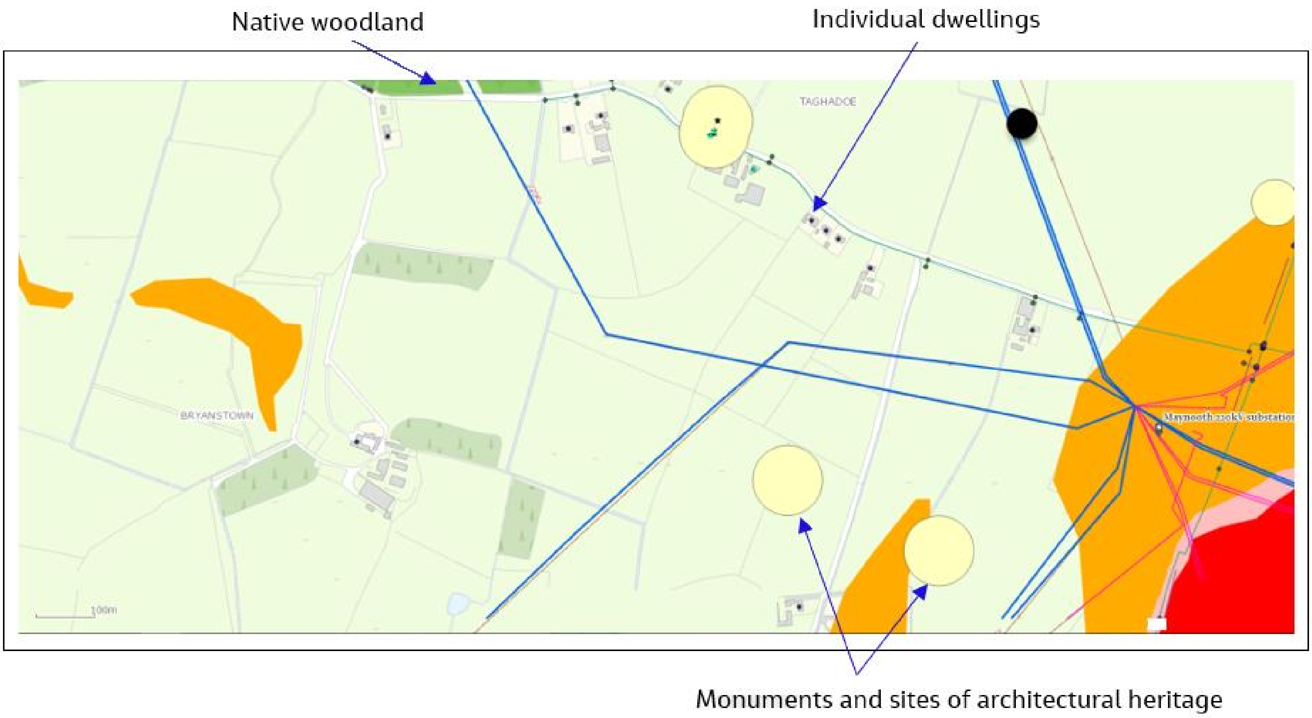


Figure 2.3. Constraints in proximity to Maynooth Substation

The site visit concluded that land use in the study area appears to be largely agricultural which indicates that clearance from ground to any new OHL conductor should not be a major concern, however clearances to any new OHL still needs to be confirmed in accordance with EirGrid functional specification LDS-EFS-00-001-R0 section 6.4 and account for any third-party activity.

2.4.5 Structural Design

For each OHL option identified an assessment of the technical feasibility has been undertaken. This has been limited to:

- use of available standard designs for any new OHL support structures
- modification or replacement of existing OHL support structures on the same site that will satisfy the project's system design requirements i.e. uprated from 220kV to 400kV
- A cable connection requiring a cable sealing end compound with downleads from a terminal tower onto either a line termination structure or anchor blocks.

The proposed OHL towers will therefore be either standard EirGrid structure designs in accordance with EirGrid Functional Specification LDS-EFS-00-001-R0, or existing 220kV towers upgraded to operate at 400kV by replacing the structure on existing (or upgraded) foundations and uprating the conductor system accordingly. The upgrade of existing structures is subject to the successful outcome of a separate trial project by EirGrid.

2.4.6 Constructability and Outage Implications

Each option has been developed on the basis that it can be constructed using a single circuit outage or series of single circuit outages, recognising that where the two circuits are being joined, as proposed at Maynooth, then simultaneous outages on each circuit will be required at some stage.

The basis for construction of towers off-line, but in proximity to existing network assets, has been that while there may potentially be sufficient space available for the construction of new OHL infrastructure without the need for a proximity outage, this cannot be guaranteed at this stage and proximity outages may therefore be required.

Options for any reconfiguration will need to account for the related outage implications associated with the route up-voltage works on the basis that these will be carried out simultaneously and may require the use of temporary OHL diversions.

A sequence of work has been suggested for options A, B and C. The study assumes that any modifications required to achieve the connection near Maynooth will be carried out in conjunction with the proposed up-voltage works planned for these circuits. At this stage the EirGrid strategy for delivering the up-voltage works has not been confirmed, however in order to maintain overall system security, the outage implications associated with delivering this could be significant in determining the preferred option at Maynooth. The study assumes that while there may be single circuit outage opportunities to construct any one of the options presented during the up-voltage works, the outage duration for each option, should it be constructed in isolation (i.e. independently of the up-voltage works) could be useful to EirGrid in determining a preferred option.

2.4.7 Maintenance

The basis for the maintenance assessment has been that any existing OHL towers that are proposed to be reused in a revised configuration should still be maintainable using standard EirGrid working practices, however any such tower will be noted as ‘non-standard’ to recognise that an alteration has been made from the original installation and additional maintenance considerations may be required.

2.5 Other assumptions made in the study

No detailed design work is involved in Step 3 of the framework development process therefore various other assumptions are noted in relation to the feasibility assessment:

- Conductor system has not been confirmed but is assumed to be 2 x 600 mm² ACSR (Curlew) or equivalent as per EirGrid Functional Specification LDS-EFS-00-001-R0 section 6.5.9,
- No assets records have been provided for the existing OHL routes therefore:
    - Ø the type of foundation at existing tower sites is unknown,
    - Ø existing profiles have not been confirmed or any site-specific clearance requirements noted;
- The condition of existing assets is presently unknown therefore the study has assumed that condition will not influence the construction methodology,
- No third-party data other than that derived from Jacobs study reports or from publicly available aerial imagery has been used in the study,
- No structural analysis has been undertaken,
- Outline sequences of work have been considered and are presented for each option.
- No indicative tower locations or profile drawings have been produced,

- The study has only considered the technical feasibility of options; no consent or planning factors have been considered,
- The presence of fibre optic services on existing TAO assets has not been confirmed or the potential implications of separate fibre outages on the options under consideration.

3. Option development

3.1 Site Visit Observation

A site visit was undertaken prior to the evaluation of options but was limited to observation from public roads and a viewpoint from within Maynooth substation. No access was possible to the existing circuit crossing point and no asset records were available for the site visit.

The following observations were made from the site visit:

- The surrounding area is generally rural area with evidence of commercial activity (driving school) and agriculture.
- The topography of the study area is reasonably level or gently undulating.
- Field boundaries are generally fencing and hedgerow and there are various areas of woodland including one on the north side of the L5037 road where the existing OHL is cut through a wood recognised to be 'native woodland'.
- The Dunstown – Maynooth circuit over sails the Gorman – Maynooth circuit where indicated in Figures 3.1 and 3.2.

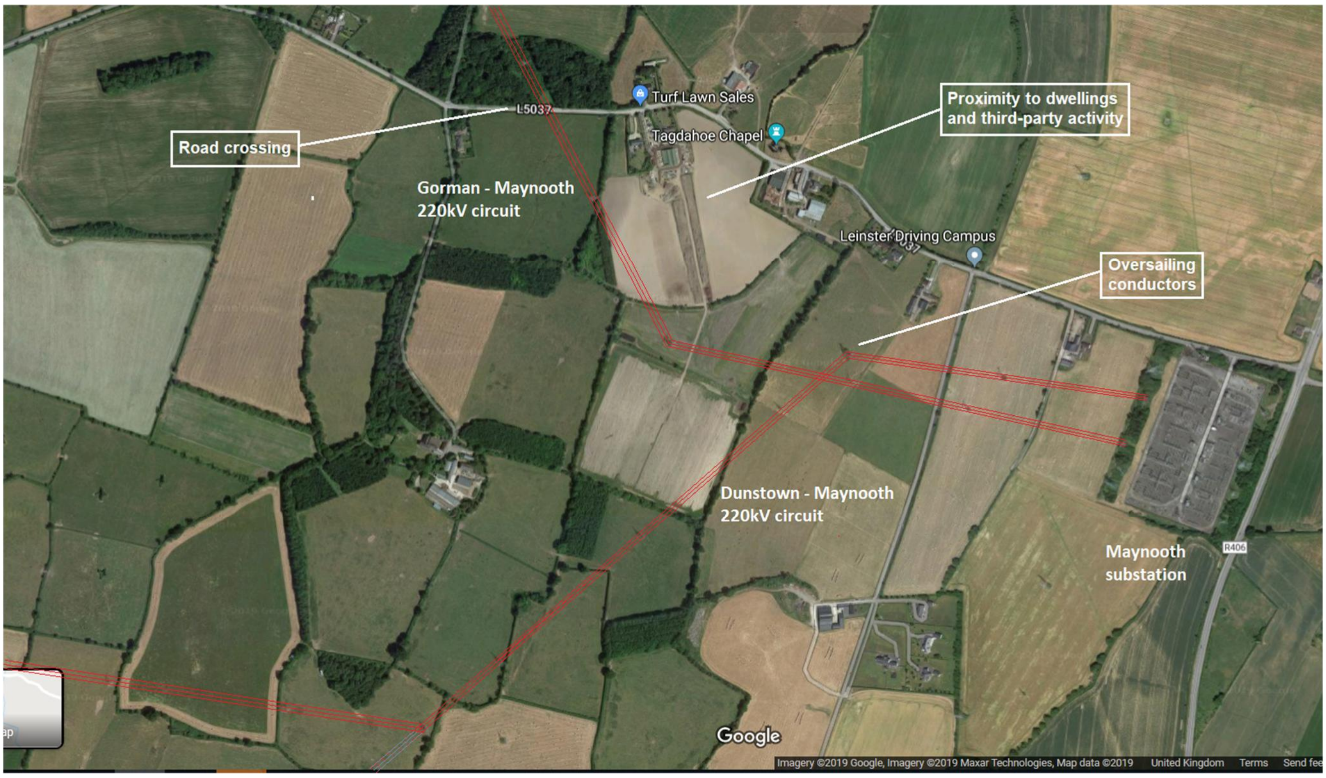


Figure 3.1. Dunstown and Gorman 220kV Lines at Maynooth

Figure 3.2. Oversailing Conductors outside Maynooth Substation

3.2 Line Diagram

A diagrammatic representation of the Gorman and Dunstown 220kV circuits at Maynooth is presented in Figure 3.3 (not to scale) which has subsequently been used for presentation of the various options considered.

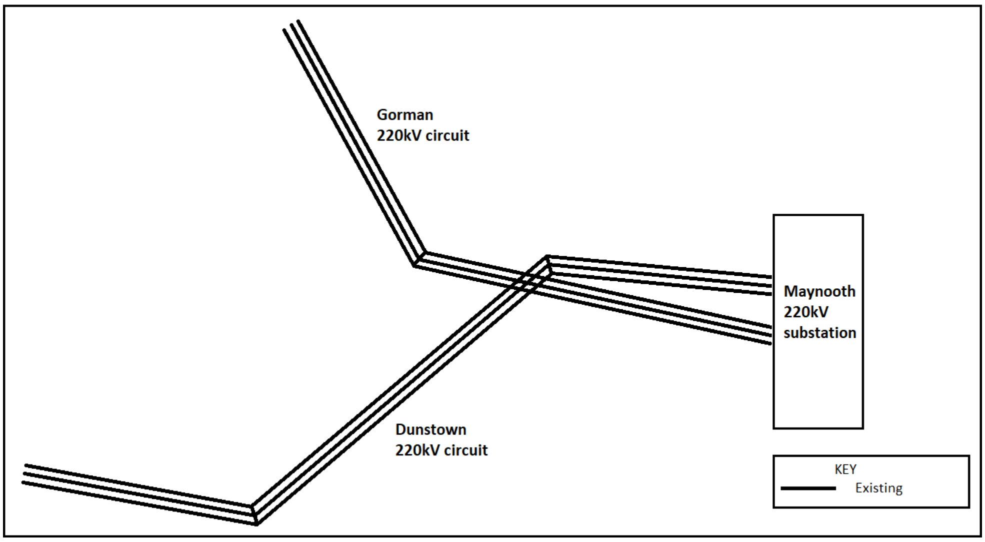


Figure 3.3. Line Diagram of the existing arrangement at Maynooth

3.3 Option A – Online Structures

3.3.1 Objective

The objective of Option A is to join the two circuits with new towers positioned on the line of existing OHL alignments. The benefit of this being that no towers should be constructed in a non-standard configuration and therefore that all towers, whether new or existing, should be maintainable using existing EirGrid procedures. Alignment presented in figure 3.4 is only an indication of the route principle. The connection could be made from various point along each alignment although this will affect the length of the new section

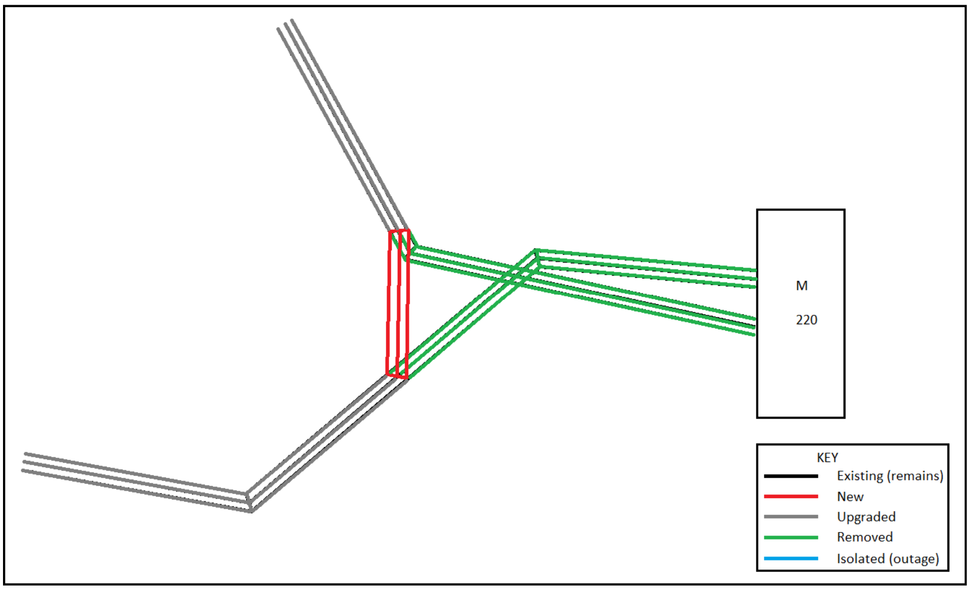


Figure 3.4. Option A

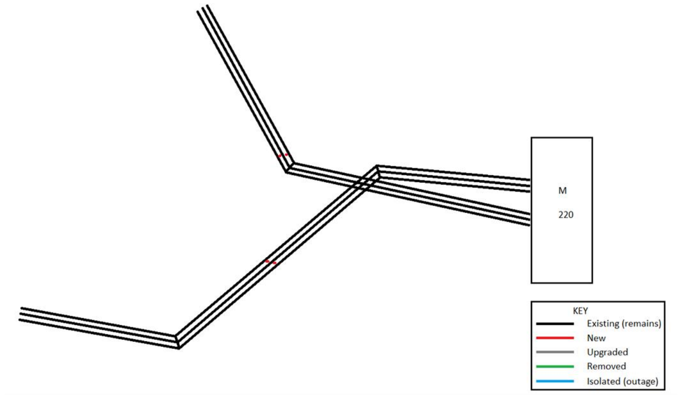
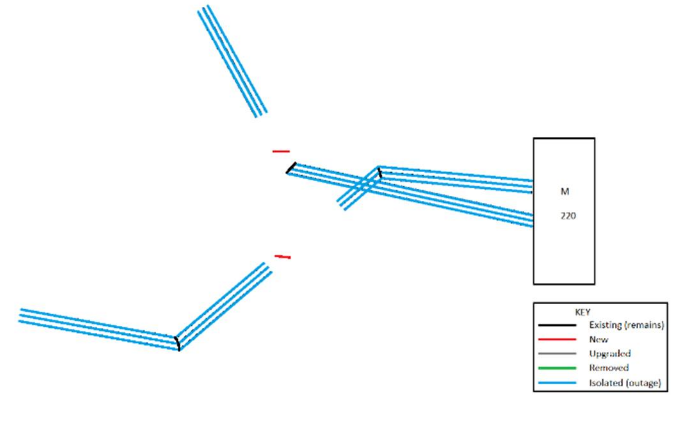
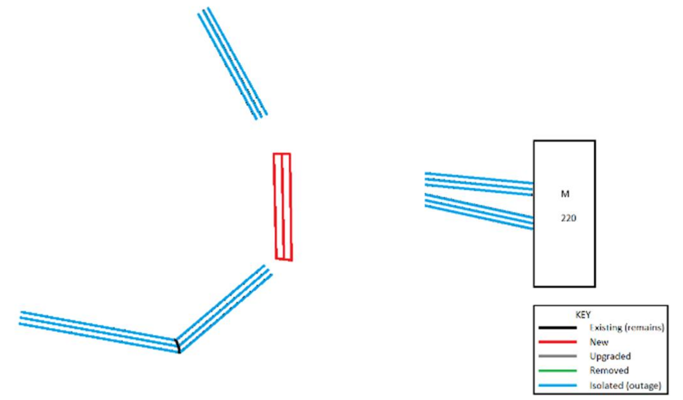
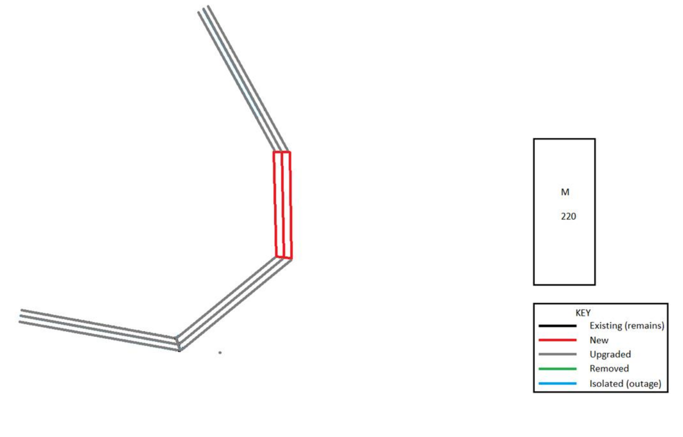
New OHL towers are proposed on-line of the existing circuits and would interface with upgraded OHL.

3.3.2 Observations:

- Additional towers may potentially be required in the 'new route' corridor
- Re-use of existing towers may require the upgrade design to account for additional site-specific requirements, however this should be limited to confirmation of suspension type towers
- Arrangements should be maintainable using currently available procedures
- Direct connection; length of the 'new route' section would be determined by positions of existing structures and availability of sites for new towers
- Profile of conductor to ground will affect both agricultural activity and any other third-party activity in the 'new route' corridor
- As sections of existing OHL will be removed the visual impact of OHLs in this area may be improved. Furthermore, existing woodland may offer the opportunity to screen any new OHL.

3.3.3 Outline Sequence of Work (Stage Diagrams)

The following sequence of work is suggested for construction of option A:

	Stage 1. Pre-Outage 1) Construct foundations for new 400kV towers beneath existing conductor systems Assumes sufficient working height permitting is available for foundation construction without an outage.
	Stage 2. 2 x Single circuit outages (3 weeks) 1) Outage and decommissioning of each 220kV circuit 2) Cut and back-stay conductors to create working areas (may necessitate removal of other towers) 3) Erect new towers
	Stage 3. (same outages) 1) Install new conductors between new towers (backstay as necessary) 2) Remove any redundant assets that may be in proximity.
	Stage 4. (up-voltage project related duration) 1) Connect upgraded conductor system from each direction. 2) Commission new 400kV Dunstown – Woodlands circuit (assumes coordinated with works elsewhere) 3) Remove any remaining redundant assets

3.4 Option B – Offline Structures

3.4.1 Objective

The objective of Option B is to join the two circuits with one or more new towers positioned off the line of existing OHL alignments. This option may offer EirGrid a more efficient solution in terms of re-using existing towers rather than replacing them, albeit this may create non-standard arrangements. This option may also offer opportunities to minimise the outage implications. Alignments presented in figure 3.5 are only an indication of the route principle. The connection could be made from various point along each alignment although this will affect the length of the new section. Two alternatives have been noted in figure 3.5 however only one of these is commented on thereafter.

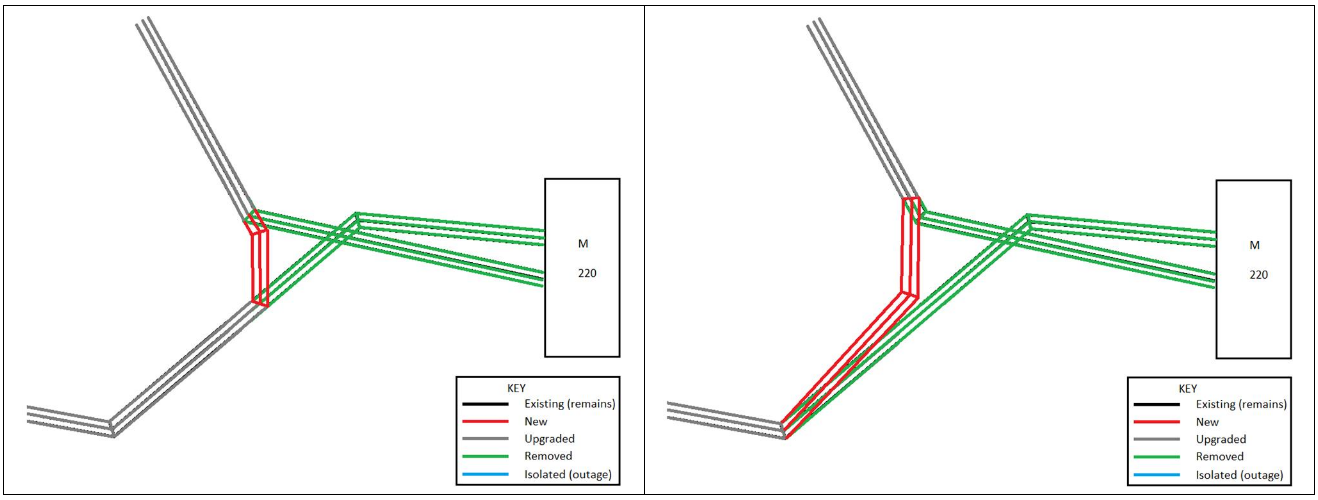


Figure 3.5. Option B

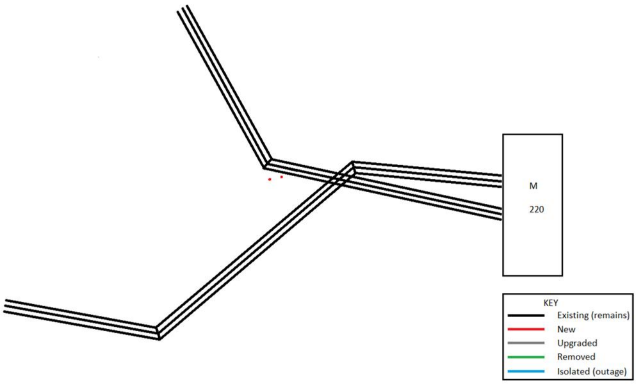
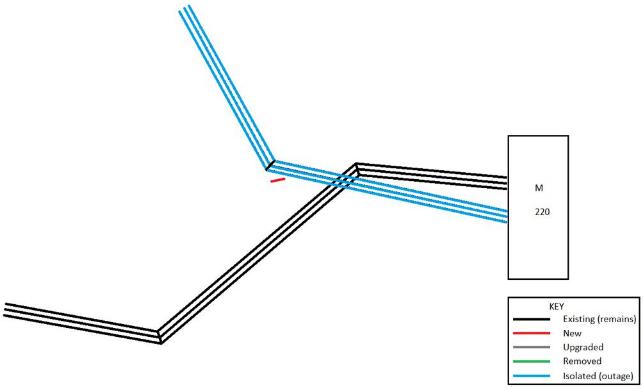
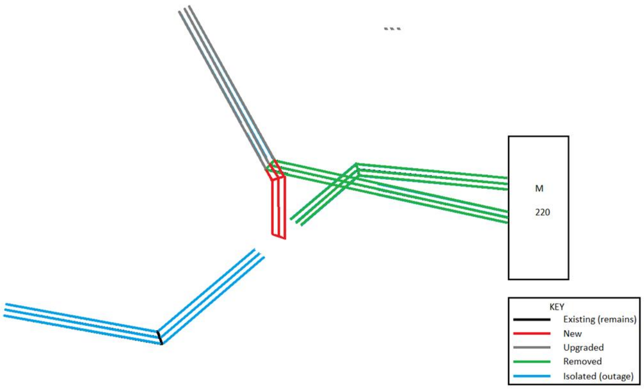
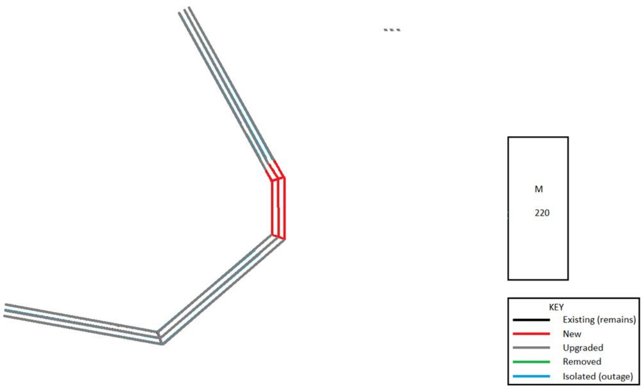
New OHL towers may be positioned off-line to interface with upgraded OHL

3.4.2 Observations:

- Re-use of existing towers will require the upgrade design to account for additional site-specific requirements resulting from the reconfiguration.
- Existing angle towers affected by the modification may be no longer set on the bisector of the angle of deviation.
- Non-standard configurations may affect future maintenance requirements or require site-specific procedures
- Tower positions would need to be confirmed from available site information.
- Potentially additional towers may be required in the ‘new route’ corridor
- Length of the connection determined by the suitability of existing structures to facilitate the connection and also the availability of sites for new towers
- Profile of conductor to ground will affect both agricultural activity and any other third-party activity in the ‘new route’ corridor
- As for option A, as sections of existing OHL will be removed the visual impact of OHLs in this area may be improved and existing woodland may offer the opportunity to screen any new OHL.

3.4.3 Outline Sequence of Work (Stage Diagrams)

The following sequence of work is suggested for construction of option B:

	Stage 1. Pre-Outage 1) Construct foundations for new 400kV towers adjacent to existing conductor systems 2) Assumes sufficient horizontal clearance is available for foundation construction without an outage
	Stage 2. Outage 1 (1 week) 1) Outage and decommissioning of Gorman 220kV circuit 2) Erect new tower 3) Assumes proximity outage required to construct tower
	Stage 3 – Outage 2 (2 weeks) 1) Outage and decommissioning of Dunstown 220kV circuit 2) Backstay existing conductors 3) Construct new tower on-line and install new conductors between new towers (backstay as necessary) 4) Remove any redundant assets that may be in proximity.
	Stage 4. (up-voltage project related duration) 1) Connect upgraded conductor system from each direction. 2) Commission new 400kV Dunstown – Woodlands circuit (assumes coordinated with works elsewhere) 3) Remove any remaining redundant assets

3.5 Option C – Underground Cable Connection

3.5.1 Objective

The objective of Option C is to join the two circuits with two new terminal towers positioned either on or off the line of existing OHL alignments and construct an underground cable connection between these towers. Alignment presented in Figure 3.6 is only an indication of the route principle. The connection could be made from various point along each alignment although this will affect the lengths of new OHL and cable sections. Two alternatives have been noted in figure 3.6 however only one of these (the on-line option) is commented on thereafter.

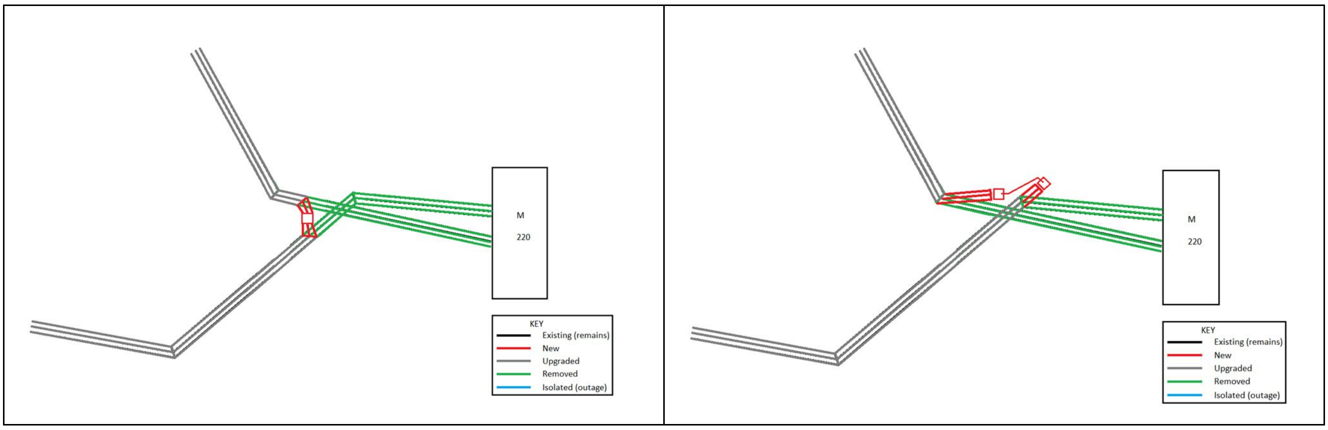


Figure 3.6. Option C

Cable connection made between new terminal towers and associated cable sealing end compounds, that utilises the existing crossing point location to minimise effects elsewhere.

3.5.2 Observations:

The effects of any new towers on existing OHL is likely to be similar to those presented for option B plus the following points:

- A cable solution is considered technically feasible but economically expensive; the cable will need to match the rating of the OHL conductor (one or two cables per phase) plus cable sealing ends, surge arresters and earth switches will be required within a cable sealing end compound.
- Cable length manufactured as a minimum length may be greater than that required and therefore economically inefficient.
- Two 400kV cable sealing end compounds will be required unless the line termination towers can be located close enough for the connection to be made within one compound in which case EirGrid may wish to consider a connection between the two using conductor or busbar
- As for options A and B, as sections of existing OHL will be removed the visual impact of OHLs in this area may be improved and existing woodland may offer the opportunity to screen any new OHL. However, the addition of a cable sealing end compound will offset some of these visual gains.

3.5.3 Outline Sequence of Work (Stage Diagrams)

The following sequence of work is suggested for construction of option C:

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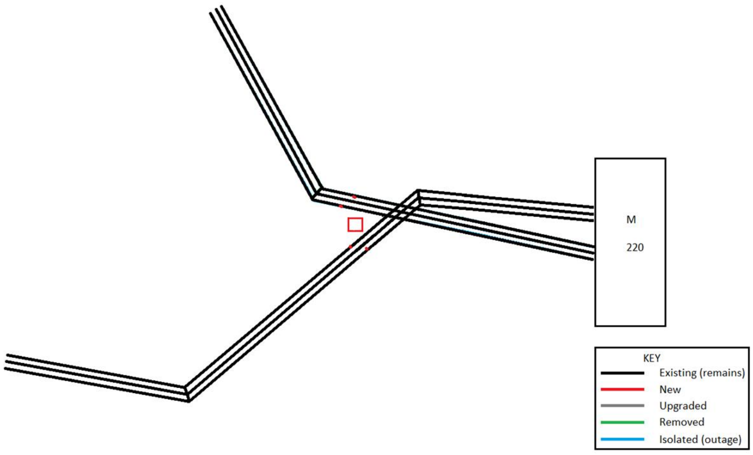
<td>


</td>
<td>
Stage 1. Pre-Outage

1) Construct cable sealing end compound adjacent to existing conductor systems
2) Construct foundations for new 400kV towers beneath existing conductor systems

Assumes sufficient working height permitting is available for foundation construction, and sufficient horizontal clearance is available for compound construction without an outage
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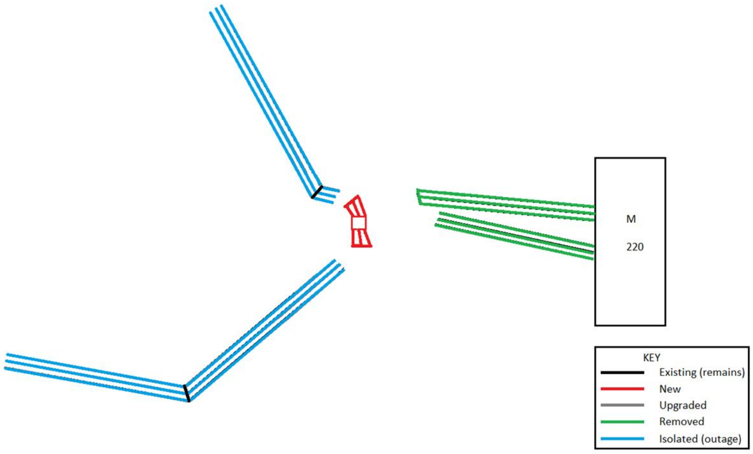

</td>
<td>
Stage 2. 2 x Single circuit outages (3 weeks)

1) Outage and decommissioning Gorman and Dunstown 220kV circuits
2) Backstay existing conductors
3) Erect new towers and connect downleads into compound
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</tr>
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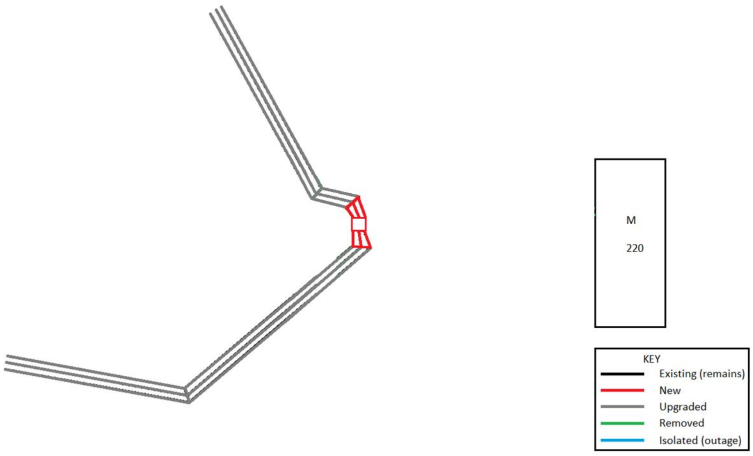
<td>


</td>
<td>
Stage 3. (up-voltage project related duration)

1) Connect upgraded conductor system
2) Commission new 400kV circuit
3) Remove remaining redundant assets.
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3.6 Option D – Connection of the two circuits within Maynooth substation

3.6.1 Objective

To join the two circuits from existing OHL alignments within Maynooth substation as indicated in figure 3.7.

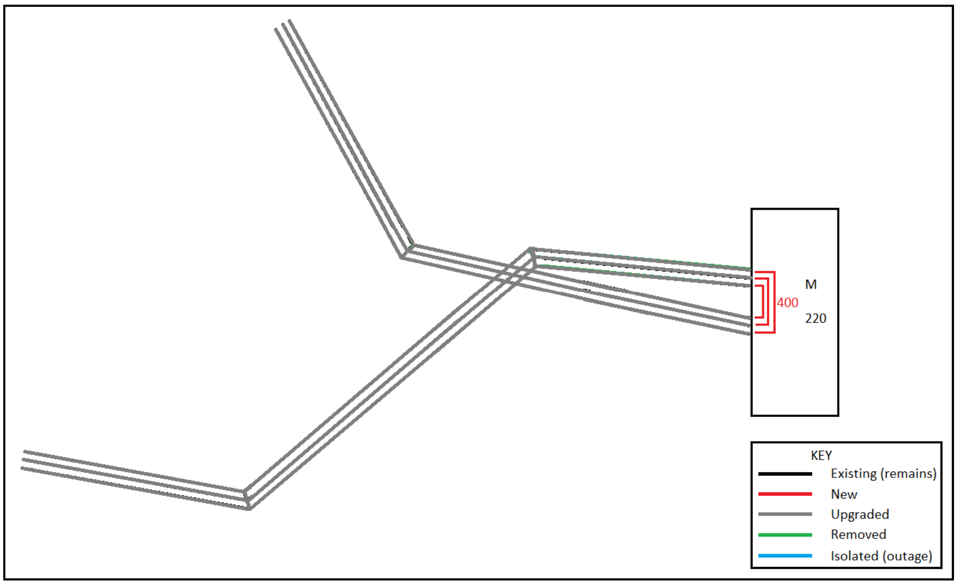

Figure 3.7. Option D

The connection would be made entirely within Maynooth substation from the upgraded OHL which will minimise the effects on the OHL configuration. 400kV bays could either replace existing 220kV bays or be constructed in an adjacent location to enable the 220kV circuits to remain operational until circuit transfer is required. This option offers EirGrid the potential to undertake the connection entirely within the boundary of the existing substation

EirGrid may wish to consider whether a cross site OHL connection or an underground cable connection could be achieved in proximity to the existing terminal towers at Maynooth substation, thereby providing a solution which may limit the impact to the existing substation area, and on existing OHLs to that associated with the up-voltage work.

3.6.2 Observations:

In order to construct this arrangement two scenarios are envisaged, either:

- Exceptionally long outages on both existing 220kV circuits to construct replacement 400kV switchgear, which is likely to have network operation implications, or
- A separate 400kV switchgear bay constructed somewhere within the 220kV compound with a separate connection to enable both 220kV circuits to remain operational.

Based upon the need to better understand the implication of these scenarios, a sequence of work has not been determined for this option.

Other observations are that:

- Existing OHL, upgraded to operate at 400kV will be left in place that other options remove.

- The oversailing conductors will still be present where the 220kV circuits presently cross adjacent to Maynooth substation, however this will be at 400kV in the final arrangement, which could necessitate taller towers being required to maintain the necessary clearance between live conductors. EirGrid could consider reconfiguring the circuit at this location to eliminate the crossing and thereby reduce the visual impact of the upgraded OHL at this point.
- This represents a complex solution with significant technical and constructability challenges. This option has not been costed but by observation is likely to be the most expensive.
- This option may offer EirGrid the opportunity to maintain flexible arrangements should there be a future need to connect Maynooth substation to the new 400kV OHL from Dunstown to Woodland'

3.7 Design Considerations

3.7.1 Design Capability of Upgraded Towers

As part of the up-voltage works, existing 220kV structures will be replaced above ground level and foundations upgraded as required. EirGrid has not specified the conductor system for the proposed connection however the study assumes the existing conductors will be replaced with a standard 400kV system. As such the replacement structures should have the same basic capability as those presented in the EirGrid Functional Specification LDS-EFS-00-001-R0.

Accordingly, the suspension type tower (Figure 3.8) will only be capable of supporting conductor systems purely in suspension and without deviation (any permissible deviation therefore only being because of constructability issues and not by design). By positioning new structures on-line, existing suspension towers should not be adversely affected; subject to ground profiling and tower heights the weight span on existing suspension towers will be altered, however this is likely to be very limited in magnitude.

Figure 3.8. Single circuit 220kV Suspension Towers (Maynooth-Gorman)

Section or Angle type tension towers in the EirGrid Functional Specification LDS-EFS-00-001-R0 are available to suit angles of deviation ranging from 0° to 30° through to 60° and 100°.

Conventionally, Section or Angle towers (figure 3.9) are set on the bisector of the angle of deviation, indeed EirGrid functional specification LDS-EFS-00-001-R0 stipulates that angle supports shall be correctly orientated in plan so that the transverse axis of the support is aligned with the bisector of the line angle within a tolerance of ± 2°, however this does not mean that structurally an existing tower cannot be modified to create unequal angles of entry in each side of the tower, thus enabling an existing Section or Angle tower to be used to deviate the existing alignment onto a new section of OHL as suggested for option B. Any such reuse should however be considered a non-standard configuration as it could have structural or maintenance implications.

Figure 3.9. Single Circuit 220kV Section / Angle Towers (Dunstown-Maynooth)

3.7.2 Design Capability of New Towers

Any proposed new towers should be standard designs in accordance with the EirGrid Functional Specification LDS-EFS-00-001-R0. Accordingly, suspension type towers should be as noted above for existing towers and Section or Angle type tension towers set on the bisector of the angle of deviation.

3.7.3 The Up-voltage Technology (220kV to 400kV)

EirGrid has specified an option to consider upgrading existing 220kV towers to be capable of supporting a replacement 400kV conductor system with polymeric insulators and accordingly has proposed an outline replacement structure.

How these are to be replaced is currently being developed by EirGrid with a trial exercise on the redundant section of OHL. The process of upgrading related foundations will presumably be undertaken without outages, however there could be significant outage implications associated with replacing existing structures and conductor systems and EirGrid will therefore need to consider how these outages can be managed. Unless the EirGrid network can be configured to provide the necessary system security during an extended outage period to replace existing towers, some form of temporary circuit diversion will be necessary.

The study assumes that where towers will be replaced, the equivalent up-voltage design suspension or section type of tower will be used and that where replacement with an alternative tower type is required, then this will be undertaken on an adjacent site.

3.7.4 Temporary Structures

Temporary diversions are used by network operators to provide short-term structural support of an overhead conductor system while either emergency repairs or planned works are undertaken on existing permanent structures. The benefit of these being that the network can continue to operate albeit at a slightly reduced level of security due to the temporary nature of the support system; as such they can represent a risk. Occasionally these systems are used for work on complete sections of OHL, however the duration of work may necessitate increasing the levels of security in the design. Temporary support tends to be guyed structures positioned on simple pad foundations as these are less intrusive.

At this stage the study has not considered the need for temporary diversions as the outage implications of proposed solutions have not been confirmed. Any assessment of the need for a temporary diversion should recognise the following factors:

§ That the OHL structures being modified are supporting a horizontal configuration of phase conductors which may require a similar corridor width for the temporary diversion,

§ That section towers may well be supporting angles of deviation and differential conductor tensions that will need to be accommodated in the temporary diversion.

§ That complete sections of OHL will need to be replaced i.e. the corridor space for the temporary diversion will need to be available alongside any one section for the construction of mast and associated guys in proximity to the existing OHL circuits.

3.8 Cost Considerations

A provisional table of quantities has been produced for each option such that an economic comparison can be made by EirGrid and is presented in table 3. As each option has only been developed as a concept, the details of each for quantity are based on the stated assumptions.

Option	Towers	Conductor	Cable	Cable Accessories	Substation	Land
A. Online towers	3 x new	500m x 3 phases	-	-	-	3 new tower sites and OHL corridor
B. Offline towers	1 x new 2 x existing towers modified	500m x 3 phases	-	-	-	1 new tower site and OHL corridor
C. Cable connection	2 x new	500m x 3 phases	150m x 3 phases	Cable sealing ends x6 or x12 depending upon cables per phase Surge arrestors x 3 phases	Compound civil costs	2 new tower sites, compounds and OHL corridor
D. Substation connection	-	-	-	-	400kV AIS bay	-

Table 3. Table of quantities

3.8.1 Assumptions

- For each of the OHL options, assume a 500m section of new OHL will be required
- For the cable connection, assume two 250m spans of new OHL will be required, plus 150m of cable and associated cable sealing ends

- For the substation option, assume existing towers will be upgraded to suit the cable connection requirements and therefore the additional OHL costs will only be those resulting from modifications to planned upvoltaging works.

Option A. Two new towers online and one additional new tower positioned between these two.

Option B. One additional new tower positioned between two existing towers modified to suit the configuration.

Option C. Two new towers online and a cable sealing end compound at each plus an underground cable connection between these between these points.

Option D. 400kV Air Insulated Switchgear bay(s) to facilitate the connection between the two sections of OHL undertaken entirely within the substation boundary.

The longer-term implications of maintenance activities have not been accounted for. In relation to the OHL related options A, B and C, there may be a cost implication associated with maintaining non-standard or site-specific arrangements.

4. Evaluation of the Options

4.1 Option Review

4.1.1 Technical Performance

EirGrid considers favourable options to be those which extend technical performance beyond minimum acceptable levels, provide operational switching flexibility and which minimise risks to operation during maintenance. The extent to which future reinforcement or modification to the transmission network can be facilitated should also be considered.

Option A proposes new OHL towers on-line of the existing circuits which would interface with upgraded OHL and recognises that while the re-use of existing towers may require the upgrade design to account for additional site-specific requirements, this should be limited in extent or impact. The benefit of this is that the towers should be maintainable using current procedures, notwithstanding that the consequences of introducing the up-voltage design is likely to require a review of existing procedures anyway.

Option B by comparison, proposes new towers off-line which would increase the probability of needing modification to existing structures affected by the change and could leave those towers in a non-standard arrangement e.g. no longer set on the bisector of the angle of deviation which may impact on the maintenance activities or require site-specific procedures at these towers.

Option C introduces underground cable technology and therefore increased complexity as well as additional maintenance requirements for both switchgear and property (cable sealing end compound).

Options A, B and C will all introduce new spans of conductor and therefore constrain the working clearance available in these spans for both agricultural activity and any other third-party activity. The span alignments indicated for Option C are altered least and therefore likely to have least impact in this respect.

Option D is technically the most complex and would leave the existing OHL configuration intact unless EirGrid decided to remove the oversailing conductors. This will enable a connection to be made entirely within Maynooth substation from the upgraded OHL. This option may offer EirGrid an opportunity to develop the 400kV network around Maynooth in the future or conceivably enable EirGrid to manage the network differently during planned maintenance.

4.1.2 Economic Performance

In the absence of cost data for individual OHL elements this aspect of the study has been limited to estimated quantities of different technologies, however experience indicates that OHL based options will generally cost less to construct than the cable or substation connection options and subsequently cost less to maintain.

4.1.3 Deliverability

The deliverability considers programme as well as engineering, constructability and planning risks.

Each of options A, B and C are likely to have planning implication for EirGrid as each is in a public area, albeit in proximity to existing OHL infrastructure that has been constructed within an existing planning framework. Option D could conceivably be undertaken entirely within Maynooth substation and therefore with no apparent or perhaps limited planning implications.

Option C is likely to have the largest visual impact given the need for cable sealing compounds; the impact of options A and B will be determined by the extent of connection required to achieve the outcome.

The apparent constraints identified within the limited study area do not at this stage appear to significantly impact on the constructability of the proposed options, however the ‘locally important aquifer’, which is noted to extend across the entire study area (depth unknown) could impact on the construction of tower foundations should these extend into the water table.

The construction implications of options A, B and C are similar in so far as the outage implications will need to be confirmed in relation to the proposed up-voltage works on both circuits. All options include construction on-line that would necessitate an outage, or off-line construction that may have proximity outage implications. The study suggests that each of options A, B and C that include OHL work, will need around three weeks of outages in total to achieve the outcome, however this is based on assumptions in relation to proximity, i.e. to allow construction of towers in option B and cable sealing end compounds in option C, and also works associated with the up-voltage works.

The construction implications of option D are that unless EirGrid can identify space for the non-outage based development of 400kV bay(s), then extended outages on the existing 220kV circuits will be required to enable the replacement of Air Insulated Switchgear.

The study area contains a road network which should make delivery of construction materials and plant reasonably straightforward for each of the options, however temporary roads will be required to each construction site other than within the Maynooth substation.

4.1.4 Environmental

OHL based options are considered to have the lowest environmental impact although this will be affected by the number of new towers required to achieve a solution. As a result of the up-voltaging all towers will increase in height and therefore impose a greater visual impact with option D having greatest effect as no (or few) towers will be removed. Cable option C is considered to have the greatest overall impact due to the potential effects in biodiversity, soils and water.

4.1.5 Socio-economic

All of the options are considered to have a low social impact.

4.2 Criteria Assessment

The feasibility assessment for these options, in accordance with EirGrid criteria, is presented in table 4.

The effect on each criteria parameter is presented along a range from “more significant”/”more difficult”/“more risk” to “less significant”/”less difficult”/“less risk”. The following scale is used to illustrate each criteria parameter:

More significant/difficult/risk Less significant/difficult/risk

Assessment Criteria	A. Online towers	B. Offline towers	C. Cable connection	D. Substation connection
Technical Performance				
Economic Performance				
Deliverability				
Environmental				
Socio-economic				
Combined Performance				

Table 4. Criteria assessment

OHL based options A and B are considered technical less complex than the alternative options C and D and are also considered economically beneficial in terms of construction costs.

Option A would be constructed to ensure that the final configuration was entirely in accordance with the EirGrid functional specification, while option B could include site-specific or non-standard arrangements and therefore the potential for increased risk during subsequent maintenance.

Option D offers EirGrid the opportunity to enable the connection within the boundary of the existing substation and could offer future proofing options and flexibility for future 400kV development at Maynooth, however there would be increased complexity of operation within the substation.

The subsequent maintenance costs of the OHL based options are also likely to be less on the basis that cable and substation technologies are more complex and individual components such as underground cable and cable sealing ends more expensive to repair or replace.

5. Conclusions

Four options have been considered in relation to achieving a cross-connection at Maynooth. Use of standard towers designs is proposed for each of the options although re-use of existing or upgraded towers may require additional assessment to confirm compliance with the EirGrid functional specification.

An assessment of the presented options has been made using the EirGrid colour coding system which ranges from high risk (dark blue) to low risk (cream). The outcome of this being that:

- The OHL options A and B are considered economically advantageous, technically less complex and environmentally favourable,
- The cable option C is considered more complex and expensive than either of the alternative OHL options due to the additional land, materials and components required, but may offer flexibility for achieving the connection. Environmentally, option C also is considered to have the largest effect.
- The substation option D is considered more expensive than any of the alternative options and technically the most complex but does potentially allow EirGrid to manage the works entirely within the boundary of the substation. Environmentally, option D also is considered the most visually intrusive.

Three of the options require replacement or additional towers and conceivably cable sealing end compounds therefore use of third-party land not presently occupied by the Transmission Asset Owner (TAO) will be required for all but the substation option. Agreements will therefore be required with landownerships not currently occupied with TAO assets.

As no records of existing assets have been provided for the study, or site investigation data to confirm the geotechnical conditions, the type of tower foundations required in the study area cannot be confirmed but could reasonably be estimated from records of existing tower foundations in this area.

On the basis that the OHL will be constructed in accordance with the EirGrid functional specification LDS-EFS-00-001-R0, then a 2 × 600mm² ACSR (Curlew) conductor system will be employed by EirGrid on each of the options with OHL content.

As land use in the study area appears to be largely agricultural, there are no obvious clearance issues, however clearances will need to be confirmed in accordance with EirGrid functional specification LDS-EFS-00-001-R0 section 6.4.

Overall, the environmental and socio-economic factors associated with the options under consideration in the study area are considered to be low impact/risk.

The study area contains a road network which should make delivery of construction materials and plant reasonably straightforward for each of the options, however temporary roads will be required to each construction site other than within Maynooth substation.

Overall, the best performing technical option is considered to be an OHL based solution however it is presently unclear whether option A or option B has a clear advantage. Option A will provide EirGrid with new towers constructed in-line with the existing upgraded circuits and therefore assets in accordance with the functional specification and with no site-specific design being required, while option B offers some economic efficiencies in relation to option A but could result in assets that are not entirely in accordance with the functional specification or which require site-specific maintenance procedures. The determining factors could be the number of new towers required to achieve a solution and the outage implications of the proposed up-voltage works, as these will establish whether there are any construction programme or operational implications and consequently any economic advantages that can be gained that are not presently evident.