Final Step 3 Report

The East Meath to North Dublin Network Reinforcement Project

Capital Project 1021

August 2022

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Revision Table:

Revision	Issue Date	Description
01	17 June 2022	Draft
02	05 July 2022	Review and incorporation of comments provided to Rev 1 by the CFT
03	15 July 2022	Second review of comments incorporated
04	01 August	Remaining comments resolved

1 Table of Contents

2 Introduction

The East Meath to North Dublin Network Reinforcement Project (Capital Project 1021) is a reinforcement of the electricity network between Woodland 400 kV substation in County Meath and Belcamp 220 kV or Finglas 220 kV substation in County Dublin.

The need is based on two drivers - identified in the Tomorrow's Energy Scenarios (TES) 2019[1], in the Shaping Our Electricity Future Roadmap[2] published in 2021, and in subsequent studies carried out since to re-confirm the need - namely integration of generation and an increase in demand on Irish East Coast. A review of the needs in Step 3 has shown that the previously identified drivers still remain and have further increased the need to strengthen the transmission network between either Finglas or Belcamp and Woodland substations, and that the need for the reinforcement is still valid and robust.

This report describes the outcome of various assessments with regards to identified options for the project as well as presents the results that underpin the identified best performing option.

EirGrid follows a six-step approach when we develop and implement a solution to any identified transmission network problem. This six-step approach is described in the document 'Have Your Say' published on EirGrid's website[3]. The six steps are shown below. Each step has a distinct purpose with defined deliverables.

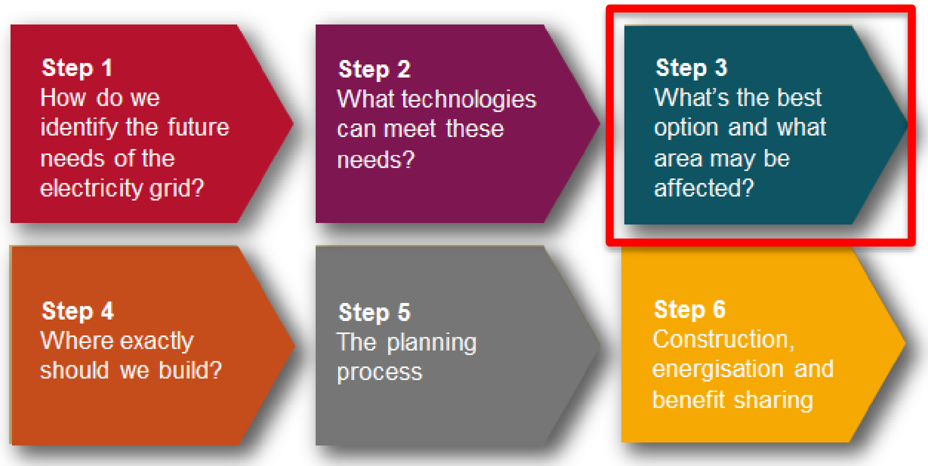

Figure 1 High level description of EirGrid's Project Development Process

[1] Tomorrow's Energy Scenarios (TES, 2019) presents credible pathways for Ireland's clean energy transition with specific focus on what this means for the electricity transmission system over the next twenty years. The report is available on our website: https://www.eirgridgroup.com/customer-and-industry/energy-future/

[2] https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping_Our_Electricity_Future_Roadmap.pdf

[3] https://www.eirgridgroup.com/__uuid/7d658280-91a2-4dbb-b438-ef005a857761/EirGrid-Have-Your-Say_May-2017.pdf

At the time of writing this report, this project is coming towards end of Step 3 of EirGrid's six step approach shown above. This report was initially written before the conclusion of Step 3 in June 2022.

The purpose of this report is to document the decision making and the analysis that was undertaken to date, which has informed decision making during the Step 3 process and which underpins the governance approval to proceed.

Following the successful conclusion of this Step 3, the project will enter Step 4, where further investigation, analysis, and assessment of the various underground cable route options, from Woodland 400 kV substation in County Meath and new 400 kV infrastructure at the existing Belcamp 220 kV substation in County Dublin, will be undertaken. As this report concludes, this is the Best Performing Option.

The process followed in Step 3 along with the activities undertaken to get us to here are described in Section 4.

A summary of the options review and the evaluation of the four options are outlined in Section 5.

The detailed assessment for each option can be read in Sections 6-9 followed by a conclusion in Section 10.

In Step 3, the process activities reference some terminology which will be used throughout this report. For clarity, these terminologies and expressions are introduced and listed below:

<u>Emerging Best Performing Option (EBPO)</u>

This is the option that emerged as the best performing option in Step 3 following the feasibility studies and which was taken forward for a period of public information campaign, in terms of the choice of technology and end node substations.

<u>Public Awareness Raising of the EBPO</u>

We held an awareness campaign on the EBPO for 8 weeks in May and June 2022. This period allowed for stakeholders and communities to be informed about the EBPO and any possible alternatives.

<u>Consideration of feedback</u>

Any feedback received throughout the awareness raising period will be carefully considered and will inform the activities to be carried out in Step 4 which will include a 12-week consultation period for local communities and other stakeholders on the route options, currently scheduled for the Autumn 2022.

Best Performing Option (BPO)

The Best Performing Option is identified at the end of Step 3 and documented in this report, Final Step 3 report. It is then approved for progression to the next step. In this case this is the underground cable route option, identified in this report, which will be taken forward for further investigation and development into a planning application for review and decision (in Step 5) by the relevant consenting authority and further on toward detailed design, construction, and energisation (in Step 6).

2.1 External professional assistance with the assessment

In Step 3 we assessed the various options against five criteria; these are described further in section 4. The assessments and investigations in relation to the environmental and socio-economic criteria as well as some technical feasibility studies have been carried out by external parties. Where relevant, this is highlighted in this report and the referenced reports are named and a summary of the findings is presented.

Jacobs[4] assessed the environmental and socio-economic criteria and conducted certain technical feasibility studies. PSC[5] carried out the technical cable integration study. The detailed assessment reports can be found on our website[6].

[4] Jacobs Ireland Ltd
[5] PSC Ireland
[6] https://www.eirgridgroup.com/the-grid/projects/cp1021/the-project/

3 The Project

3.1 Confirmation of the Need

CP1021 is a proposed electricity transmission development project that will help strengthen the grid to facilitate increased demand in East Meath and north Dublin and variability in generation output in Dublin. This section provides a summary of the need; the detailed report is available on our website[7] together with reports from previous steps.

The need is based on two drivers - identified in the Tomorrow's Energy Scenarios (TES) 2019[8], in the Shaping Our Electricity Future Roadmap[9] published in 2021, and in subsequent studies carried out since to re-confirm the need - namely integration of generation and an increase in demand on Irish East Coast. A review of the needs in Step 3 indicates that the previously identified drivers still remain and have further increased the need to strengthen the transmission network between either Finglas or Belcamp and Woodland substations, and that the need for the reinforcement is still valid and robust.

A significant number of Ireland's electricity generators are located in the South and South-West regions of the country. This is where many wind farms and some modern, conventional generators are located. This power needs to be transported to where it is used. The need is also present when planned offshore wind generation facilities connect on the East Coast. The project is essential to enable the further integration of renewable energy in line with government policy. The Government's Climate Action Plan sets a target to connect 3.5 GW of offshore wind by 2030. Once connected to the transmission system, this offshore power will have to be transported around the network to where it is required for use.

It will also be a key enabler in meeting the growing demand for electricity in the east region, by improving the capacity of the network in this region. The forecasted growth within the region is due to increased economic activity and the planned connection of new large-scale energy users.

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[7] https://www.eirgridgroup.com/the-grid/projects/cp1021/related-documents/

[8] Tomorrow's Energy Scenarios (TES, 2019) presents credible pathways for Ireland's clean energy transition with specific focus on what this means for the electricity transmission system over the next twenty years. The report is available on our website: https://www.eirgridgroup.com/customer-and-industry/energy-future/

[9] https://www.eirgridgroup.com/site-files/library/EirGrid/Shaping_Our_Electricity_Future_Roadmap.pdf

When the transmission system is experiencing generation and demand patterns that lead to high volume power flows on the existing corridor of transmission circuits between the Woodland substation and the Corduff, Clonee, Finglas and Belcamp substations, the system analysis indicates that the network experiences significant violations of the Transmission System Security and Planning Standards (TSSPS)[10]. The TSSPS is the standard which the transmission network should adhere to so that a reliable and secure electricity system can be provided for all customers in Ireland.

3.2 Options considered

All options involve a transmission network reinforcement centred on strengthening the network between Woodland 400 kV substation in County Meath and the existing Finglas 220kV or Belcamp 220 kV substations in County Dublin.

Four solution options were brought forward from Step 2[11] (reduced from seven options in Step 2) for more detailed analysis in Step 3. They represent two different technologies to connect Woodland 400 kV substation and either Belcamp 220 kV substation, or Finglas 220 kV substation, namely:

- Overhead line (OHL); and
- Underground cable (UGC)

The four options that have been assessed in Stage 3 as part of the options review are:

1. New Finglas – Woodland 400kV overhead line (OHL)
2. New Finglas – Woodland 400kV underground cable (UGC)
3. New Belcamp - Woodland 400kV overhead line (OHL)
4. New Belcamp - Woodland 400kV underground cable (UGC)

3.3 Project Study Area

The original Project Study Area was defined in Step 2 as the area investigated for the possible installation of any of the four options in Step 3.

[10] https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf
[11] For details of Step 2 outcome and documents please refer to our website. https://www.eirgridgroup.com/the-grid/projects/cp1021/related-documents/

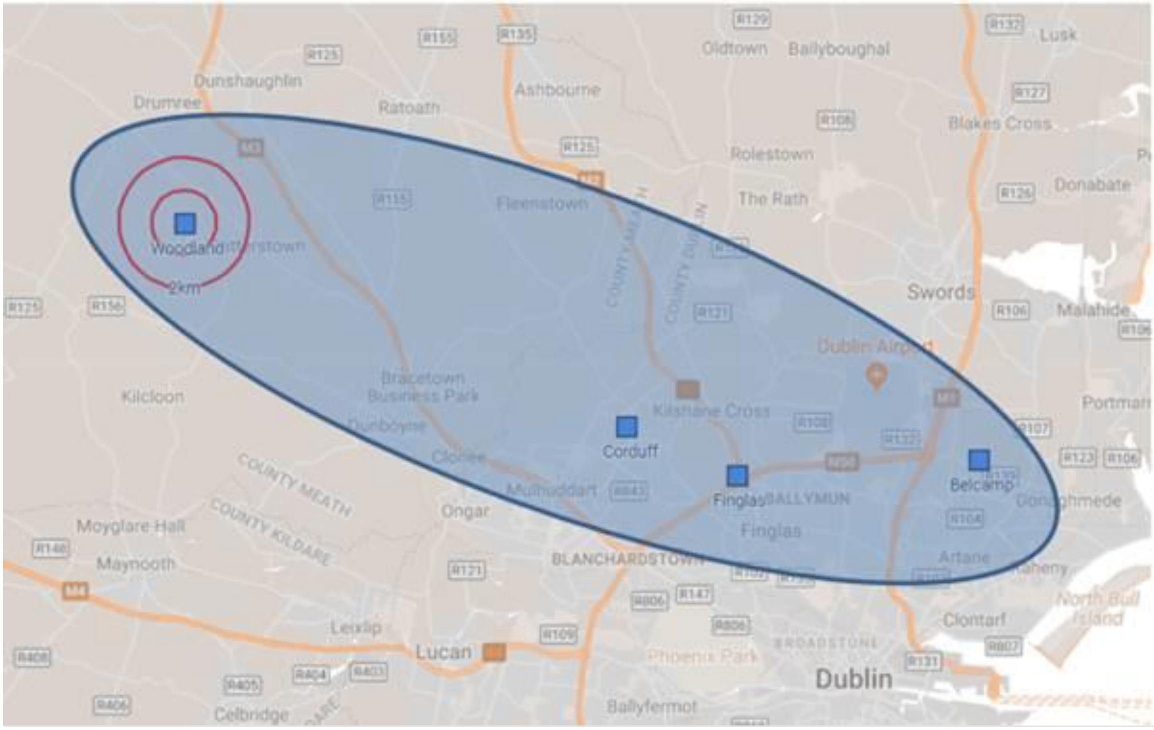

Figure 2 Step 2b Study Area

In defining the Study Area for this particular project, regard was paid to the M50 corridor and the highly urban and built-up area south of it; Dublin International Airport; significant towns and settlements such as Dunboyne, Blanchardstown, Swords and Malahide; environmental constraints such as Malahide Estuary; and the need to take the shortest and straightest route possible and to stay within the public road network wherever possible for the underground cable.

During Step 3, the area south of the M50 has been removed as this was not considered feasible for a variety of reasons including the proliferation and density of existing utilities residential and industrial buildings and the significant disruption of traffic flows and congestion that would likely occur during construction. Similarly, the area south of the N2 has been disregarded where it encroaches on the M50 for the same reasons. The M50 itself has been omitted, given that it is a protected road route[12] which would not be feasible for accommodating grid infrastructure. To the north, Dublin International Airport and its exclusion zone would impact an OHL route; for this reason, the towns of Swords and Malahide were included in the Step 3 Study Area so that the feasibility of bringing an OHL between Swords and Malahide could be investigated.

[12] Roads Act 1993 - https://www.irishstatutebook.ie/eli/1993/act/14/section/45/enacted/en/html

Figure 3 Step 3 Study Area

As part of Step 3, the Study Area has been further refined by considering a wide variety of factors. These included stakeholder and community feedback as well as technical requirements of the project, road network presence, settlements, presence of existing electrical utilities, physical constraints e.g., motorway, river or rail crossings and environmental constraints.

To ensure that a comprehensive and accurate environmental and social appraisal is carried out, a wider perspective is often needed for particular topics of relevancy (e.g., Natura 2000 Sites which may be located beyond the study area but are connected). The assessment of the project will cover all likely significant environmental impacts whether they occur inside the study areas or outside of it.

The study area for this project was further refined in March 2022 as a result of the feasibility studies and assessments. Option 4 – Woodland to Belcamp 400 kV UGC was identified as the Emerging Best Performing Option and study area refined as shown in below:

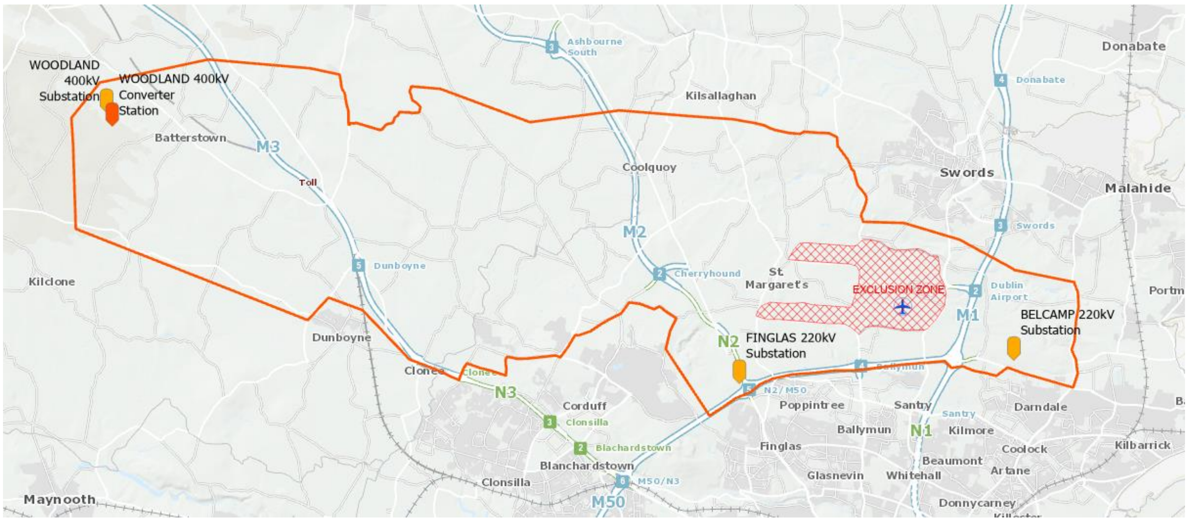

Figure 4 CP1021 refined study area after decision was made to progress with Option 4

3.4 Stakeholder Engagement

The aim of Step 3 Stakeholder Engagement was to present the Emerging Best Performing Option for this grid development project, namely a 400kV underground cable circuit from Woodland substation near Batterstown in County Meath to Belcamp substation near Clonshaugh in north Dublin to all stakeholders within the chosen study area and to outline the rationale that led to this decision. The purpose of this Step 3 engagement was to:

- Provide information about the project to date so stakeholders could provide informed feedback;
- Understand any issues of public concern around the project;
- Ensure local communities understood potential benefits of the project;
- Learn more about the local area;
- Identify potential issues that could restrict options in the study area;
- Set up engagement methods for future engagement, e.g. an East Meath-North Dublin Grid Upgrade Community Forum.
- Inform stakeholders of the 12-week consultation period that will occur in September - November 2022.

Step 3 Stakeholder Engagement was completed by way of an 8-week awareness and engagement campaign that took place from 4th May – 29th June 2022.

An array of activities were carried out in order to promote the engagement process and raise awareness of the project:

- Email correspondence to local authorities, councillors, TDs, public participation networks, chambers of commerce and local stakeholders;
- Bespoke letter drop to over 10,000 residents within the study area outlining information about the project and how stakeholders could find out more;
- Campaign advertising took place through print media, including Meath Chronicle, The Herald, Irish Daily Mirror, The Star, Dublin Gazette and the Dublin People;
- Radio advertising took place on LMFM, Radio Nova and Sunshine;
- Digital advertising took place on digital hubs in various locations including Applegreen and SuperValu's; and
- Online digital media advertising took place on platforms including Facebook, Instagram and twitter.

In-person engagement activities included:

- an open day at Swords County Hall where members of the public dropped in to learn more about the project;
- attendance at the Fingal Public Participation Network (PPN) Plenary meeting where over 80 community organisations were in attendance;
- a presentation to members of Fingal PPN linkage groups, these are thematic networks where local community organise advocacy around thematic issues important to them;
- door-to-door engagement in the vicinity of the two substations at Woodland and Belcamp; and
- several information days at locations within the project study area., namely Tyrrelstown, Kinsealy Garden Centre, St Margaret's GAA Club, Dunboyne, Kilbride, Airport Road in Fingal and Batterstown, Co Meath.

A webinar was held to provide a project update to attendees and offer the opportunity to engage in a Q&A session with the project managers on this grid development project.

In addition to raising awareness about the project development specifically, this campaign also raised awareness about the commencement of an East Meath-North Dublin Grid Upgrade Community Forum and the associated Community Benefit scheme that goes hand in hand with grid development projects at EirGrid. An information evening was held for the 14th of July, at which all stakeholders with an interest in joining the community forum were updated about the project and updated on the purpose, benefits and scope of the Community Forum. Expressions of interest for the community forum were invited during the period 4th July until 29th July.

Feedback received throughout the engagement period included;

- Concerns raised about potential disruption to lives and businesses.
- Road closures.
- Impacts on the environment, on Dublin Airport, and on other EirGrid projects in the area.
- Satisfaction regarding the early engagement with the public ahead of the Step 4 consultation and staff knowledge during in-person engagement.
- Support for the decision to route the cables underground and for the route to be road based.

The feedback from this awareness campaign has informed the overall direction of this grid development project and will be reflected in the route options that will be presented as part of the 12-week consultation period that commences in September 2022.

4 Process and multi-criteria applied

4.1 Description of process

As previously outlined, EirGrid assesses the performance of each of the options against five set criteria (Technical, Economic, , Deliverability, Environmental, Socio-Economic), and a multi-criteria performance matrix is used to compare the options against each other. Section 5 of this report details the outcome this assessment.

4.2 Criteria used for comparison of options

In line with EirGrid's roles and responsibilities, we have an obligation to develop a safe, secure, reliable, economical, and efficient electricity transmission system while having due regard for the environment of Ireland. In our decision making, these fundamentals are captured in the five criteria listed below. In addition, our decision-making process also provides for public participation and stakeholder engagement and deliverability aspects.

In Step 3, we considered a broad assessment of performance for each of the identified options. The broad assessment considered five different criteria that ensure that the full range of impacts and benefits of each option can be appropriately understood.

All of the five criteria are important when considering the options in the assessment and establishing the Best Performing Option. The options were assessed on an equal basis with no weighting applied for any of the criteria. We have also taken on board experience from other projects where applicable.

These five criteria are:

- Technical performance;
- Economic performance;
- Deliverability aspects;
- Environmental aspects; and
- Socio-economic aspects.

Descriptions of the five criteria are provided below. The assessments undertaken for each option in Step 3 were for comparative purposes between the options and are not absolute assessments of the individual options.

4.2.1 Technical performance criteria

The technical performance criterion includes seven sub-criteria. Descriptions of these are provided below.

- Compliance with health and safety standards

  Regardless of the technical option chosen, it will be designed, constructed, and maintained in accordance with applicable Irish and EU health and safety regulations and approved codes of practice. In undertaking a project, we are at all times aware of, and comply with, the applicable health and safety legislation, approved codes of practice and industry standards and all subsequent modifications or amendments in relation to same.

  The solution option should comply with relevant safety standards such as those from the European Committee for Electrotechnical Standardisation (CENELEC). Materials should comply with IEC or CENELEC standards.

- Compliance with EirGrid Security and Planning Standards

  The solution option should comply with the network reliability and security standards defined in the Transmission System Security and Planning Standards (TSSPS) and the Operation Security Standards (OSS)[13]. All options investigated will meet the minimum technical requirements set out in the above standards. Options which extend or enhance technical performance margins beyond minimum acceptable levels are favoured over others.

  To be able to distinguish between the individual technical performance of each solution option, the options are assessed against three main technical criteria. A short description of these is given below. The technical criteria are based on the previous technical criteria used in the Step 2B report[14] and relate to the need identified. The criteria are thermal overload and performance during maintenance conditions. It should be noted that in Step 2B, we also investigated short circuit performance.

  For the analysis in Step 3, we have not assessed the short circuit performance of the solution options as it was found in Step 2B that all of the options have very

[13] EirGrid, Operational Security Standards, 2021 (https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_Operating-Security-Standards_2021.pdf)

[14] https://www.eirgridgroup.com/site-files/library/EirGrid/CP1021-draft-Step-2-Part-B-Options-Report_Website_Version-Signing-page-removed.pdf

similar outcomes, and the short circuit performance will not be the deciding factor between the options.

The reactive support requirements have been assessed in cable integration studies that assess the specific impact that cables will have on the network and the mitigation required to remain within TSSPS limits.

Thermal overload criteria

The options are assessed for compliance with the TSSPS. For this technical criterion, we have assessed the options based on how they reduced or removed the forecasted thermal overloads on the network between East Meath and the North of Dublin. This will provide an indication of how the options are performing in terms of adding thermal capacity.

Performance during maintenance conditions

The options are assessed based on the remaining network congestion in the area of interest following a subsequent loss of plant and equipment whilst another is out for planned maintenance. This is used as an indicator of the benefit of an option in terms of minimising generator constraint during planned outages, or an indicator of future additional network reinforcement requirements.

For the purpose of this assessment in Step 3, we have only assessed the number of indicated violations of thermal capacity for each option and these possible additional reinforcements are not included in the full solution list of the options.

- Reliability performance

The technologies and equipment associated with the different options have different performance and reliability characteristics. The reliability of transmission infrastructure is associated with two categories or type of outages, namely unplanned outages and planned outages. Each technology or type of equipment is associated with faults (unplanned outages) that routinely occur. These can be represented as average failure rates usually expressed as unplanned outages/100km/year.

This criterion will also account for the mean time to repair. This is the time taken to return the equipment to service after a fault has occurred. The assessment has been based on transmission performance statistics[15] or industry standard reliability data.

This sub-criterion will also assess the typical time the options would be unavailable for during planned outages. Planned outages are normally associated with annual routine maintenance and will be based on typical outage durations taken from maintenance policies. The reliability for each option will be based on a combination of the above type of outages. The reliability of the station equipment associated with the options is assumed to be the same for all options and is therefore not included in this analysis.

- Headroom

  This criterion assesses the ability of each option to accommodate increases in large scale demand growth in the Dublin and mid-east region, and replacement of thermal generation located in Dublin with increased renewable generation in the west and south of the country.

  Each option is compared relative to the others to determine the increase in demand, or renewable generation outside Dublin, that can be accommodated without further network reinforcements being required. The limit for each option can be found by increasing large scale demand in Dublin and renewable generation in the south and west until a voltage stability limit is reached.

  The headroom for each option is the difference between the demand that can be accommodated by the network with that option included and the demand that can be accommodated by the network with no option included.

- Expansion or extendibility

  This considers the ease with which the option can be expanded, i.e., it may be possible to uprate an OHL to a higher capacity or a new voltage in the future. It will also consider the rating or capacity of the options.

- Repeatability

  This criterion examines whether this option can be readily repeated in the Irish network. One-off or bespoke solutions carry additional system integration, operational, and maintenance complexity. For example, an OHL option is very repeatable, but a fully or partially underground cable option is less repeatable as there may be harmonic filter and reactive compensation requirements that are

[15] Analysis of System Disturbances 2018, EirGrid, April 2019

bespoke for each option. The amount of cable that can be integrated in certain parts of the network may also be limited.

- Technical operational risk

  This criterion aims to capture the risk of operating different technologies on the network. It will consider if the option requires special procedures when energising or switching in the network. An example would be long cables which may require reactive compensation and special procedures when energised to prevent technical issues in the network.

4.2.2 Economic performance criteria

The economic appraisal we conduct as part of the Multi Criteria Assessment assesses the relative overall cost performance of the various options which meet the TSSPS and the impact on overall costs of production in meeting the demands on the system – it does not seek to replicate the economic trade-offs which have already been considered within the TSSPS itself.

The TSSPS, in driving new investment in transmission reinforcements, recognises that the economic cost to society of not preserving the security of supply standards defined by the TSSPS (N-1 etc.) is greater than the cost of maintaining such a standard. The TSSPS reflects the explicit and implicit economic trade-offs between enhanced security of supply and reduced risk of interruptions on the one hand and additional cost, including the full societal cost, of grid development on the other.

In this context then, the economic assessment described in Step 3 considers costs and benefits associated with each option.

A description of each of the cost criteria is given below.

- Pre-engineering cost

  The pre-engineering cost refers to the cost associated with the design and specification, route evaluation and management of the statutory planning application. The costs are capital in nature and are typically costs incurred by the Transmission System Operator (TSO) in the development of the reinforcement. The cost for the TSO to develop the option is based on experience of developing other current and previous projects.

- Implementation cost

  The project implementation costs are the costs associated with the procurement, installation, and commissioning of the option. The capital cost estimates have been developed with input from the Transmission Asset Owner (TAO) and are based on desktop designs and costings for similar works. The capital cost estimates include all items to achieve a fully compliant solution with Transmission System Security and Planning Standards (TSSPS) and other investment policies, but exclude reinforcements driven by maintenance conditions as discussed in Section 4.2.1.

Where capital costs were not available for a particular technology, the best, most recent estimates or quotes from manufacturers or assumed costs based on EirGrid or international experience have been used. The assumed cost for landowner payments, community fund and proximity payments are included under this cost category, as these costs are typically incurred during the implementation phase of the option.

- Life-cycle cost

  Life-cycle costs refer to the costs incurred over the useful life of the option and include the on-going cost of ensuring that it remains viable for the evaluation period. For the purposes of our assessments, decommissioning of assets is not considered. This criterion includes:

  - Operation and maintenance cost

    These costs are annualised and are based on estimated costs incurred to be able to maintain the option.

  - Electrical losses

    Losses are the electrical energy consumed by the transmission system as it transmits electricity. The more efficient a transmission reinforcement is, the lower the electrical losses it incurs.

    The quantity of electrical losses is calculated for a standard year with each option included in turn and compared with the reference situation without the reinforcement. The losses calculation for a standard year includes assumptions in regard to other plant and equipment being unavailable due to faults or planned routine maintenance.

    During the months between March and October, in any given year, the operation of the transmission system caters for approximately 20 circuits unavailable for various reasons per day. During the winter months, the transmission system has less than five circuits unavailable for various reasons per day.

The calculation has taken these aspects into account to a certain degree and assumed different 220 kV circuits, one at a time, unavailable for a week during the entire maintenance season simultaneously with different 110 kV circuits, one at a time, unavailable for a week during the entire year.

This assumption will provide a better understanding of the benefit in terms of losses that the proposed reinforcements will bring. A cost will be put against the losses incurred for each year during its lifetime following commissioning of the option. For this analysis, the average Day Ahead Market (DAM) price is used to represent the marginal cost of generation and is calculated to be €50.3 per MWh. The figure has been derived from the average Day Ahead Market (DAM) price for 2019, which was sourced from the Single Electricity Market Operator (SEMO) website[16].

- Replacement cost

The standard lifespan of a transmission asset is 50 years, and this is the also the evaluation period for the economic assessment. Assets that have a shorter useful life would have to include the cost of replacement at the end of its useful life and thereafter factor in a residual value equivalent to the depreciated asset value at the end of the evaluation period.

In the economic assessments, it has been assumed that underground cable (UGC) options will have a useful lifespan of 40 years. The assumption is based on research of other utilities internationally. This indicates that there is recognition by some reputable utilities that the useful lives of OHL and UGC may not be the same. There isn't consensus about what the useful lifespan of UGCs could be and it may be dependent on differences in environmental conditions, duty cycle and operational use, installation choices etc. The cost of replacement is taken to be precisely the same as the project pre- engineering cost and project implementation cost.

A description of the benefit criteria is provided below.

- Socio-economic welfare:

The benefits arising from transmission reinforcement project will usually be avoided costs. The value of some of these avoided costs is difficult to measure, especially in terms of beneficial contributions to society and the

[16] https://www.semopx.com/news/market-summary-2019-repor-1/

country's welfare and economy. Benefits in relation to the transmission system and its operations only have been taken into account in this assessment. In this case, the benefits refer to the difference in production cost savings between the system with the reinforcement option and the system without the reinforcement.

The transmission system operational benefit can be measured by the amount of generation that is not constrained due the lack of transmission capability of the existing infrastructure. The benefit is therefore expressed as savings in generation costs due to the enhanced transmission capability. The constraints calculations are a result of annual market simulations. The simulations optimise the generation dispatch required to meet the electricity demand while taking into account the power carrying capability of the transmission system and contingencies.

The calculation of the production cost savings for each option is based on the assumption that each MW produced by a generation unit that can't be exported due to a capacity constraint in the transmission network has to be procured elsewhere from another generation unit. The buying and selling of electricity is facilitated by the Single Electricity Market in order to meet the electricity demand in the All-Island electricity system.

On a very high level, the market is operated on the basis that the most efficient (cheapest) generation unit should be generating at any given time to reduce the electricity price. When the most efficient units are constrained due to a capacity constraint in the transmission network, a more expensive generation unit will be used to supply the electricity required. This will incur a higher cost in the operation of the system and market.

Transmission reinforcements will address network constraints and as such will help to reduce cost incurred. The project benefit can be expressed as expected annual savings of generation costs in the All-Island system depending on the respective option. For the estimate of annual savings in generation costs the hourly marginal generation costs are used from the simulations carried out.

- Cost to the Single Electricity Market

  This criterion will take account of the impact of the cost to the electricity market for the periods where the reinforcement option is not available. The technologies and equipment associated with the different options have different performance and reliability characteristics. The reliability of transmission infrastructure is associated with two categories or type of outages, namely unplanned outages, and planned outages. The reliability performance criterion was described in Section 4.2.1 and will be used in combination with the calculated production cost benefits described in Section 4.2.2 to represent the cost to the Single Electricity Market for each option.

The robustness of each option's economic performance is also considered as part of the economic assessment. The robustness test considers two different aspects, namely:

- Least worst regrets

  To assess the robustness of each option's economic performance, 'Least Worst Regret' (LWR) analysis is carried out. This will indicate if some options perform better or worse under different future energy scenarios.

- Sensitivity analysis

  In addition, the options' sensitivity to changes in the reference parameters (implementation cost, WACC and Benefits) are assessed and taken into account.

4.2.3 Deliverability

In Step 3, the deliverability performance criterion includes a number of sub-criteria. A short description of these is provided below.

- Implementation timelines

  This criterion assesses the length of time required for each option to progress through each phase (including pre-consenting, consenting, pre-engineering (detailed design) and implementation (construction) up to project energisation). This will include timelines starting from Step 4, where the process will identify the exact location of the development. It assumes planning consent times or other permissions required, with the assumption of no unreasonable delays and/or potential judicial review.

- Project plan flexibility

  This criterion assesses the flexibility of the project plan to include for issues arising during pre-planning conceptual design, post-planning design, consenting and construction.

- Risk of untried technology

This criterion assesses any aspects (positive or negative) and risks each technology option may have including if the technology has been used in the past internationally or on the Irish transmission network.

- Dependence on other projects (outages)

  This criterion assesses dependence on completion of other projects and outage length required to implement the option. It also considers general inter-dependence with other projects, including in terms of multi-project programme sequencing.

- Supply chain constraints, permits, wayleaves

  This criterion assesses any constraints (e.g., small number of suppliers in Ireland or internationally) that would affect the procurement of materials or services (e.g. cable laying vessels waiting list lead time) to complete the project. This criterion also assesses the complexity and challenge in respect of various permissions and consents required, including the potential risk to achieving statutory consent(s) without reasonable delay (having regard to environmental and other impacts), the potential level of public interest, and the potential for Oral Hearings, considered potential for Judicial Review.

  This criterion also addresses the complexity and challenge of obtaining community and landowner “social licence” to construct an option, including securing access to land for pre-application survey, and obtaining post-consent wayleaves/easements.

4.2.4 Environmental

This criterion is assessed to identify and describe the types of environmental constraints that are most likely to be affected by the construction and operation of the identified solution options. It is based on a review of publicly available datasets, information gathered from County Development Plans (CDP) and Local Area Plans and mapping from state agencies such as the National Parks and Wildlife Service (NPWS) and the Environmental Protection Agency (EPA).

This assessment was carried out by Jacobs and a summary of its findings are presented in this report. Jacobs’ detailed report (CP1021 Environmental Constraints Report)

The environmental constraints have been organised into the following topics to aid understanding and presentation of the assessment findings:

- **Biodiversity**: Assessment of the potential impacts on protected sites for nature conservation, habitats and protected species.
- **Soils and Water Impacts**: Potential impact on soils and geological features (geology, Irish geological heritage sites, etc.) and water (water quality of surface waters and groundwater);
- **Planning Policy and Land Use**: Impact on land use (forestry, farmland, bogs/peats, horticulture);
- **Landscape and Visual**: Assessment of landscape constraints and designations and the potential impact on visual amenity; and
- **Cultural Heritage** (Archaeological and Architectural Heritage): The potential for impacts on the cultural heritage resources.
- **Noise and Vibration**: Assessment of the potential impact of noise and vibration during construction and operation.
- **Climate Change**: Potential impact of climate change on the asset.

These topics have been selected as they are the most likely to represent the key considerations, constraints, risks, and opportunities for the project.

Only environmental constraints are described in this criterion; the socio-economic constraints are described under the socio-economic criterion. It is acknowledged that there is potential for environmental issues to result in socioeconomic effects; this is particularly the case for potential effects on amenities of local communities which could be adversely affected by noise, views and traffic. Notwithstanding this interrelationship, this criterion does not consider amenity effects; these are presented in the socio-economic criteria.

4.2.5 Socio-Economic

This criterion is assessed to identify and describe the social issues and their potential impacts within the study area(s) that are most likely to be affected by the construction and operation of the identified solution options. This assessment was carried out by Jacobs and a summary of its findings are presented in this report. Jacobs' detailed report (321084AE-REP-003 – CP 966 Strategic SIA Scoping Report) is available on our website – see Section 2.1 for the link.

The assessment is based on a number of data sources, such as County Development Plans, Census 2016 Data, Central Statistical Office (CSO.ie), National datasets from Prime 2 (Ordnance Survey Ireland's central database of spatial information) and some of the other findings from the investigation carried out by Jacobs as part of its assessment.

The social issues considered have been organised under particular topics to aid understanding and presentation of the assessment findings. These topics have been selected as they are the most likely to represent the key considerations, constraints, risks and opportunities for the project. Other criteria such as Land Use and Cultural Heritage are assessed under the environmental criterion.

- **Traffic & transport**: This considers potential effects on traffic and transport in the study area, during the construction phases of the different solutions. Of concern to communities is the potential for severance, isolation and significant delays during the construction phase. Also considered in this topic are potential effects on the crossings of major roads, railways and navigable waterways if relevant
- **Amenity**: Here 'amenity' is the term used to describe the overall pleasantness or attractiveness of surroundings. This includes effects on local communities, community facilities, local businesses and recreation and tourism assets. This builds on the work in the 321084AJ-REP-004Environmental Constraints report compiled by Jacobs.
- **Health**: To determine potential effects on humans, this considers amenity effects as well as considering WHO health thresholds; EMF is considered as set out in EirGrid's Guidelines[17];
- **Economy**: Effects on the regional and local economy;
- **Utilities**: Consideration of third-party assets, including telecommunications and aviation.

4.3 Scale used to assess each criterion

The colour-code scale below is used to illustrate the performance of each criterion. The assessment is carried out by specialist EirGrid personnel who considers evidence from a number of data sources in making the evaluation; in this case Jacobs have assisted by carrying out feasibility studies to assess and compare the various options against the multi-assessment criteria. The assessments undertaken for each option in Step 3 are for comparison against each other and are not absolute assessments of the individual options.

The effect on each criterion parameter is qualitatively determined using expert judgement and experience. This is presented by means of colour coding, along a range

[17] http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-The-Electricity-Grid-and-Your-Health.pdf

from “more significant”/”more difficult”/“more risk” to “less significant”/”less difficult”/“less risk”.

The below illustration shows the colour coding applied to each option when assessing the five criteria:

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

In the text, this colour-coded scale is qualified by text comprising:

- Low (Cream);
- Low-Moderate (Green);
- Moderate (Mid-level) (Dark Green);
- Moderate-High (Blue);
- High (Dark Blue).

Figure 5 Colour coding applied to each option

5 Option Evaluation Summary

In Step 3, the short-listed options, described in Section 3.2, are further analysed and assessed. Each short-listed option has been assessed against the five criteria and sub-criteria, which are outlined in Section 4 of this report.

The summary of this multi-criteria assessment is presented in this section and outlines the rationale for the Best Performing Option (BPO). Further detail on each option is provided in Section 6.

5.1 Best Performing Option based on the multi-criteria assessment

Table 1 provides a summary of the performance of each option against the five evaluation criteria and the resulting overall combined performance. The detail of the performance of each option for each criterion is contained in sections 6 this report.

Based on the multi-criteria assessment, Option 4, New Belcamp – Woodland 400kV underground cable, is the Best Performing Option.

	Option 1 Woodland – Finglas OHL	Option 2 Woodland – Finglas UGC	Option 3 Woodland – Belcamp OHL	Option 4 Woodland – Belcamp UGC
Technical Performance				
Economic Performance				
Deliverability				
Environmental				
Socio-Economic				
Combined Performance				

Table 1 Overall comparison of options applying the multi-criteria assessment in Step 3

Options 1 and 3, representing the 400 kV OHL options from Woodland 400 kV substation to either Finglas 220 kV substation or Belcamp 220 kV substation respectively, perform well from a technical and economic performance perspective.

However, they are considered to have high risk or significant risk and difficulty from a deliverability perspective. This presents risks that would be difficult to mitigate and could have significant impacts on project progress. Therefore, it has been given an overall performance of high (**Dark Blue**) difficulties/risk.

Option 2, the new 400 kV UGC from Woodland 400 kV substation to Finglas 220 kV substation option, performs well from an environmental and socio-economic performance perspective. Option 2 may face considerable technical and deliverability risks which would be difficult to mitigate and could have significant impacts on project progress. Therefore, it has been given an overall performance of high (**Dark Blue**) difficulties/risk.

Option 4, the new 400 kV UGC from Woodland 400 kV substation to Belcamp 220 kV substation option, performs well from a technical, environmental, and socio-economic perspective and while some deliverability difficulties are foreseen. It is believed these can be effectively mitigated with appropriate design solutions. This option has therefore been given an overall performance of moderate (**Dark Green**) difficulties/risk and is the most preferable option.

5.2 Summary of technical performance of options

All options investigated will meet the minimum technical requirements. Options which extend or enhance technical performance margins beyond minimum acceptable levels are favoured over others. Table 2 shows the technical performance of the various options in relation to the different sub-criteria. This table is also displayed in Appendix 2.

Summary of technical performance all options				
	Option 1 Finglas – Woodland 400 kV OHL	Option 2 Finglas – Woodland 400 kV UGC	Option 3 Belcamp – Woodland 400 kV OHL	Option 4 Belcamp – Woodland 400 kV UGC
Health and Safety Standard Compliance				
Security and Planning Standard Compliance				
Reliability Performance				
Headroom				
Expansion or Extendibility				
Repeatability				
Technical Operating Risk				
Combined Technical Performance				

Table 2 Summary of technical performance of all options

Option 1 and Option 3, the two OHL options, has similar technical performance across all of the sub-criteria, except the Expansion or Expandability sub-criteria. That difference result in a combined technical performance that distinguish the two options in their overall performance with Option 3 having a much better expandability opportunity terminating at the Belcamp 220 kV substation.

Option 2 and Option 4, the two UGC options, has similar technical performance across all of the sub-criteria, except the Headroom and Expansion or Expandability sub-criteria. That difference result in a combined technical performance that distinguish the two options in their overall performance with Option 4 having a much better expandability opportunity terminating at the Belcamp 220 kV substation.

The two UGC options, Option 2 and 4, have some challenges in relation to reliability, extendibility, repeatability and technical operational risk.

The options that terminate at Finglas, Options 1 and 2, each have performed poorly in relation to Expansion and Extendibility due to the limits to expansion of a new 400 kV substation at Finglas and that the existing 220 kV station has no remaining spare bays nor space to develop new 220 kV bays.

5.3 Summary of economic performance of options

The economic performance of each option is a combination of the economic result and a robustness test. All options have costs and savings which are considered in the economic result. A robustness test to check the options' performance for different credible future energy scenarios was also carried out including sensitivity to changes in some reference parameters. Table 3 shows a summary of the economic assessment inputs and resulting economic performance of the various options. This table is also displayed in Appendix 3.

Summary of economic performance all options 2022 values					
	units	**Option 1 FIN OHL**	**Option 2 FIN UGC**	**Option 3 BEL OHL**	**Option 4 BEL UGC**
Pre-Engineering Costs	[€M]	10	10	10	11
Project Implementation Costs	[€M]	114	300	130	396
Project Life-Cycle Costs (Losses)	[€M] pa	46	82	63	108
Project Life-Cycle Costs (O & M) Presented in period of years (1-20), (20-40), (40-50)	[€k] pa	230 337 2623	247 193 247	327 493 2452	286 206 286
Project Life-Cycle Costs (Decommissioning & Replacement)	[€M]	N/A	60	N/A	78
Cost to SEM based on unavailability of reinforcement (TES Scenario used)	[€M] pa	Range 62 to 321	Range 74 to 384	Range -17 to 251	Range -20 to 298
Combined Economic Performance					

Table 3 Summary of economic inputs and performance for all options

Options 1 and 3 have equal best economic performance, with options 2 and 4 having the worst economic performance.

5.4 Summary of deliverability aspects of the options

All options would be challenging to deliver, but for different reasons. Table 4 shows the deliverability performance of the various options in relation to the different sub-criteria. This table is also displayed in Appendix 4.

Option 4 performs the best under the overall deliverability criterion with options 1, 2 and 3 all performing similarly and very poorly.

Option 1 has the worst deliverability performance with this option facing major challenges regarding implementation timelines, project plan flexibility and high dependence on other projects given the highly constrained nature of Finglas substation. Option 2 faces similar constraints at the substation however the underground performs slightly better in regard to flexibility and timelines.

Option 3 faces significant deliverability constraints with timelines and project flexibility given the nature of the study area surrounding the Belcamp area with significant constraints such as the Dublin Airport and Malahide SAC areas.

Option 4 performs the best in the deliverability criterion; however, it still faces some deliverability constraints with the risk of untried technology and project plan flexibility given the proximity to the airport. This option does perform best on implementation timelines and Belcamp substation does not present as many deliverability challenges.

The dark blue rating for deliverability for Options 1-3 suggests significant risks to project delivery and as a result can deem the projects undeliverable. In contrast the potential deliverability challenges relating to Option 4 can be mitigated by appropriate design solutions. Option 4 can therefore be considered viable from a deliverability perspective.

Summary of Deliverability Performance of all Options				
	Option 1 Woodland – Finglas OHL	Option 2 Woodland – Finglas UGC	Option 3 Woodland – Belcamp OHL	Option 4 Woodland – Belcamp UGC
Implementation Timelines				
Project Plan Flexibility				
Risk of untried technology				
Dependence on other projects				
Supply chain constraints, permits wayleaves etc.				
Overall Summary				

Table 4 Summary of Deliverability Performance of all options

5.5 Summary of Environmental aspects of the options

Table 5 shows the environmental performance of the various options in relation to the different sub-criteria. This table is also displayed in Appendix 5.

Summary of Environmental Performance of all Options				
	Option 1 Woodland – Finglas OHL	Option 2 Woodland – Finglas UGC	Option 3 Woodland – Belcamp OHL	Option 4 Woodland – Belcamp UGC
Biodiversity				
Soil and Water				
Land Use (and Planning)				
Landscape and Visual				
Cultural Heritage				
Noise and Vibration				
Climate Change				
Overall Summary				

Table 5 Summary of Environmental Performance of all options

5.5.1 Option 1 Woodland to Finglas OHL

The greatest risks of significant impacts as a result of this option are associated with biodiversity and landscape and views, which have a moderate to high-risk rating. This is as a result of OHLs posing a collision risk to migratory birds, a loss of mature trees and significant impacts on views. This option also has the potential to conflict with local planning policies, impact on the setting of cultural assets and is less resilient to climate change than an underground option would be. As a result, this option has an overall moderate risk of significant impacts on the environment (**Dark Green**).

5.5.2 Option 2 Woodland to Finglas UGC

The greatest risks to the environment from this option are on soil and water, owing to the high number of water bodies in the study area, the likelihood of having to come off-road to cross them in the more rural areas and the number of roadside ditches present. For other environmental aspects, the risks are low to moderate that this option would cause significant impacts; for all topics any risk would be during construction and therefore of a temporary nature. UGC are in accordance with local planning policy ambitions and are more resilient to the impacts of climate change. As a result, this option has an overall low to moderate risk of significant impacts on the environment (**Green**).

5.5.3 Option 3 Woodland to Belcamp OHL

As with Option 1, the greatest risks of significant impacts as a result of this option are associated with biodiversity and landscape and views, which have a high-risk rating. Again, this is as a result of OHLs posing a collision risk to migratory birds, a loss of mature trees and significant impacts on views. However, this option is closer to European protected areas along the coast and migratory routes for birds and is longer so has the potential to impact on more views than Option 1. This option also has the potential to conflict with local planning policies, impact on the setting of cultural assets and is less resilient to climate change than an underground option would be. As a result, this option has a moderate to high risk of significant impacts to the environment overall (**Blue**).

5.5.4 Option 4 Woodland to Belcamp UGC

A number of environmental factors are at a moderate risk of significant impacts as a result of this option; this is because the impacts are similar to those for Option 2 where many of the factors were considered to be at low to moderate risk, however this option is longer and so this increases the risk of such impacts. For soil and water, the greatest risks are as a result of open cut crossing of water bodies and constructing trenches in roads with roadside ditches alongside. These are most likely to occur in the more rural western part of the study area and are of a similar magnitude to those identified for Option 2. The risk to soil and water remains moderate. For all topics any risk would be during construction and therefore of a temporary nature. UGC are in accordance with local planning policy ambitions and are more resilient to the impacts of climate change. As a result, this option has an overall moderate risk of significant impacts on the environment (**Dark Green**).

5.6 Summary of Socio-Economic aspects of the options

The assessment in this criterion has not considered the feedback from the consultation and stakeholder engagement, as this process has not yet been concluded. Table 6 shows the socio-economic performance of the various options in relation to the different sub-criteria. This table is also displayed in Appendix 6.

Summary of Socio-Economic Performance of all Options				
	Option 1 Woodland – Finglas OHL	Option 2 Woodland – Finglas UGC	Option 3 Woodland – Belcamp OHL	Option 4 Woodland – Belcamp UGC
Traffic & Transport				
Amenity				
Health				
Economy				
Utilities				
Overall Summary				

Table 6 Summary of the Socio-economic performance of all options

5.6.1 *Option 1 Woodland to Finglas OHL*

The greatest risks from a socio-economic perspective from this option are to amenity. Risks to the economy and utilities are low; Traffic and Transport and health risks are considered to be low to moderate. The risk to amenity is as a result of the significant impacts an OHL would have on landscape and views. As a result, this option as a moderate risk of significant impacts from a socio-economic perspective (**Dark Green**).

5.6.2 *Option 2 Woodland to Finglas UGC*

The greatest risk of this option, from a socio-economic perspective, is on Traffic and Transport. For other socio-economic topics the risk of significant impacts is considered to be low to moderate or low (economy). The impacts on traffic are not insubstantial, especially in the more urban areas of the study area; however, they are temporary in nature. As a result, this option has an overall low to moderate risk of significant impacts from a socio-economic perspective (**Green**).

5.6.3 Option 3 Woodland to Belcamp OHL

The greatest risks from a socio-economic perspective from this option are to amenity. Risks to the economy and utilities are low; Traffic and Transport and health risks are considered to be moderate and moderate to low respectively. The risk to amenity is as a result of the significant impacts an OHL would have on landscape and views. As a result, this option as a moderate to high risk of significant impacts from a socio-economic perspective (**Blue**).

5.6.4 Option 4 Woodland to Belcamp UGC

The greatest risk of this option, from a socio-economic perspective, is on Traffic and Transport. For other socio-economic topics the risk of significant impacts is considered to be moderate (utilities) low to moderate or low (economy). The impacts on traffic are not insubstantial, especially in the more urban areas of the study area; however, they are temporary in nature. As a result, this option has an overall moderate risk of significant impacts from a socio-economic perspective (**Dark Green**).

6 New Finglas to Woodland 400 kV Overhead Line (OHL)

This section describes the assessment of the new Finglas to Woodland 400 kV OHL option against the five criteria and their sub-criteria as described in Section 4.2. Each criterion is described in separate sections and a summary of the overall performance of the option is provided in Section 6.7.

The assessments for the environmental and socio-economic criteria have been carried out by Jacobs, and a summary of its findings are presented in this report. Jacobs' detailed reports of these assessments can be found on our website and the links can be found in Section 2.1.

6.1 Description of option

This option involves a transmission network reinforcement centred on strengthening the network between the existing Finglas 220 kV substation in County Dublin and Woodland 400 kV substation in County Meath. These consist of:

- Construction of a new 400 kV overhead line linking Finglas 220 kV station to Woodland 400 kV station. For the purpose of this investigation, we have assumed the length of the overhead line to be approximately 22 km;
- At the existing Finglas 220 kV station a new 400 kV C-Type busbar, and one 400/220 kV transformer. The new 400 kV station development must be capable of accommodating a future second 400/220 kV transformer and future additional 400 kV circuits, and expansion of the station to an enhanced ring busbar.
- At the existing Finglas 220 kV station new 220 kV transformer bay will be required to connect the new 400/220 kV transformer.
- At the existing Woodland 400 kV station a new line bay will be required to connect the new circuit.

Figure 6 Illustrative map showing the study area where the new Finglas - Woodland 400 kV OHL option could be located

6.2 Technical Performance

6.2.1 Compliance with health and safety standards

Please refer to Section 4.2.1 for a detailed description. The new Finglas – Woodland 400 kV OHL option will be compliant with the relevant safety standards and is considered to have a low (**Cream**) risk of not complying with health and safety standards.

6.2.2 Compliance with Security and Planning Standards

The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operational Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The new Finglas – Woodland 400 kV OHL option proposed will comply with the relevant system reliability and security standards referenced above. Although the option will meet the minimum technical requirements, certain aspects may differentiate the option's technical performance compared to other options. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), of either of the existing 220 kV circuits between Woodland and Corduff or Clonee, would lead to power flows in excess of the capacity of the remaining circuit. The analysis indicated that generation redispatch to increase conventional generation in North Dublin would be required to mitigate the overloads. This issue was shown to worsen as demand in Dublin increases.

When the new Finglas – Woodland 400 kV OHL option is added to the system model, the analysis indicates an improvement in these issues by removing the expected overloads between Woodland and Corduff or Clonee.

An assessment was undertaken into keeping the transmission network within standards following a loss of plant and equipment while another is out for planned maintenance. Maintenance is carried out annually during March to October. For planned outages, some re-dispatch of generation is allowed, but this should be kept to a minimum to ensure the most cost-effective generation is dispatched.

The assessment determined the worst case to manage was planned maintenance on the new Finglas – Woodland 400 kV OHL or the new 400/220 kV transformer at Finglas. This requires generation redispatch within allowed limits to manage a subsequent unplanned loss of transmission equipment. Without redispatch the issues identified in the need assessment would be experienced, with the unplanned loss of the Corduff – Woodland 220 kV circuit leading to a loading of 146% on Clonee - Woodland. This is an improvement on the issues indicated in the needs assessment, which showed that during a maintenance and trip combination the Clonee – Woodland circuit could expect an overload of 172% depending on dispatch conditions.

When all aspects are considered, the new Finglas – Woodland 400 kV OHL option is considered to have good compliance when assessed against the above standards and hence has been given a low impact (**Cream**) in the assessment.

6.2.3 Reliability performance

This criterion has been assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the asset. The reliability and outages of the station equipment associated with the circuit is assumed to be same for all options and is therefore not included in this analysis.

The statistics for reliability are based on EirGrid’s and international failure statistics, the mean time to repair and the availability in days per 100 km per year for OHL and UGC. It has been assumed that the new OHL circuit will be approximately 22 km in length for the purpose of this assessment.

There are 439 km of existing 400 kV OHLs in Ireland. This length of 400 kV OHL is too small a sample for determining meaningful performance statistics.

Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity of 400 kV, 275 kV and 220 kV OHLs (approximately 2317 km) in the All-Island transmission system.

Unplanned Outages:

Almost all OHL faults are of short duration as a result of transient faults such as lightning strikes. If an auto-reclose function is provided for the protection of the line, it will restore the circuit shortly after the fault, generally in 0.5 – 3 seconds. Even if the line suffers physical damage, faults can be rapidly located and identified by visual inspection from the ground or air, and repairs effected in a matter of hours. Transmission system statistics indicate that 91.7 % of overhead line outages lasted less than one day[18].

Taking the fault statistics of the above combined network length of OHL for the period 2004 to 2020, gives a projected fault rate of 0.54 unplanned outages/100km/year.

Given typical repair times, this would equate to the circuit being out of service due to a permanent fault for 6 hours approx. per annum. The average failure rates during normal operation, average repair times and availabilities of the main elements of a typical 400kV OHL are set out in Table 7 and adjusted to reflect the length of the proposed option.

Transient faults are not considered, as any interruptions to supply that they may cause would be of such short duration that their effect is considered to be negligible, while acknowledged it may be an inconvenience for electricity users.

Planned outages:

Planned outages are normally associated with routine maintenance. For a 400 kV OHL, much of the required routine maintenance can be completed without an outage of the circuit. The planned outage rates and the typical outage durations taken from our maintenance policies[19] result in an annual planned outage rate of 0.65% for the 400 kV option, or circa 2.5 days per annum[20].

Combination of the planned and unplanned outages:

[18] EirGrid, Analysis of Disturbance and Faults 2020, System Performance, July 2021
[19] EirGrid, Routine Maintenance Activities Overhead Transmission Lines, April 2018
[20] EirGrid, Transmission Engineering Maintenance Statistics

Due to the length of the new OHL circuit (approximately 22km), the total unplanned outage time per year is circa 6 hours, which combined with the planned outage rate of 2.5 days sums to a total of 3 days per annum (rounded to nearest half day).

Parameter	Average statistics for 400 kV & 220 kV OHL combined
Reliability (Unplanned outages/22km/year)	0.12
Mean time to repair (days)	Circa 2 days
Unplanned Outages (combined) Unavailability due to disturbance (h/24km/year)	0.26 days (c.6 hours)
Planned Outages	2.5 days
Total Annual Unavailability (days/22km/year)	3 days

Table 7 Average failure statistics for a 22 km 400 kV OHL

The availability rate for the new Finglas – Woodland 400 kV OHL option is high at 99.2% over any given year and this OHL option is deemed to have a low risk of introducing additional reliability issues in the system (**Cream**).

6.2.4 Headroom

The new 400 kV OHL option accommodates a similar amount of large-scale demand in the Dublin and Mid-East region compared to the other options.

The assessment indicates that the new Finglas – Woodland 400 kV OHL option creates headroom (increases the amount of additional large-scale demand that could be accommodated) of approximately 275 - 325 MW compared to no reinforcement, depending on which scenario is analysed.

The new Finglas – Woodland 400 kV OHL option performs well in the headroom criterion compared to the other options and is deemed to have a moderate (**Dark Green**) performance in terms of headroom.

6.2.5 Expansion or extendibility

The new Finglas – Woodland 400 kV OHL option is based on Overhead Line (OHL) technology and has a thermal capacity[21] equivalent to the existing 400 kV circuits. The option provides a platform for future demand or generation development within the east of the country.

In the event that another connection along the circuit would be required, this could be achieved by constructing another substation which could be connected into this line. This is a very common way to expand the transmission network and is normally technically feasible and achievable, depending on the required connection size. As such, this option has the potential to provide a good base for any further expansion of the transmission network.

However, the substation feasibility analysis for the proposed new 400 kV substation at Finglas has shown that future expansion of the 400 kV busbar within the boundary of the existing substation is not possible. Further land would have to be acquired to allow expansion, and there is evidence that expansion into the land immediately surrounding the existing substation is not possible.

While the expandability and extendibility of the new circuit is good, it is countered by the distinct challenges to that of the required 400 kV substation. As such, this option has moderate to poor potential to provide a base for any further expansion of the transmission network (**Blue**).

6.2.6 Repeatability

Overhead Line (OHL) technology is already in use on the Irish transmission system with more than 4,500 km of circuit length. This criterion is assessed on a technical basis and there are few technical issues with OHL technology that would introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of OHL circuits on the Irish transmission system. There may of course be other challenges with OHL technology, but they are assessed under other criteria.

Similarly, substations using both Air Insulated and Gas Insulated switchgear are already used extensively in the Irish transmission system and so will not introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of the technology on the Irish transmission system.

[21] Thermal capacity of existing 400 kV OHL is a winter rating of 2963 A and summer rating of 2506A based on conductor 2 x 600 mm2 ACSR CURLEW at 80°C,

This option is considered to have a low risk of not meeting the repeatability criteria (**Cream**).

6.2.7 Technical operational risk

The new Finglas – Woodland 400 kV OHL option is based on Overhead Line (OHL) technology and Air or Gas insulated substation switchgear. This technology is tried and tested internationally and in Ireland and it is considered to have a low operational risk. This option is therefore considered lowest on the difficult/ risk scale (**Cream**) in terms of operational risk.

6.2.8 Conclusion of technical performance

This option is considered to perform well when all of the technical sub-criteria are considered and hence has been given a moderate impact (**Dark Green**) in the assessment.

Summary of technical performance of Finglas – Woodland 400 kV OHL option	
Health and Safety Standard compliance	
Security & Planning Standard compliance	
Reliability performance	
Headroom	
Expansion or Extendibility	
Repeatability	
Technical Operational risk	
Combined Technical Performance	

Table 8 Summary of technical performance of the new Finglas - Woodland 400 kV OHL option

6.3 Economic Assessment

The economic performance of the options is represented using our colour scale with the individual performance of an option assessed relative to the performance of the other solution options.

6.3.1 Input cost to the economic appraisal

6.3.1.1 Pre-engineering cost

The pre-engineering costs are estimated to be €10 million. In the economic appraisal, a contingency provision of 5% has been applied to this amount.

The phasing of the pre-engineering costs is as follows:

Phasing of Pre-Engineering Spend – New Finglas – Woodland 400 kV OHL option					
2022	***2023***	***2024***	***2025***	***2026***	***2027***
17%	45%	15%	15%	8%	0%

Table 9 Phasing of pre-engineering spend for New Finglas - Woodland 400 kV OHL

6.3.1.2 Implementation cost

The capital investment required to deliver the new Finglas – Woodland 400 kV OHL option is estimated to be €147 million. A provision for Transmission System Operator (TSO) related implementation cost and landowner payments, proximity allowance and local community fund has been included in this cost. In the economic appraisal, a contingency provision of 10% has been applied to this amount. The estimated implementation cost is categorised into its general components and is summarised in Table 10.

Categorised implementation cost Option 1 – New Finglas – Woodland 400 kV OHL	
Cost category	**Implementation cost (€m)**
Overhead line	26.0
Underground cable	N/A
Stations	91.5
Other (flexibility & proximity payments and other allowances)	16.4
SUB-TOTAL	133.8
Contingency (10%)	13.4
TOTAL	147.8

Table 10 Categorised implementation cost for Finglas - Woodland 400 kV OHL option

The phasing of the implementation costs is as follows:

Phasing of implementation spend – New Finglas – Woodland 400 kV OHL option										
2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
10%	25%	20%	10%	10%	10%	5%	5%	5%	0%	0%

Table 11 Phasing of implementation cost spend for New Finglas - Woodland 400 kV OHL

6.3.1.3 Life-cycle cost

This sub-criterion consists of three separate inputs incurred over the useful life of the option, namely operation and maintenance cost, electrical losses and replacement cost.

The equipment associated with the new Finglas – Woodland 400 kV OHL option is expected to be maintained in accordance with the well-established existing practices. The operation and maintenance cost varies over the assets' lifetime and as such three periods of approximate costs are assumed. Table 12 displays rounded figures to the nearest thousand. No replacement cost is assumed as the equipment has a life expectancy of 50 years which is line with the period for the economic assessment.

Life-cycle cost for New Finglas – Woodland 400 kV OHL		
Annual Operation and maintenance cost (€k)	0-20 year period	€230k
	21-40 year period	€337k
	41-50 year period	€161k
Annual Electrical losses cost (€M)	€2.8M	
Replacement cost	N/A	

Table 12 Life-cycle cost for the Finglas - Woodland 400 kV OHL option

6.3.1.4 Cost to Single Electricity Market

As described in Section 4.2.2, Economic performance criteria, the cost to the Single Electricity Market represents the cost for the periods when the reinforcement is unavailable. The unavailability is based on the reliability performance of the option. This is a cost to the single electricity market and is calculated as a combination of the benefit in production cost saving (project benefit) and reliability performance of the option.

The reliability performance of the option is taken from Section 4.2.1 Technical Performance Criteria. The production cost savings assessment used the TES 2019 scenarios and as such a range of annual production cost savings are used in the assessments as the different scenarios have different demand and generation patterns. Table 13 show the input for this criterion.

Cost to Single Electricity Market for Finglas – Woodland 400 kV OHL option	
Annual Production cost saving (Benefit) (€m/annum)	Range €4.4m to €22.8m
Annual unavailability of option during which benefits cannot be attributed	Unavailable for 3 days, available 99.18%
Annual Cost (saving) to SEM	Range €4.4m to €22.6m

Table 13 Cost to single electricity market of the new Finglas – Woodland 400 kV OHL option

6.3.2 Economic performance for the new Finglas – Woodland 400 kV OHL option.

When all of the above costs and savings are considered, the economic result of the new Finglas – Woodland 400 kV OHL option indicates a good result compared to the other options and hence is considered to have a moderate to low (**Green**) impact on the economic result. To be able to differentiate between competing options in a measured way and to check the options' performance in different credible future energy scenarios, a robustness and sensitivity test was carried out. The objective is to identify the option that is impacted the least in its economic result for a range of credible future energy scenarios. This robustness test indicates a stable performance compared to the other options independent from which future energy scenario is used in the assessment.

After considering both the economic result and the robustness test, the new Finglas - Woodland 400 kV OHL is considered to provide a good economic performance in comparison with the other options and hence has been given a moderate to low impact (**Green**) in the assessment.

Summary of economic performance of the new Finglas – Woodland 400 kV OHL option	
Economic result	Green
Robustness	Green
Combined Economic Performance	Green

Table 14 Summary of economic performance for new Finglas - Woodland 400 kV OHL option

6.4 Deliverability

6.4.1 Implementation timelines

The expected timeline for implementation of the 400 kV overhead line option from Woodland to Finglas is a period of 20 years in total. This time frame can be divided into two phases.

The first phase is based on 5.25 years for the outline design, environmental assessment and the planning process, and would be subject to the outcome of the consenting process.

The second phase is 14.75 years and includes detailed design, procurement of materials and construction works. This assumption includes time for the design to be confirmed, all landowner consents to be obtained by EirGrid including the use of compulsory acquisition powers if necessary, and materials procurement in the first 5.75 years of this period.

This includes a period of one (1) year to allow for a modification of the approved planning permission, which in EirGrid's experience of grid development is a normal process, as the permitted development is subject to detailed design and the accommodation where possible of landowner preferences for tower siting. The time to construct the OHL (five (5) years) includes construction access, foundation works, tower erection and stringing which would include sections that require transmission outages.

The design works, material procurement and construction period for the works required in the existing substations has been incorporated into the above timeline for the OHL works. The timeline for new 400 kV bay at Woodland 400 kV station is estimated at 1.5 years. At Finglas substation there are several impediments to the implementation timelines. A new 400 kV GIS substation is to be built on the already constrained site. The site for the 400 kV GIS is currently occupied by the old 110 kV AIS infrastructure. There are still transfer of existing circuits required before this older equipment can be decommissioned, and the site cleared.

In addition, the only remaining spare bay is a line bay which would need to be converted to a transformer bay and the outages to complete this are rarely granted. Timelines for the procurement of the required transformer is approximately 2 years.

There are yet unknown cable diversions at lower voltages which would have to be completed before the substation and circuit could be energised. Taking all of these impediments into consideration equates to approximately 1 year to design and 4 years to construction timeline.

The implementation timeline for the 400 kV OHL option is the longest compared to the other options. The impact of the implementation timelines is assessed to be high (**Dark Blue**) for the 400 kV OHL option.

6.4.2 Project plan flexibility

Route corridors for the OHL would be developed in Step 4 of our grid development process and would factor in constraints in the study area. Within the corridors, there would be a reasonable level of flexibility to identify the OHL routes. Once the route options have considered all the constraints, an emerging preferred OHL route would be the basis for the planning submission. The preferred route would be designed within the identified corridor and the design would consider the access routes for construction, stringing locations and tree cutting requirements. The design would be completed to a level that we would consider the foundation requirements and would identify all the requirements for the line construction. There would be very little flexibility on the route once the planning consent is in place. Some of the tower locations may have the potential for minor modifications, which could require a modification to the planning consent. Access routes to the tower locations would also form part of the planning consent and changes to these would also require modification to the planning consent. The 400 kV OHL option is assessed to have a moderate (**Dark Blue**) impact on the project plan flexibility compared to the other options.

6.4.3 Risk to untried technology

OHL technology is tried and tested in Ireland and internationally. This technology is considered international best practice and is a proven technical solution for transmission of high-voltage electricity. It is the technology around which the transmission network in Ireland has been developed to date. Nevertheless, it has been some time since new 400 kV infrastructure was built in Ireland in the 1980's and therefore it is not without some technological risk. Overall, this option is considered to have a moderate (**Dark Green**) risk in relation to this sub-criterion when compared to the other options.

6.4.4 Dependence on other projects (outages)

This option has a number of elements which would require planned outages.

The required work in both Woodland and Finglas substations would need proximity and commissioning outages. In Woodland, the work is in relation to the construction of the 400kV bay, which is included in CP1194 Woodland 400 kV redevelopment project.

In Finglas, the work involves the redevelopment of an existing 220kV bay as there is no room for extension to the busbar in Finglas substation. There would also be the construction of a new 400kV GIS substation which is dependent on CP0646 Finglas 110 kV decommissioning works of the old AIS switch gear. On-going projects in both these substations may cause conflicting outages depending on the projects' individual programmes. This would have to be taken into consideration and could have impacts on granting necessary outages. There are efforts ongoing to masterplan stations elements, but this has not been developed for Finglas. The impact on the dependence on other projects for the 400 kV overhead line option is considered to be at a high (**Dark Blue**) level.

6.4.5 Supply chain constraints, permits, wayleaves

For the purposes of this analysis, it is assumed that 400 kV structures, apparatus and equipment would be equivalent, if not similar in terms of nature and extent of materials, to that being planned and procured for the North South Interconnector (NSIC) development.

In terms of significant supply chain constraints envisaged, EirGrid is aware that there is a two-year lead time to procure a 400 kV/220kV transformer. Similarly, permitting is also likely to be very challenging, with the provision of new 400 kV OHL infrastructure in what can be described as a peri-urban commuter belt of the Greater Dublin Area, irrespective of final design and location. The Woodland substation is also the terminus of the existing Moneypoint – Woodland 400 kV OHL circuit, and the permitted North-South Interconnector (NSIC) 400 kV OHL. Based on established precedent, the infrastructure development comprising the provision of a new 400 kV OHL circuit is likely to be the subject of an application directly to An Bord Pleanála (ABP) as Strategic Infrastructure Development (SID). Given the nature of the proposed development as comprising a new 400 kV OHL circuit, the planning application would be subject to Environmental Impact Assessment (EIA). These factors make it almost inevitable that ABP would hold a full Oral Hearing in respect of a new 400 kV OHL development. A new 400 kV OHL circuit would need to be located on a new alignment. This would result in potentially significant environmental and social impacts on receiving environments and communities, including biodiversity, land use activities, and visual impacts. Social impacts may include community concerns regarding the provision of new large-scale OHL within an area. Significant engagement with landowners and communities would be required in the delivery of the new circuit, for such purposes as surveying, siting and construction. These parties may be new to accommodating electricity infrastructure on their landholdings and within their communities. New wayleaves would be required to facilitate construction of the new circuit. Based on recent precedent in terms of the provision of new 400 kV transmission infrastructure, there is the potential for significant landowner, community and public concerns with this option, with the likely consequence of project delays or difficulties in gaining access to land. Having regard to all the above aspects, the 400 kV OHL option is deemed to have a high (**Dark Blue**) impact and risk in terms of Supply Chain Constraints, Permits and Wayleaves.

6.4.6 Conclusion of deliverability performance

There are five sub criteria considered when the overall deliverability performance is assessed. For Option 1, an OHL to Finglas, most of these aspects indicate a high significance. This means that overall, this option is considered significantly challenging to deliver, with some risks and unknown technical issues that will have to be solved during the subsequent stages of project development.

The implementation timeline for any network reinforcement is important to be able to ensure that the transmission network will be in compliance with security standards and that all consumers have a secure electricity supply. The time it takes to develop, and construct reinforcements is also important in terms of accommodating new generation and demand that would like to connect to the system.

This option has the longest implementation timeline compared to the other options and this, in combination with the perceived risk of delays due to societal acceptance, means this option does not perform well from a deliverability point of view and this has been taken into account in the overall assessment of this option.

When all of these deliverability aspects are considered, this option is deemed to have high (**Dark Blue**) impact from a deliverability point of view.

Topic	Option 1 (New Finglas to Woodland OHL)
Implementation timelines	
Project plan flexibility	
Risk of untried technology	
Dependence on other projects	
Supply chain constraints, permits, wayleaves etc.	
Combined Deliverability Performance	

Table 15 Summary of deliverability performance for the new Finglas - Woodland 400 kV OHL option

6.5 Environmental Assessment

6.5.1 Biodiversity

There is a moderate to high risk of significant impacts on biodiversity as a result of this option. There is potential for impacts on protected sites as al of the water bodies in the study area are hydrologically connected to European designated sits on the coast; there will be a permanent loss of habitat within the footprint of the pylons and as a result of a loss of some mature trees and there is a collision risk to birds migrating across the study area. Although literature suggests that bird collisions with power lines are generally considered to be rare events, there is still potential for collision risk to bird species from the new OHL in addition to disturbance leading to displacement.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a moderate (**Blue**) impact and risk in terms of Biodiversity.

6.5.2 Soils and Water

There is a low risk of significant impacts on soils and water as a result of this option. The impacts would be only likely to occur during construction. These impacts would be fairly limited as Option 1 would aim to avoid designated water bodies and excavations would be limited to new pylon foundations. Short access tracks from local roads would be used, where possible, and would require minimal soil strip in site preparation.

Having regard to the above, the 400 kV OHL option is deemed to have a low (**Cream**) impact and risk in terms of Soils and Waters.

6.5.3 Material Assets - Planning Policy and Land Use

There is a moderate risk of conflict with planning policy and significant impacts on land use as a result of this option. There are some potential interactions with plan zonings within the Finglas Study Area; plan policies are broadly in support of electricity conveyance improvement and reinforcement development within the Finglas Study Area, however, it is possible that Option 1 would not fully accord with county planning policies, as new structures are proposed and there is a preference for new transmission connections to be underground. Perceived and actual impacts on land values may present significant constraints both in rural and urban areas. With careful routeing of OHL in consultation with communities and landowners, the risk of impacts would be reduced.

There is little scope for installing OHL in public roads however as there is for UGC so almost all of the land use would be 3rd party lands. New OHL corridors would require limited and temporary land take for construction, with short access tracks from local roads being used, wherever possible. Permanent land take would be limited to the footprint of the OHL pylons. There would however be a small number of significant impacts on particular parcels of land during the operational phase due to potential land use restrictions.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a moderate (**Dark Green**) impact and risk in terms of Planning Policy and Land Use.

6.5.4 Landscape and Visual

There is a Moderate to High risk of significant impacts on landscape and views as a result of this option. The potential for significant visual impacts in particular is identified and these would be permanent. However, with sensitive landscapes, viewpoints and main settlements largely avoided, this impact would be reduced somewhat to a moderate to high (**Blue**) risk.

6.5.5 Cultural Heritage

There is a Moderate risk of significant impacts on cultural heritage as a result of this option. There would be a combined impact of the potential to encounter unknown archaeological assets during construction and the potential to impact the setting of built heritage assets during operation. Of these two potential impacts, however, the more significant impacts would be likely to arise on the setting of heritage features during operation.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a moderate (**Dark Green**) impact and risk in terms of Cultural Heritage.

6.5.6 Noise and Vibration

There is a low to moderate risk of significant impacts from noise and vibration as a result of this option. The construction of a new OHL and associated pylons would be likely to generate noise and vibration, most notably from works for pylon foundations. This noise impact would be temporary. There may also be some low levels of noise associated with the OHLs during operation. There is likely to be a greater impact in the area of Woodland substation due to its rural nature.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a low to moderate (**Green**) impact and risk in terms of Noise and Vibration.

6.5.7 Climate Change

There is a Moderate risk of significant impacts to and from climate change as a result of this option. The OHL would be vulnerable to predicted future climate impacts associated with storms and winds and increased rainfall. Damage done could be difficult to repair as a result of increased flooding. This is a long-term risk and one that is predicted to increase over time. This would impact security of supply. The volume of material required to construct an OHL between Woodland and Finglas is significant and carries with it associated embodied energy.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a moderate (**Dark Green**) impact and risk in terms of the effect of climate change on the asset.

6.5.8 Summary of Environmental assessment of the Finglas – Woodland 400 kV OHL option

The greatest risks of significant impacts as a result of this option are associated with biodiversity and landscape and views, which have a moderate to high risk rating. This is as a result of OHLs posing a collision risk to migratory birds, a loss of mature trees and significant impacts on views. This option also has the potential to conflict with local planning policies, impact on the setting of cultural assets and is less resilient to climate change than an underground option would be. As a result, this option has a moderate risk of significant impacts to the environment overall (**Dark Green**).

Topic	Option 1 (New Finglas to Woodland 400 kV OHL)
Biodiversity	
Soil and Water	
Planning Policy and Land Use	
Landscape and Visual	
Cultural Heritage	
Noise and Vibration	
Climate Change	
Combined Environmental Performance	

Table 16 Summary of environmental performance for the new Finglas - Woodland 400 kV OHL option

6.6 Socio-economic Assessment

6.6.1 Traffic and Transport

There is a low to moderate risk of significant impacts on Traffic and Transport as a result of this option. The greatest impacts to Traffic and Transport would be during construction as a result of construction traffic using local and regional roads as haul routes and accessing points to construction compounds or other construction installations. Such an occurrence could lead to driver and pedestrian delay; increased fear and intimidation for pedestrians, especially where there are no footpaths along the roads being used; and potentially severance of communities, community facilities and businesses if any roads need to close. Whilst impacts are temporary and comprise of construction traffic only, with no lengthy road closures anticipated, construction over a period of two years in an area as densely populated and congested as the study area would have a potentially significant impact on local traffic.

Having regard to the above aspects, the 400 kV OHL option is deemed to have a low to moderate (**Green**) impact and risk in terms of the effect of Traffic and Transport.

6.6.2 Amenity

Amenity considers combined impacts: during construction, there is the potential for impacts on amenity as a result of a combination of impacts on Traffic and Transport, Views and from Noise and Vibration; during operation amenity impacts could occur as a result of combined impacts on views and from noise. There is a moderate to high risk of significant impacts on amenity as s a result of this option. When considering the relative impacts identified for each of these topics in the assessment and then combining them, consideration is also given to the temporary or permanent nature of the impacts: Landscape and views are at a moderate to high risk of significant impacts and this is a permanent impact; traffic impacts would be temporary only, albeit over a long period of time; noise impacts would occur in both construction and operation but are not considered to be significant. As a result, and taking a precautionary approach, the combined assessment considers that there is a moderate to high risk of impacts on amenity.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a moderate to high (**Blue**) impact and risk in terms of Amenity.

6.6.3 Health

There is a low to moderate risk of significant impacts on health as a result of this option. Potential impacts relate to stress and anxiety associated with Traffic impacts, amenity impacts and ‘nuisance’ emissions such as noise. No significant impacts are anticipated from noise there is a moderate to high risk of amenity impacts which could lead to stress and anxiety, Concerns relating to EMFs relating to electrical transmission lines can also lead to increased stress and health issues. EirGrid's design standards require all OHLs to operate to existing public exposure guidelines from ICNIRP and as such there should be no direct impact from EMFs; despite this EMFs are likely to remain a concern for local communities. This has been demonstrated in a number of public consultations. As a result, there remains a low to moderate (**Green**) risk to health as a result of this option.

6.6.4 Local Economy

There is a low risk of significant impacts on the economy as a result of this option. Impacts considered under this topic are confined to the direct impacts the option might have during construction or operation. The aims of the Proposed Project, to facilitate economic growth in Ireland are not considered in the options appraisal as these aims and the resultant security of supply are common to all of the options. In terms of employment, during construction the workforce would be relatively small in the context of the local and regional economy; it is likely to require specialist labour which may not be available locally. In operation there would be limited scope for employment opportunities. In terms of expenditure, there would be positive impacts on the local and regional economy, but this would be relatively low in magnitude. Again, specialist equipment is likely to be required from outside of the study area.

Having regard to above, the 400 kV OHL option is deemed to have a low (**Cream**) impact and risk in terms of the local economy.

6.6.5 Utilities

There is a low risk of significant impacts to third party utilities as a result of this option. Above ground utilities include telephone network cables and OHLs. Connected to Woodland 400kV substation, there is the existing Moneypoint to Woodland 400kV OHL travelling east to west; and two 220kV OHLs, one travelling south and connecting into the Clonee to Maynooth 220kV OHL and one travelling east and then south to Corduff. There is also a 100kV OHL crossing to the south of Woodland substation in a north west to south east direction. At Finglas 220kV substation, there are numerous 220kV and 100kV OHL and UGC connections, in particular connecting Finglas to Corduff and Poolbeg in Dublin. There are likely to be a number of underground utilities in the regional road network between Woodland and Finglas, including other electricity cables; telephone and broadband cables; sewers; and private water supplies. There are unlikely to be significant issues with any existing utilities in the construction or operation of Option 1, with the exception of other OHL, some of which may need to be over-sailed or undergrounded. Third party utility surveys will be undertaken prior to excavation for pylon foundations, thereby removing the risk of impacting underground cables, water supply pipes, private water sources or wastewater treatment systems.

Having regard to all the above aspects, the 400 kV OHL option is deemed to have a low (**Cream**) impact and risk in terms of Utilities.

6.6.6 Summary of Socio-economic assessment of the Finglas – Woodland 400 kV OHL option

The greatest risks from a socio-economic perspective from this option are to amenity. Risks to the economy and utilities are low; Traffic and Transport and health risks are considered to be low to moderate. The risk to amenity is as a result of the significant impacts an OHL would have on landscape and views. As a result, this option as a moderate risk of significant impacts from a socio-economic perspective (**Green**).

Topic	Option 1 (New Finglas to Woodland 400 kV OHL)
Traffic & Transport	
Amenity	
Health	
Economy	
Utilities	
Combined Socio-Economic Performance	

Table 17 Summary of Socio-Economic performance for the new Finglas - Woodland 400 kV OHL option

6.7 Summary of the assessment for the Finglas – Woodland 400 kV OHL option

This option would involve constructing a new 400 kV OHL between Woodland 400 kV and Finglas 220 kV substations. This option is the best performing option in the economic criteria compared to the other options. The environmental criterion is considered to be of moderate impact when compared to the other options.

Based on other projects of a similar nature, some aspects under the deliverability and the socio-economic criteria are anticipated to be very challenging and would bring high risks to the completion of the project.

Having considered all of the five criteria, the outcome of the multi-criteria assessment indicates that the new Woodland – Finglas 400 kV OHL option (Option 1) does not perform very well, and it has been given a high impact (**Dark Blue**) on its overall performance.

Topic	Option 1 (New Finglas to Woodland 400 kV OHL)
Technical Performance	
Economic Performance	
Deliverability	
Environmental	
Socio-economic	
Combined Performance	

Table 18 Overall assessment outcome for the new Finglas - Woodland 400 kV OHL option

7 New Finglas to Woodland 400 kV Underground Cable (UGC)

This section describes the assessment of the new Finglas – Woodland 400 kV UGC option against the five criteria, and their sub-criteria as described in Section 4.2. Each criterion is described in separate sections and a summary of the overall performance of the option is provided in Section 7.7.

The assessments for the environmental and socio-economic criteria have been carried out by Jacobs, and a summary of its findings are presented in this report. Jacobs' detailed reports of these assessments can be found on our website and the links can be found in Section 2.1.

Due to the nature of UGC, additional investigations were carried out to better inform the assessment from a feasibility and technical point of view. There are certain aspects that we need to understand before an UGC option can be deemed feasible. For instance, the power carrying capacity (rating) of the cable is dependent on how it is laid in the ground.

These investigations included a high-level feasibility study to determine if indicative feasible routes (which achieve adequate capacity ratings) can be found in the road network in the study area and what type of obstacles the cables may have to cross. Jacobs carried out this assessment and its detailed report (321084J-REP-002 Rev A03 – Cable Feasibility Report).

Also, other technical behaviours of UGCs had to be examined to avoid the cables causing damage to other electrical equipment once installed. These investigations included cable integration studies and indicative reactive compensation requirements, harmonic filter requirements, and temporary overvoltage assessments (TOV).

PSC carried out these assessments and its detailed report (Capital Project 1021 East Meath to North Dublin Grid Upgrade Cable Studies, EIR-014270, Rev 3, 7th June 2022) can be found on our website.

Further investigations will have to be carried out in relation to these issues if any of the underground cable options are brought forward to Step 4 to reflect the actual route and parameters of the cable option.

7.1 Description of option

This option involves a transmission network reinforcement centred on strengthening the network between the existing Finglas 220 kV substation in County Dublin and Woodland 400 kV substation in County Meath. This consists of:

- Construction of a new 400 kV underground cable linking a new 400 kV busbar at the existing Finglas 220 kV station to Woodland 400 kV station. For the purpose of this investigation, we have assumed the length of the cable to be approximately 30 km;
- At the existing Finglas 220 kV station a new 400 kV C-Type busbar, and one 400/220 kV transformer. The new 400 kV station development must be capable of accommodating a future second 400/220 kV transformer and future additional 400 kV circuits, and expansion of the station to an enhanced ring busbar.
- At the existing Finglas 220 kV station new 220 kV transformer bay will be required to connect the new 400/220 kV transformer.
- At the existing Woodland 400 kV station a new line bay will be required to connect the new circuit.
- Reactor of c.100 MVAr at each station end of the new cable circuit will be required. The size of the reactor compensation will be verified in further cable integration studies when circuit route and cable type are selected in later steps of the Six Step process.

7.2 Technical Performance

7.2.1 Compliance with health and safety standards

Please refer to Section 4.2.1 for a detailed description. The new Finglas – Woodland 400 kV UGC option will be compliant with the relevant safety standards and is considered to have a low (**Cream**) risk of not complying with health and safety standards.

7.2.2 Compliance with Security and Planning Standards

The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operational Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The new Finglas – Woodland 400 kV UGC option proposed will comply with the relevant system reliability and security standards referenced above. Although the option will meet the minimum technical requirements, certain aspects may differentiate the option's technical performance compared to other options. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), of either of the existing 220 kV circuits between Woodland and Corduff or Clonee , would lead to power flows in excess of the capacity of the remaining circuit. The analysis indicated that generation redispatch to increase conventional generation in North Dublin would be required to mitigate the overloads. This issue was shown to worsen as demand in Dublin increases.

When the new Finglas – Woodland 400 kV UGC option is added to the system model, the analysis indicates an improvement in these issues by removing the expected overloads between Woodland and Corduff or Clonee.

An assessment was undertaken into keeping the transmission network within standards following a loss of plant and equipment while another is out for planned maintenance. Maintenance is carried out annually during March to October. For planned outages, some re-dispatch of generation is allowed, but this should be kept to a minimum to ensure the most cost-effective generation is dispatched.

The assessment determined the worst case to manage was planned maintenance on the new Finglas – Woodland 400 kV UGC. This requires generation redispatch within allowed limits to manage a subsequent unplanned loss of transmission equipment. Without redispatch the issues identified in the need assessment would be experienced, with the unplanned loss of the Corduff – Woodland 220 kV circuit leading to a loading of 143% on Clonee - Woodland. This is an improvement on the issues indicated in the needs assessment, which showed that during a maintenance and trip combination the Clonee – Woodland circuit could expect an overload of 172% depending on dispatch conditions.

When all aspects are considered, the new Finglas – Woodland 400 kV UGC option is considered to have good compliance when assessed against the above standards and hence has been given a low impact (**Cream**) in the assessment.

7.2.3 Reliability performance

This criterion has been assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the asset. The reliability and outages of the station equipment associated with the circuit is assumed to be same for all options and is therefore not included in this analysis.

The statistics for reliability are based on EirGrid's and international failure statistics, the mean time to repair and the availability in days per 100 km per year for UGC. It has been assumed that the new Finglas – Woodland 400 kV UGC circuit will be approximately 30 km in length for the purpose of this assessment.

Unplanned Outages*:*

As mentioned in Section 6.2.3, almost all faults on OHLs are of short duration as a result of transient faults. If an auto-reclose function is provided for the protection of the OHL, it will restore the circuit shortly after the fault. Auto-reclose is not available for faults on UGC and as such faults are considered to be long-lasting and will not be re-energised until an investigation has been undertaken. Consequently, when a cable fault occurs, finding a fault location and resolving it can result in prolonged circuit outages. As such, cable circuits have a lower availability than OHLs because of the prolonged outage times in the event of a fault.

There is only 1 km of existing 400 kV UGC in Ireland. This length of 400 kV UGC is too small a sample for determining meaningful performance statistics.

Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity (approximately 144 km) of 400 kV and 220 kV UGC under our control along with international failure statistics for cables[22]. Taking the fault statistics of this existing 144 km of UGC for the period 2004 to 2020, and the international failure for XLPE land cables from 220 kV to 400 kV, gives a projected fault rate of 0.27 Unplanned outages/100km/year.

Parameter	Average statistics for 400 kV & 220 kV UGC combined
Reliability (Unplanned outages/100km/year)	0.27
Mean time to repair (days)	25 – 45 Days[23]
Unavailability due to disturbance (days/100km/year)	7 – 12 days

Table 19 Average failure statistics for a 100km 400 kV UGC

[22] Cigre, TB379 Update of service experience of HV underground and submarine cable systems, 2020
[23] Dependant on installation method and number of joint bays

Table 20 shows the statistics for reliability, the mean time to repair faults, and the unavailability for 220 kV and 400kV cables (based on international failure statistics for cables[22]). These statistics, given that they apply to XLPE[24] cables, are taken to be applicable for this option.

Planned outages:

Planned outages are normally associated with routine maintenance. The typical routine maintenance outage duration for 400 kV cables taken from our maintenance policies is 2-3 days per annum (dependent on the number of joint bays and cable sections). Each year an operational test is performed, and periodically an ordinary service. These maintenance outages equate to a total unavailability of 0.84%, or c.2.5 days per annum.

Combination of the planned and unplanned outages:

The combination of the planned and unplanned outages the Finglas – Woodland 400 kV UGC option and the total annual unavailability are set out in the table below and adjusted to reflect the length of the proposed option (30 km).

Topic	Finglas – Woodland 400 kV UGC (30 km)
Reliability (Unplanned outages/circuit length(km)/year)	0.082
Mean time to repair (days)	25 – 45 days
Unplanned outages (Combined) Unavailability due to disturbances (days/circuit length(km)/year)	2– 3.7 days/annum
Planned Outages	2.5 days
Total Annual Unavailability	4.5 – 6.2 days/annum
Difficulty/risk scale	

Table 20 Average failure statistics for a 30 km 400 kV UGC

The average failure rate and time to repair for the new Finglas – Woodland 400 kV UGC option is deemed to be high when compared to the OHL alternative. The availability of this option as a result of outages is in the range of 98.3-98.8% at best and unavailability could potentially be greater than a month per annum. Based on this assessment, the

[24] XLPE cable means cross linked polyethylene

reliability criterion for the new Finglas – Woodland 400 kV UGC is considered to be at a moderate performance (**Dark Green)**.

7.2.4 Headroom

The new Finglas – Woodland 400 kV UGC option accommodates a similar amount of large-scale demand in the Dublin and Mid-East region compared to the other options. Underground cable options were noted to provide marginally better headroom due to their lower overall electrical impedance, and circuit options that terminate at Finglas were shown to perform marginally better than those terminating at Belcamp due to Finglas substation being connected to all the existing 220 kV circuit between Woodland and North Dublin.

The assessment indicates that the new Finglas – Woodland 400 kV UGC option creates headroom (increases the amount of additional large-scale demand that could be accommodated) of approximately 300 - 350 MW compared to no reinforcement, depending on which scenario is analysed.

The new Finglas – Woodland 400 kV UGC option performs well in the headroom criteria compared to the other options and is deemed to have a moderate to good (**Green**) performance in terms of headroom.

7.2.5 Expansion or extendibility

The new Finglas – Woodland 400 kV UGC will provide a future new circuit and as such there are opportunities for further expansion of the transmission network using this circuit as a platform in the future. In the event that another connection along the cable route is required, these cable options may make the opportunity for expansion and extendibility more challenging and difficult compared to if an OHL technology was used.

There are a number of aspects which make this more challenging. The cable circuit is relatively long and requires bespoke reactors at each end of the of the cable to limit the impact during energisation of the cables and also during normal operation as the reactors will make sure that the voltage does not deviate outside planning standards.

If the length of the cable is changed then these reactors would have to be resized and new reactors purchased. In the event that the cable is associated with harmonic filters, then additional studies would have to be undertaken to ensure that the filters are properly tuned for any new cable length and size. This could mean that some purchased equipment would become redundant in the future if the cable option chosen is altered. There may also be limitations on route options for diversions or connections to the new circuit in the road network (cables are preferably accommodated in roads to have easier access to the asset for maintenance and repair).

The new Finglas – Woodland 400 kV UGC option has a target thermal capacity[25] equivalent to the existing 400 kV circuits. Assessments of cable types available to maximise the capacity of the new circuit are under way at the time of this report. The result of these assessments will be an input to analysis in later steps of the Six Step process. The route selected will also be analysed for thermal pinch points, such as crossing roads or waterways or other cable circuits, that limit the capacity of the new circuit allowing mitigations to be developed where possible.

After considering all aspects in this criterion, all cable options provide a worse base for any further expansion of the transmission network compared to OHL technology.

In addition, the substation feasibility analysis for the proposed new 400 kV substation at Finglas has shown that future expansion of the 400 kV busbar within the boundary of the existing substation is not possible. Further land would have to be acquired to allow expansion, and there is evidence that expansion into the land immediately surrounding the existing substation is not possible.

The implications of the opportunity for expansion and extendibility is more challenging and difficult compared to OHL technology and new Finglas – Woodland 400 kV UGC option will have a high (**Dark Blue**) impact in terms of difficulty to accommodate potential for future expansion.

7.2.6 Repeatability

Underground Cable (UGC) technology for 220 kV and 400 kV voltages is already in use in the Irish transmission system, but on a smaller scale compared to OHL. Every time an UGC option is proposed as a solution, each cable option will have to be studied on its own merits. Bespoke network design would have to be considered for each option that would take account of necessary harmonic distortion introduced by any cable or if voltage limiting equipment is required to accommodate the cable options into the transmission network.

Substations using both Air Insulated and Gas Insulated switchgear are already used extensively in the Irish transmission system and so will not introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of the technology on the Irish transmission system.

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[25] Thermal capacity of existing 400 kV OHL is a winter rating of 2963 A and summer rating of 2506A based on conductor 2 x 600 mm2 ACSR CURLEW at 80°C,

In terms of repeatability, it is recognised that there may be limitations in the network in regards to accommodating cables. The impacts of the above points are usually greater the higher the operating voltage of the cable used. As such, it is considered that the new Finglas – Woodland 400 kV UGC option has high to moderate risk of not meeting the repeatability criteria (**Blue**).

7.2.7 Technical operational risk

Underground cable and Air or Gas insulated substation switchgear are technologies that are tried and tested internationally and in Ireland. However, the nature of cable technology means that when cables are used over long lengths, they require a bespoke design to be able to be accommodated into the network while remaining within the technical network design standards.

The voltage level and the considerable length will influence the technical operational risk in regards to cable options. Special energising and switching procedures will be required to manage any of the UGC options in an operational environment.

These aspects and additional equipment required to accommodate the underground cable will increase the technical operational risk. The new Finglas – Woodland 400 kV UGC option is considered to have a high to moderate (**Blue**) impact in relation to technical operational risk.

7.2.8 Conclusion of technical performance

This option is considered to perform poorly when all of the technical sub-criteria are considered and hence has been given a moderate to high (**Blue**) impact in the assessment.

Summary of technical performance of the Finglas – Woodland 400 kV UGC option	
Health and Safety Standard compliance	
Security & Planning Standard compliance	
Reliability performance	
Headroom	
Expansion or Extendibility	
Repeatability	
Technical Operational risk	
Combined Technical Performance	

Table 21 Summary of technical performance for Finglas - Woodland 400 kV UGC option

7.3 Economic Performance

The economic performance of the options is represented using our colour scale with the individual performance of an option assessed relative to the performance of the other solution options.

7.3.1 Input cost to the economic appraisal

7.3.1.1 Pre-engineering cost

The pre-engineering costs are estimated to be €10 million. In the economic appraisal, a contingency provision of 5% has been applied to this amount.

The phasing of the pre-engineering costs is as follows:

Phasing of Pre-Engineering Spend– New Finglas – Woodland 400 kV UGC					
2022	*2023*	*2024*	*2025*	*2026*	*2027*
20%	51%	15%	15%	0%	0%

Table 22 Phasing of pre-engineering spend for New Finglas - Woodland 400 kV UGC

7.3.1.2 Implementation cost

The capital investment required to deliver the new Finglas – Woodland 400 kV UGC option is estimated to be €367 million. A provision for Transmission System Operator (TSO) related implementation cost and landowner payments, proximity allowance and local community fund has been included in this cost. In the economic appraisal, a contingency provision of 10% has been applied to this amount. The estimated implementation cost is categorised into its general components and is summarised in Table 23.

Categorised implementation cost Option 2 – New Finglas – Woodland 400 kV UGC	
Cost category	**Implementation cost (€m)**
Underground cable	241.1
Stations	88.0
Other (flexibility & proximity payments and other allowances)	5.9
SUB-TOTAL	335.1
Contingency (10%)	33.5
TOTAL	368.6

Table 23 Categorised implementation cost for new Finglas - Woodland 400 kV UGC

The phasing of the implementation costs is as follows:

Phasing of implementation spend – New Finglas – Woodland 400 kV UGC option										
2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
15%	30%	40%	15%	0%	0%	0%	0%	0%	0%	0%

Table 24 Phasing of implementation cost spend for New Finglas – Woodland 400 kV UGC option

7.3.1.3 Life-cycle cost

This sub-criterion consists of three separate inputs incurred over the useful life of the option, namely operation and maintenance cost, electrical losses and replacement cost.

The equipment associated with the new Finglas – Woodland 400 kV UGC option is expected to be maintained in accordance with the well-established existing practices. The operation and maintenance cost vary over the assets' life time and as such three periods of approximate costs are assumed. Table 25 displays rounded figures to the nearest thousand. No replacement cost is assumed as the equipment has a life expectancy of 50 years which is line with the period for the economic assessment.

Life-cycle cost for New Finglas – Woodland 400 kV UGC		
Annual Operation and maintenance cost (€k)	0-20 year period	€247k
	21-40 year period	€193k
	41-50 year period	€247k
Annual Electrical losses cost (€M)	€2.8M	
Replacement cost	€60M	

Table 25 Life-cycle cost for the Finglas - Woodland 400 kV UGC option

7.3.1.0 Cost to Single Electricity Market

As described in Section 4.2.2, Economic performance criteria, the cost to the Single Electricity Market represents the cost for the periods when the reinforcement is unavailable. The unavailability is based on the reliability performance of the option. This is a cost to the single electricity market and is calculated as a combination of the benefit in production cost saving (project benefit) and reliability performance of the option.

The reliability performance of the option is taken from Section 7.2.3 Reliability. The production cost savings assessment used the TES 2019 scenarios and as such a range of annual production cost savings are used in the assessments as the different scenarios have different demand and generation patterns. Table 26 show the input for this criterion.

Cost to Single Electricity Market for Finglas – Woodland 400 kV UGC option	
Annual Production cost saving (Benefit) (€m/annum)	Range €4.4m to €22.8m
Annual unavailability of option during which benefits cannot be attributed	Unavailable for 6 days, available 98.36%
Annual Cost (saving) to SEM	Range €4.3m to €22.4m

Table 26 Cost to single electricity market for the new Finglas - Woodland 400 kV UGC option

7.3.2 Economic performance for the new Finglas – Woodland 400 kV UGC option.

When all of the above costs and savings are considered, the economic result of the new Finglas – Woodland 400 kV UGC option indicates a poor result compared to the other options and hence is considered to have a moderate to high (**Blue**) impact on the economic result. To be able to differentiate between competing options in a measured way and to check the options' performance in different credible future energy scenarios, a robustness and sensitivity test was carried out. The objective is to identify the option that is impacted the least in its economic result for a range of credible future energy scenarios. This robustness test indicates a stable performance compared to the other options independent from which future energy scenario is used in the assessment.

After considering both the economic result and the robustness test, the new Finglas – Woodland 400 kV UGC is considered to provide a poor economic performance in comparison with the other options hence has been given a moderate to high impact (**Blue**) in the assessment.

Summary of economic performance of the new Finglas – Woodland 400 kV UGC option	
Economic result	
Robustness	
Combined Economic Performance	

Table 27 Summary of economic performance for Finglas - Woodland 400 kV UGC option

7.4 Deliverability

7.4.1 Implementation timelines

The expected timeline for the implementation of the 400 kV single circuit cable option is a period of 7.75 years in total. This is subject to and following statutory consenting for the structures and associated access routes. This time frame can be divided into two phases.

The first phase for all options is based on 4.5 years for the outline design, environmental assessment and the planning and permits process.

The second phase for the 400 kV single circuit cable option totals 3.25 years and includes detailed design, procurement of materials and construction works. This assumption includes time for the design to be confirmed, landowner consents being obtained by EirGrid and materials ordered in the first 1.5 years of this period. The design works, material procurement and construction period for the works required in the existing substations will be incorporated into the timeline.

The new 400 kV bays at Woodland 400 kV substation are estimated to take 1.5 years. At Finglas substation there are several impediments to the implementation timelines. A new 400 kV GIS substation is to be built on the already constrained site. The site for the 400 kV GIS is currently occupied by the old 110 kV AIS infrastructure. There are still transfer of existing circuits required before this older equipment can be decommissioned, and the site cleared.

In addition, the only remaining spare bay is a line bay which would need to be converted to a transformer bay and the outages to complete this are rarely granted. Timelines for the procurement of the required transformer is approximately 2 years.

There are yet unknown cable diversions at lower voltages which would have to be completed before the station and circuit could be energised. Taking all of these impediments into consideration equates to approximately 1 year to design and 4 years to construction timeline.

The UGC option has the shortest timeline of all of the options. The impact of the implementation timelines on the project is assessed to be moderate (**Blue**) for this option.

7.4.2 Project plan flexibility

Routes for the cable options will be developed in Step 4 of our grid development process should they be brought forward to that step. The cable route would be developed in line with EirGrid standard practices. It is established practice in grid development that transmission cables should be constructed in the existing public road network if possible. This is to make access and maintenance to the cable easier once the project is constructed.

One consideration in the selection of suitable roads to accommodate the cable options is the width of the required cable trench. All the cable options will require approx. 2.1 metre-wide trench and a working strip area wide enough to accommodate the required machinery. The road network in the study area will provide some flexibility in the identification of the best performing route. The use of Horizontal Directional Drill (HDD) technology to cross existing rivers, rail and roads will provide flexibility to avoid crossing point constraints.

Once the emerging preferred route has been submitted for planning consent, there is limited flexibility as we would need to work within the constraints of the site development boundary (otherwise known as the redline) of the route and the technical limitations of the cable route such as bending radius and fixed joint bay locations of the cable.

This option considered to have a moderate to high (**Blue**) impact on the project plan flexibility.

7.4.3 Risk to untried technology

In general, cables are increasingly used in transmission systems across the world and the mitigations to technical issues that arise with the technology are well known, and generally tried, and tested. In an Irish context, the first 220 kV XLPE cable was installed in 1984, and there are a number of recent projects on the Irish transmission system using this technology.

Another consideration in terms of untried technology is the use of long sections of UGC. This can lead to many technical issues which require specialised technical studies to determine if it is technically feasible to use a particular length of cable. Although, these studies have been carried out in Step 3 they may have to be repeated in Step 4 if any cable option is progressed to take account of the actual cable route determined. All cable options will require shunt reactors at either end of the cable to compensate the cable capacitance to keep the voltage within standards under normal operation.

Although shunt reactors are in place in the transmission system today, the size of the required shunt reactors for some of the UGC options is large and there is limited experience with these types of installations. The cable option may also require installation of filters in several substations in the network to mitigate any harmonic voltage distortions. The location of the filters cannot be determined until the design of the cable is known and this poses a risk for UGC options.

The installation of long lengths of 400 kV XLPE UGC became possible in the late 1990s with the development of a suitable cable joint for connecting lengths of such cable together. Nevertheless, EirGrid's experience with 400 kV cable is limited, with only a very small amount currently installed on the network.

Another aspect in relation to the UGC option is that Horizontal Directional Drilling (HDD) technology will very likely have to be used to cross specific obstacles within the study area, such as rivers and motorways, for short lengths of the cable route. This poses another risk to the UGC options as it is an expensive methodology, requiring the use of specialist equipment.

The risk to untried technology for the 400 kV single route cable option is considered to moderate to high (**Blue**).

7.4.4 Dependence on other projects (outages)

The UGC options would require a number of elements which would require planned outages.

The required work in both Woodland and Finglas substations would need proximity and commissioning outages. In Woodland, the work is in relation to the construction of the 400kV bay, which is included in CP1194 Woodland 400 kV redevelopment project.
In Finglas, the work involves the redevelopment of an existing 220kV bay as there is no room for extension to the busbar in Finglas substation. There would also be the construction of a new 400kV GIS substation which is dependent on CP0646 Finglas 110 kV decommissioning works of the old AIS switch gear. On-going projects in both these substations may cause conflicting outages depending on the projects' individual

programmes. This would have to be taken into consideration and could have impacts on granting necessary outages. There are efforts ongoing to masterplan stations elements, but this has not been developed for Finglas.

The dependence on other projects for Option 2 is considered to have a high (**Dark Blue**) level of impact.

7.4.5 Supply chain constraints, permits, wayleaves

For the new 400 kV UGC option, there may be significant supply chain constraints. This relates to the procurement and delivery of significant lengths (approx. 40km) of 400 kV UGC, the required filters and other associated large-scale equipment and testing apparatus. Cumulatively, this could result in significant supply chain constraints.

Permitting is likely to be challenging, with the provision of 400 kV UGC infrastructure in a suburban area of the Greater Dublin Area, irrespective of final design and location. It is confirmed, for the purpose of this analysis, that cable trenches will require to be 4m in width; in addition, it is envisaged that an 8m working width corridor will be required adjacent to the cable trench, thereby requiring an overall cable alignment width (permanent and temporary) of approx. 12m.

There are no roads within the receiving environment that could accommodate this width of construction corridor without significant temporary and/or permanent alteration, such as the removal of ditches, boundary vegetation, front gardens, walls and piers etc. Moreover, such roads would have to be closed for a considerable period of time, with potentially significant implications for traffic movements for both local access and commuter traffic. Overall, this would result in an impact of some significant scale and extent along the entire width of any UGC route.

It is currently considered that the UGC options, due to their size, scale and likely impact, are likely to require planning permission. If statutory consent is required, it is likely to be the subject of an application directly to An Bord Pleanála (ABP) as Strategic Infrastructure Development (SID). It is considered likely that, given the nature and extent of the development and its potential environmental and community impact, as well as the potential public interest in the proposed development, ABP would hold a full Oral Hearing in respect of a new 400 kV UGC development.

There is the potential for the UGC circuits to occur cross-country – i.e. away from public roads. This brings its own significant challenges in terms of landowner engagement and concerns, environmental and land use impacts – in particular the inability to undertake certain types of agricultural activity thereon.

It is assumed that significant engagement with landowners with properties along public roads would be required in the delivery of a new 400 kV circuit, for such purposes as surveying, siting and construction. These landowners may be new to accommodating electricity infrastructure on their landholdings. New temporary and permanent easements would be required to facilitate construction of the new circuit. Based on recent precedent in terms of the provision of new high-voltage UGC transmission infrastructure, there is the potential for significant landowner opposition to this option.

Having regard to all the above, this option is considered to have a moderate (**Dark Green**) impact in relation to the Supply Chain Constraints, Permits and Wayleaves criterion.

7.4.6 Conclusion of deliverability performance

There are five sub criteria considered when the overall deliverability performance is assessed. The UGC options have the best implementation timelines when compared to the other options under consideration. This is a benefit to these options as implementation timelines for any network reinforcement are important to be able to assure that the transmission network will be in compliance with security standards and that all consumers have a secure electricity supply.

It is likely that all of the UGC options would require planning permission or statutory consent, due to their size, scale and likely impact on the receiving environment. They would preferably be accommodated in the public road network and would require a 2.1 m cable trench and an additional working strip, thereby requiring an overall cable alignment width (permanent and temporary) of up to 12 metres in certain places. This could have significant impacts and may impact deliverability of these UGC options. Road closures and potentially significant implications for traffic movements for both local access and commuter traffic would be a factor for all the UGC options during construction

For a new 400 kV UGC from Woodland to Finglas, some of the aspects are considered to have high to moderate impact on the deliverability of the option. The aspects with the highest risks for these options are dependence on other projects and project plan flexibility. This option is deemed to have a high (**Dark Blue**) from a deliverability point of view.

Summary of deliverability performance of Option 2: Finglas - Woodland 400 kV UGC	
Implementation timelines	
Project plan flexibility	
Risk of untried technology	
Dependence on other projects	
Supply chain constraints, permits, wayleaves etc.	
Combined Deliverability Performance	

Table 28 Summary of deliverability performance for Finglas - Woodland 400 kV UGC option

7.5 Environmental Assessment

7.5.1 Biodiversity

There is a low to moderate (**Green**) risk of significant impacts on biodiversity as a result of this option. In the absence of mitigation, the greatest effects on biodiversity would be during construction, where despite cables primarily being laid in public roads, there is potential for impacts on hedgerows, tree lines and aquatic ecosystems; other habitats and species may also be disturbed or fragmented during the construction phase and effects could be permanent in some cases. There is also the potential for permanent loss of mature trees along the route, especially where roads are very narrow or where the UGC is required to cross fields and hedgerows off-road.

7.5.2 Soils and Water

There is a moderate (**Dark Green**) risk of significant impacts on soils and water as a result of this option. The greatest impacts would be during construction. The risk to water bodies from silt and spillages during the construction process would be Moderate as there are a number of waterbodies in the Finglas Study Area which would need to be crossed; it would not always be possible to use existing bridges for this purpose and in these cases, it would be necessary to go off-road and use other crossing techniques such as open cut trenches. There is also the potential for impacts on roadside ditches during construction.

7.5.3 Materials Assets - Planning Policy and Land Use

There is a low to moderate (**Green**) risk of significant impacts on planning policy and land use as a result of this option. This option supports the ambitions of local planning policy for new transmission infrastructure to be underground where possible. There is the potential for the sterilisation of land where a UGC crosses third party lands, however that would be limited as a result of the preference to use public roads. This preference also reduces the level of land take required, except at the connections into Woodland and Finglas: here there is the potential that the cable would have to be installed across third party land, requiring significant temporary land take during construction. This land take would be limited during operation, although a permanent wayleave and some restriction of agricultural practices above the UGC is likely.

7.5.4 Landscape and Visual

There is a low to moderate (**Green**) risk of significant impacts on landscape and views as a result of this option. The impacts would be greatest during construction, but this impact would be temporary in nature. During operation, the impacts would be limited. There would be visible joint boxes periodically along the UGC route, although these would be quite small. There may also be some requirement for third party land take and permanent loss of mature trees and hedgerows at points along the route and connections to the substations.

7.5.5 Cultural Heritage

There is a low to moderate (**Green**) risk of significant impacts on cultural heritage as a result of this option. The impacts on cultural heritage from the UGC would be greatest during construction, both in terms of ground disturbance and impacts on the settings of heritage assets. The crossing of third-party lands at the substations presents a greater risk to heritage assets, especially unknown archaeological assets, than installation in the regional road network.

7.5.6 Noise and Vibration

There is a low to moderate risk of significant impacts from noise and vibration as a result of this option. Potential noise and vibration impacts from the UGC would be during the construction phase and would result from the trench works, particularly in areas of hard-standing, such as along roads. However, the baseline noise environment along roads is higher than that of rural areas, and as such, the impact is not likely to be significant. There may be a slightly greater impact at Woodland substation due to the rural nature of the area, but appropriate noise screening will be provided to minimise any noise nuisance. No impacts are anticipated during the operational phase, as the cable will be buried.

7.5.7 Climate Change

There is a low to moderate (**Green**) risk of significant impacts on and from climate change as a result of this option. UGCs are reasonably resilient to the impacts of climate change, such as storms, wind, and rain, although changes in ground temperature and reduced moisture may have impacts on the efficiency of the cables. The volume of material required to construct an UGC between Woodland and Finglas is significant and carries with it associated embodied energy.

7.5.8 Summary of Environmental assessment of a new 400 kV UGC

The greatest risks to the environment from this option are on soil and water, owing to the high number of water bodies in the study area, the likelihood of having to come off-road to cross them in the more rural areas and the number of roadside ditches present. For other environmental aspects the risks are low to moderate that this option would cause significant impacts; for all topics any risk would be during construction and therefore of a temporary nature. UGC are in accordance with local planning policy ambitions and are more resilient to the impacts of climate change. As a result, this option has an overall low to moderate risk of significant impacts on the environment (**Green**).

Topic	Option 2 (New Finglas - Woodland 400 kV UGC)
Biodiversity	
Soil and Water	
Planning Policy and Land Use	
Landscape and Visual	
Cultural Heritage	
Noise and Vibration	
Climate Change	
Combined Environmental Performance	

Table 29 Summary of environmental assessment for Finglas - Woodland 400 kV UGC option

7.6 Socio-economic Assessment

7.6.1 Traffic and Transport

There is a moderate (**Dark Green**) risk of significant impacts on Traffic and Transport as a result of this option. It is EirGrid's preference to install UGC in the public road network. As a result, assuming an UGC rote would be largely in the public road, there are potentially very significant impacts on local and regional roads during its construction. Public roads in the Study Area vary in their widths, with some being only 4m wide, up to much wider regional roads of greater than 6m. Where routing is in more narrow roads, installation may necessitate whole road closures and diversions for short periods of time. In the wider roads, one carriageway may require to be closed, resulting in the need for traffic management measures. This would lead to driver and pedestrian delay; increased fear and intimidation for pedestrians, especially where there are no footpaths along the roads being used; and potentially severance of communities, community facilities and businesses if any roads need to close. There are also potential implications for businesses, with employees and goods experiencing delays.

7.6.2 Amenity

There is a low to moderate (**Green**) risk of significant impacts on amenity as a result of Option 2. As is set out in Section 6.6.2, amenity considers the combined impacts of traffic, views and noise during construction and views and noise during operation. There would be no impacts on noise and limited impacts on views in operation so only construction impacts are considered here. Noise impacts were considered to be low to moderate given the preference to use the public road network; whilst traffic impacts during construction may be significant, as described in Section 7.6.1, they are temporary in nature. In considering the combined amenity impact a greater weight is afforded to permanent. As a result, the risk would be low to moderate that significant impacts would occur.

7.6.3 Health

There is a low to moderate (**Green**) risk of significant impacts on health as a result of this option. Potential impacts relate to stress and anxiety associated with Traffic impacts, amenity impacts and 'nuisance' emissions such as noise. No significant impacts are anticipated from noise; there is a low to moderate risk of amenity impacts; and traffic impacts are moderate, Concerns relating to EMFs relating to electrical transmission lines can also lead to increased stress and health issues. There is no electric field above ground level of underground cables as the field is fully screened by the cable sheath. Magnetic fields from UGC drop rapidly with lateral distance. EirGrid's design standards require all OHLs to operate to existing public exposure guidelines from ICNIRP; recent studies (EirGrid 2014) show that surveyed existing underground cables are well below the ICNIRP reference level set to protect public health. Taking into account all of these factors, it is considered there would be a low to moderate risk of significant impacts to health as a result of this option.

7.6.4 Economy

Potential impacts on the economy from this option are considered to be positive but are of a low (**Cream**) risk, i.e., unlikely, to be significant for the local and regional economy. This is due to the likelihood that a small construction workforce is envisaged to be required to construct this option, and its atypical nature will also require construction workers to have particular skills and experience, making it harder for currently employed individuals to gain employment on the project. Similarly, supply-chain benefits are likely to positive but limited given the specialised nature of construction. During operation, potential impacts on the economy are anticipated to be positive (in the context of reinforcing the wider electricity network), albeit limited given the nature of the project.

7.6.5 Utilities

There is a low to moderate (**Green**) risk of significant impacts on utilities as a result of this option. It is EirGrid's preferred approach for UGC solutions, to use the existing road network (burying cables within the roads themselves) rather than within greenfield agricultural lands. As such, there is a greater potential to encounter pre-existing underground utilities than may otherwise be the case were an offline route to be taken or an OHL constructed. There are likely to be a number of underground utilities in the regional and local road network between Woodland and Finglas substations, including other electricity cables, telecommunication cables, sewers, and public and private water supplies. Whilst any utilities that are required to be altered or diverted would be done so at a time when disruption to the public would be reduced insofar as possible, and any disruption would be of a short duration, there is a reasonable likelihood of encountering other utilities during construction.

7.6.6 Summary of Socio-economic assessment

The greatest risk of this option, from a socio-economic perspective, is on Traffic and Transport. For other socio-economic topics the risk of significant impacts is considered to be low to moderate or low (economy). The impacts on traffic are not insubstantial, especially in the more urban areas of the study area; however, they are temporary in nature. As a result, this option has an overall low to moderate risk of significant impacts from a socio-economic perspective (**Green**).

Topic	Option 2 (New Finglas – Woodland 400 kV UGC)
Traffic & Transport	
Amenity	
Health	
Economy	
Utilities	
Combined Socio-Economic Performance	

Table 30 Summary of Socio-Economic performance for Finglas - Woodland 400 kV UGC option

7.7 Summary of the assessment for the Woodland to Finglas 400 kV UGC option

This option would involve constructing a new 400 kV UGC between Woodland 400 kV and Finglas 220 kV substations. This option is the best performing option in the environmental and socio-economic criteria compared to the other options. The technical criterion is the worst performing compared to other options, given the expansion or extendibility difficulties at Finglas 220 kV substation.

Having considered all of the five criteria, the outcome of the multi-criteria assessment indicates that the new Woodland to Finglas 400 kV UGC option (Option 2) does not perform very well, and it has been given a high impact (**Dark Blue**) on its overall performance.

Topic	Option 2: FIN - WOO 400 kV UGC
Technical Performance	
Economic Performance	
Deliverability	
Environmental	
Socio-economic	
Combined Performance	

Table 31 Overall Assessment outcome for the Finglas - Woodland 400 kV UGC option

8 New Belcamp to Woodland 400kV Overhead Line

This section describes the assessment of the new Belcamp to Woodland 400 kV OHL option against the five criteria, and their sub-criteria as described in Section 4.2. Each criterion is described in separate sections and a summary of the overall performance of the option is provided in Section 7.7.

The assessments for the environmental and socio-economic criteria have been carried out by Jacobs, and a summary of its findings are presented in this report. Jacobs' detailed reports of these assessments can be found on our website and the links can be found in Section 2.1.

8.1 Description of option

This option involves a transmission network reinforcement centred on strengthening the network between the existing Belcamp 220 kV substation in County Dublin and Woodland 400 kV substation in County Meath. These consist of:

- Construction of a new 400 kV overhead line linking Belcamp 220 kV station to Woodland 400 kV station. For the purpose of this investigation, we have assumed the length of the overhead line to be approximately 34 km;
- At the existing Belcamp 220 kV station a new 400 kV C-Type busbar, and one 400/220 kV transformer. The new 400 kV station development must be capable of accommodating a future second 400/220 kV transformer and future additional 400 kV circuits, and expansion of the station to an enhanced ring busbar.
- At the existing Belcamp 220 kV station new 220 kV transformer bay will be required to connect the new 400/220 kV transformer.
- At the existing Woodland 400 kV station a new line bay will be required to connect the new circuit.

8.2 Technical Performance

8.2.1 Compliance with health and safety standards

Please refer to Section 4.2.1 for a detailed description. The new Belcamp – Woodland 400 kV OHL option will be compliant with the relevant safety standards and is considered to have a low (**Cream**) risk of not complying with health and safety standards.

8.2.2 Compliance with Security and Planning Standards

The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operational Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The new Belcamp – Woodland 400 kV OHL option proposed will comply with the relevant system reliability and security standards referenced above. Although the option will meet the minimum technical requirements, certain aspects may differentiate the option's technical performance compared to other options. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), of either of the existing 220 kV circuits between Woodland and Corduff or Clonee, would lead to power flows in excess of the capacity of those circuits. The analysis indicated that generation redispatch to increase conventional generation in North Dublin would be required to mitigate the overloads. This issue was shown to worsen as demand in Dublin increases.

When the new Belcamp – Woodland 400 kV OHL option is added to the system model, the analysis indicates an improvement in these issues by removing the expected overloads between Woodland and Corduff or Clonee.

An assessment was undertaken into keeping the transmission network within standards following a loss of plant and equipment while another is out for planned maintenance. Maintenance is carried out annually during March to October. For planned outages, some re-dispatch of generation is allowed, but this should be kept to a minimum to ensure the most cost-effective generation is dispatched.

The assessment determined the worst case to manage was planned maintenance on the new Belcamp – Woodland 400 kV OHL. This requires generation redispatch within allowed limits to manage a subsequent unplanned loss of transmission equipment. Without redispatch the issues identified in the need assessment would be experienced, with the unplanned loss of the Corduff – Woodland 220 kV circuit leading to a loading of 146% on Clonee - Woodland. This is an improvement on the issues indicated in the needs assessment, which showed that during a maintenance and trip combination the Clonee – Woodland circuit could expect an overload of 172% depending on dispatch conditions.

When all aspects are considered, the new Belcamp – Woodland 400 kV OHL option is considered to have good compliance when assessed against the above standards and hence has been given a low impact (**Cream**) in the assessment.

8.2.3 Reliability performance

This criterion has been assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the asset. The reliability and outages of the station equipment associated with the circuit is assumed to be same for all options and is therefore not included in this analysis.

The statistics for reliability are based on EirGrid's and international failure statistics, the mean time to repair and the availability in days per 100 km per year for OHL and UGC. It has been assumed that the new OHL circuit will be approximately 34 km in length for the purpose of this assessment.

There are 439 km of existing 400 kV OHLs in Ireland. This length of 400 kV OHL is too small a sample for determining meaningful performance statistics.

Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity of 400 kV, 275 kV and 220 kV OHLs (approximately 2317 km) in the All-Island transmission system.

Unplanned Outages:

Almost all OHL faults are of short duration as a result of transient faults such as lightning strikes. If an auto-reclose function is provided for the protection of the line, it will restore the circuit shortly after the fault, generally in 0.5 – 3 seconds. Even if the line suffers physical damage, faults can be rapidly located and identified by visual inspection from the ground or air, and repairs effected in a matter of hours. Transmission system statistics indicate that 91.7 % of overhead line outages lasted less than one day[27].

Taking the fault statistics of the above combined network length of OHL for the period 2004 to 2020, gives a projected fault rate of 0.54 unplanned outages/100km/year.

Given typical repair times, this would equate to the circuit being out of service due to a permanent fault for 8 approx. hours per annum. The average failure rates during normal operation, average repair times and availabilities of the main elements of a typical 400 kV OHL are set out in Table 32 and adjusted to reflect the length of the proposed option.

Transient faults are not considered, as any interruptions to supply that they may cause would be of such short duration that their effect is considered to be negligible, despite acknowledging this may be an inconvenience for electricity users.

Planned outages:

Planned outages are normally associated with routine maintenance. For a 400 kV OHL, much of the required routine maintenance can be completed without an outage of the circuit. The planned outage rates and the typical outage durations taken from our maintenance policies[26] result in an annual planned outage rate of 0.65% for the 400 kV option, or circa 2.5 days per annum[27].

Combination of the planned and unplanned outages:

Due to the length of the new OHL circuit (approximately 34km), the total unplanned outage time per year is circa 9 hours, which combined with the planned outage rate of 2.5 days sums to a total of 3 days per annum (rounded to nearest half day).

Parameter	Average statistics for 400 kV & 220 kV OHL combined
Reliability (Unplanned outages/34km/year)	0.18
Mean time to repair (days)	Circa 2 days
Unplanned Outages (combined) Unavailability due to disturbance (h/34km/year)	0.34 days (c.9 hours)
Planned Outages	2.5 days
Total Annual Unavailability (days/34km/year)	3 days

Table 32 Average failure statistics for a 34km 400kV or 220kV OHL

[26] EirGrid, Analysis of Disturbance and Faults 2018, System Performance, April 2019
[27] EirGrid, Transmission Engineering Maintenance Statistics

The availability rate for the new Belcamp – Woodland 400 kV OHL option is high at 99.2% over any given year and this OHL option is deemed to have a low risk of introducing additional reliability issues in the system (**Cream**).

8.2.4 Headroom

The new 400 kV OHL option accommodates a similar amount of large-scale demand in the Dublin and Mid-East region compared to the other options.

The assessment indicates that the new Belcamp – Woodland 400 kV OHL option creates headroom (increases the amount of additional large-scale demand that could be accommodated) of approximately 275 – 300 MW compared to no reinforcement, depending on which scenario is analysed.

The new Belcamp – Woodland 400 kV OHL option performs well in the headroom criteria compared to the other options and is deemed to have a moderate (**Dark Green**) performance in terms of headroom.

8.2.5 Expansion or extendibility

The new Belcamp – Woodland 400 kV OHL option is based on Overhead Line (OHL) technology and has a thermal capacity[28] equivalent to the existing 400 kV circuits. The option provides a platform for future demand or generation development within the east of the country.

In the event that another connection along the circuit would be required, this could be achieved by constructing another substation which could be connected into this line. This is a very common way to expand the transmission network and is normally technically feasible and achievable, depending on the required connection size.

The planned expanded Belcamp site will have sufficient space for the initial 400 kV busbar and transformer required, as well as any future needs for an expansion to the busbar and any additional 400/220 kV transformers or further 400 kV circuits.

As such, this option has the potential to provide a base for any further expansion of the transmission network and the option offers a low to moderate (**Green**) difficulty to accommodate potential future expansion.

[28] Thermal capacity of existing 400 kV OHL is a winter rating of 2963 A and summer rating of 2506A based on conductor 2 x 600 mm2 ACSR CURLEW at 80°C,

8.2.6 Repeatability

Overhead Line (OHL) technology is already in use on the Irish transmission system with more than 4,500 km of circuit length. This criterion is assessed on a technical basis and there are few technical issues with OHL technology that would introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of OHL circuits on the Irish transmission system. There may of course be other challenges with OHL technology, but they are assessed under other criteria.

Similarly, substations using both Air Insulated and Gas Insulated switchgear are already used extensively in the Irish transmission system and so will not introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of the technology on the Irish transmission system.

This option is considered to have a low risk of not meeting the repeatability criteria (**Cream**).

8.2.7 Technical operational risk

The new Belcamp – Woodland 400 kV OHL option is based on Overhead Line (OHL) and Air or Gas insulated substation switchgear technology. This technology is tried and tested internationally and in Ireland and it is considered to have a low operational risk. This option is therefore considered lowest on the difficult/ risk scale (**Cream**) in terms of operational risk.

8.2.8 Conclusion of technical performance

This option is considered to perform well when all of the technical sub-criteria are considered and hence has been given a low to moderate impact (**Green**) in the assessment.

Summary of technical performance of the Belcamp – Woodland 400 kV OHL option	
Health and Safety Standard compliance	
Security & Planning Standard compliance	
Reliability performance	
Headroom	
Expansion or Extendibility	
Repeatability	
Technical Operational risk	
Combined Technical Performance	

Table 33 Summary of technical performance for the new Belcamp - Woodland 400 kV OHL option

8.3 Economic Assessment

The economic performance of the options is represented using our colour scale with the individual performance of an option assessed relative to the performance of the other solution options.

8.3.1 Input cost to the economic appraisal

8.3.1.1 Pre-engineering cost

The pre-engineering costs are estimated to be €10 million. In the economic appraisal, a contingency provision of 5% has been applied to this amount.

The phasing of the pre-engineering costs is as follows:

Phasing of Pre-Engineering Spend– New Belcamp – Woodland 400 kV OHL					
2022	*2023*	*2024*	*2025*	*2026*	*2027*
16%	45%	15%	15%	8%	0%

Table 34 Phasing of pre-engineering spend for new Belcamp - Woodland 400 kV OHL

8.3.1.2 Implementation cost

The capital investment required to deliver the new Belcamp – Woodland 400 kV OHL option is estimated to be €131.8 million. A provision for Transmission System Operator (TSO) related implementation cost and landowner payments, proximity allowance and local community fund has been included in this cost. In the economic appraisal, a contingency provision of 10% has been applied to this amount. The estimated implementation cost is categorised into its general components and is summarised in Table 35.

Categorised implementation cost – New Belcamp – Woodland 400 kV OHL	
Cost category	**Implementation cost (€m)**
Overhead line	40.1
Underground cable	N/A
Stations	69.1
Other (flexibility & proximity payments and other allowances)	10.6
SUB-TOTAL	119.8
Contingency (10%)	12.0
TOTAL	131.8

Table 35 Categorised implementation cost for new Belcamp - Woodland 400 kV OHL

The phasing of the implementation costs is as follows:

Phasing of implementation spend – New Belcamp – Woodland 400 kV OHL										
2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
10%	25%	20%	10%	10%	10%	5%	5%	5%	0%	0%

Table 36 Phasing of implementation cost spend for new Belcamp - Woodland 400 kV OHL

8.3.1.3 Life-cycle cost

This sub-criterion consists of three separate inputs incurred over the useful life of the option, namely operation and maintenance cost, electrical losses and replacement cost.

The equipment associated with the new Finglas – Woodland 400 kV OHL option is expected to be maintained in accordance with the well-established existing practices. The operation and maintenance cost varies over the assets' lifetime and as such three periods of approximate costs are assumed. Table 37 displays rounded figures to the nearest thousand. No replacement cost is assumed as the equipment has a life expectancy of 50 years which is line with the period for the economic assessment.

Life-cycle cost for New Belcamp – Woodland 400 kV OHL		
Annual Operation and maintenance cost (€k)	0-20 year period	€327k
	21-40 year period	€493k
	41-50 year period	€245k
Annual Electrical losses cost (€M)	€3.8M	
Replacement cost	N/A	

Table 37 Life-cycle cost for the new Belcamp - Woodland 400 kV OHL option

8.3.1.4 Cost to Single Electricity Market

As described in Section 4.2.2, Economic performance criteria, the cost to the Single Electricity Market represents the cost for the periods when the reinforcement is unavailable. The unavailability is based on the reliability performance of the option. This is a cost to the single electricity market and is calculated as a combination of the benefit in production cost saving (project benefit) and reliability performance of the option.

The reliability performance of the option is taken from Section 7.2.3 Reliability. The production cost savings assessment used the TES 2019 scenarios and as such a range of annual production cost savings are used in the assessments as the different scenarios have different demand and generation patterns. Table 38 show the input for this criterion.

Cost to Single Electricity Market for Belcamp – Woodland 400 kV OHL option	
Annual Production cost saving (Benefit) (€m/annum)	Range €-1.2m to €17.8m
Annual unavailability of option during which benefits cannot be attributed	Unavailable for 3 days, available 99.18%
Annual Cost (saving) to SEM	Range €-1.2m to €17.7m

Table 38 Cost to Single Electricity Market for the new Belcamp - Woodland 400 kV OHL option

8.3.2 Economic performance for the new Belcamp – Woodland 400 kV OHL option.

When all of the above costs and savings are considered, the economic result of the new Belcamp – Woodland 400 kV OHL option indicates a good result compared to the other options and hence is considered to have a low to moderate (**Green**) impact on the economic result. To be able to differentiate between competing options in a measured way and to check the options' performance in different credible future energy scenarios, a robustness and sensitivity test was carried out. The objective is to identify the option that is impacted the least in its economic result for a range of credible future energy scenarios. This robustness test indicates a stable performance compared to the other options independent from which future energy scenario is used in the assessment.

After considering both the economic result and the robustness test, the new Belcamp – Woodland 400 kV OHL is considered to provide a good economic performance in comparison with the other options hence has been given a low to moderate impact (**Green**) in the assessment.

Summary of economic performance of the new Belcamp – Woodland 400 kV OHL option	
Economic result	
Robustness	
Combined Economic Performance	

Table 39 Summary of economic performance for new Belcamp-Woodland 400kV OHL option

8.4 Deliverability

8.4.1 Implementation timelines

The expected timeline for implementation of the 400 kV overhead line option from Woodland to Belcamp is a period of 16 years in total. This time frame can be divided into two phases.

The first phase is based on 5.25 years for the outline design, environmental assessment and the planning process, and would be subject to the outcome of the consenting process.

The second phase is 10.75 years and includes detailed design, procurement of materials and construction works. This assumption includes time for the design to be confirmed, all landowner consents to be obtained by EirGrid including the use of compulsory acquisition powers if necessary, and materials procurement in the first 5.75 years of this period.

This includes a period of one (1) year to allow for a modification of the approved planning permission, which in EirGrid's experience of grid development is a normal process, as the permitted development is subject to detailed design and the accommodation where possible of landowner preferences for tower siting. The time to construct the OHL (five (5) years) includes construction access, foundation works, tower erection and stringing which would include sections that require transmission outages.

The design works, material procurement and construction period for the works required in the existing substations has been incorporated into the above timeline for the OHL works. The timeline for new 400 kV bay at Woodland 400 kV substation is estimated at

1.5 years. At Belcamp station a new 400 kV GIS substation is required, this is estimated to take 2.5 years.

The implementation timeline for the 400 kV OHL option is the second longest option. The impact of the implementation timelines is assessed to be high (**Dark Blue**) for the 400 kV OHL option.

8.4.2 Project plan flexibility

Route corridors for the OHL would be developed in Step 4 of our grid development process and would factor in constraints in the study area. Within the corridors, there would be a reasonable level of flexibility to identify the OHL routes. Once the route options have considered all the constraints, an emerging preferred OHL route would be the basis for the planning submission. The preferred route would be designed within the identified corridor and the design would consider the access routes for construction, stringing locations and tree cutting requirements. The design would be completed to a level that we would consider the foundation requirements and would identify all the requirements for the line construction. There would be very little flexibility on the route once the planning consent is in place. Some of the tower locations may have the potential for minor modifications, which could require a modification to the planning consent. Access routes to the tower locations would also form part of the planning consent and changes to these would also require modification to the planning consent. The 400 kV OHL option is assessed to have a high (**Dark Blue**) impact on the project plan flexibility compared to the other options.

8.4.3 Risk to untried technology

OHL technology is tried and tested in Ireland and internationally. This technology is considered international best practice and is a proven technical solution for transmission of high-voltage electricity. It is the technology around which the transmission network in Ireland has been developed to date. Nevertheless, it has been some time since new 400 kV infrastructure was built in Ireland in the 1980’s and therefore it is not without some technological risk. Overall, this option is considered to have a moderate (**Dark Green**) risk in relation to this sub-criterion when compared to the other options.

8.4.4 Dependence on other projects (outages)

This option has a number of elements which would require planned outages.

The required work in both Woodland and Belcamp substations would need proximity and commissioning outages. In Woodland, the work is in relation to the construction of the 400kV bay, which is included in CP1194 Woodland 400 kV redevelopment project.

In Belcamp, the work involves the construction of a 400 kV GIS substation. Other on-going projects in both these substations may cause conflicting outages depending on the projects' individual programmes and this would have to be taken into consideration and could have impacts on granting necessary outages. There are efforts ongoing to masterplan substations elements, but this has not yet been developed for Belcamp.

The impact on the dependence on other projects for the 400 kV overhead line option is considered to be at a high to moderate (**Blue**) level.

8.4.5 Supply chain constraints, permits, wayleaves

For the purposes of this analysis, it is assumed that 400 kV structures, apparatus and equipment would be equivalent, if not similar in terms of nature and extent of materials, to that being planned and procured for the North South Interconnector (NSIC) development.

There are no significant supply chain constraints envisaged, with standard procurement and design timelines and scopes involved. Permitting is likely to be very challenging, with the provision of new 400 kV OHL infrastructure in what can be described as a peri-urban commuter belt of the Greater Dublin Area, irrespective of final design and location. The Woodland substation is also the terminus of the existing Moneypoint – Woodland 400 kV OHL circuit, and the permitted North-South Interconnector (NSIC) 400 kV OHL. Based on established precedent, the infrastructure development comprising the provision of a new 400 kV OHL circuit is likely to be the subject of an application directly to An Bord Pleanála (ABP) as Strategic Infrastructure Development (SID). Given the nature of the proposed development as comprising a new 400 kV OHL circuit, the planning application would be subject to Environmental Impact Assessment (EIA). These factors make it almost inevitable that ABP would hold a full Oral Hearing in respect of a new 400 kV OHL development. A new 400 kV OHL circuit would need to be located on a new alignment. This would result in potentially significant environmental and social impacts on receiving environments and communities, including biodiversity, land use activities, and visual impacts. Social impacts may include community concerns regarding the provision of new large-scale OHL within an area. Significant engagement with landowners and communities would be required in the delivery of the new circuit, for such purposes as surveying, siting and construction. These parties may be new to accommodating electricity infrastructure on their landholdings and within their communities. New wayleaves would be required to facilitate construction of the new circuit. Based on recent precedent in terms of the provision of new 400 kV transmission infrastructure, there is the potential for significant landowner, community and public concerns with this option, with the likely consequence of project delays or difficulties in gaining access to land. Having regard to all the above aspects, the 400 kV OHL option is deemed to have a significant (**Dark Blue**) impact and risk in terms of Supply Chain Constraints, Permits and Wayleaves.

8.4.6 Conclusion of deliverability performance

There are five aspects considered when the overall deliverability performance is assessed. For Option 1, an OHL to Finglas, most of these aspects indicate a high significance. This means that overall, this option is considered significantly challenging to deliver, with some risks and unknown technical issues that will have to be solved during the subsequent stages of project development.

The implementation timeline for any network reinforcement is important to be able to ensure that the transmission network will be in compliance with security standards and that all consumers have a secure electricity supply. The time it takes to develop, and construct reinforcements is also important in terms of accommodating new generation and demand that would like to connect to the system.

This option has a long implementation timeline compared to the UGC options and this, in combination with the perceived risk of delays due to societal acceptance, means this option does not perform well from a deliverability point of view and this has been taken into account in the overall assessment of this option.

When all of these deliverability aspects are considered, this option is deemed to have high impact (**Dark Blue)** from a deliverability point of view.

Topic	Option 3 (New Woodland to Belcamp 400 kV OHL)
Implementation timelines	
Project plan flexibility	
Risk of untried technology	
Dependence on other projects	
Supply chain constraints, permits, wayleaves etc.	
Combined Deliverability Performance	

Table 40 Summary of deliverability performance for the new Belcamp - Woodland 400 kV OHL option

8.5 Environmental

This assessment was carried out by Jacobs and a summary of its findings are presented in this report. The detailed Jacobs report (321084AJ-REP-004 – CP1021 Environmental Constraints report) is available on our website – see Section 2.1 for the link.

8.5.1 Biodiversity

There is a high (**Dark Blue**) risk of significant impacts on biodiversity as a result of this option. There is potential for impacts on protected sites as all of the water bodies in the study area are hydrologically connected to European designated sites on the coast at relatively close proximity as a connection approaches Belcamp substation, especially if it were to be routed from the north across the estuary at Malahide. There will be a permanent loss of habitat within the footprint of the pylons and as a result of a loss of some mature trees and there is a collision risk to birds migrating across the study area. These risks are greater than for Option 1 as the route is longer and is closer to designated sites and bird migratory routes. Although literature suggests that bird collisions with power lines are generally considered to be rare events, there is still potential for collision risk to bird species from the new OHL in addition to disturbance leading to displacement.

8.5.2 Soils and Water

There is a low to moderate (**Green**) risk of significant impacts on soils and water as a result of this option. The impacts would be only likely to occur during construction. These impacts would be fairly limited as Option 3 would aim to avoid designated water bodies and excavations would be limited to new pylon foundations. Short access tracks from local roads would be used, where possible, and would require minimal soil strip in site preparation. However, all water bodies in the study area are connected to designated sites on the coast and the potential for impacting these during construction increases as any OHL route approaches Belcamp. In addition, the increased size of the study area, length of the OHL and number of pylons required increases risks to water bodies for this option compared to Option 1.

8.5.3 Material Assets - Planning Policy and Land Use

There is a moderate (**Dark Green**) risk of conflict with planning policy and significant impacts on land use as a result of this option. There are some potential interactions with plan zonings within the Finglas Study Area; plan policies are broadly in support of electricity conveyance improvement and reinforcement development within the Finglas Study Area, however, it is possible that Option 3 would not fully accord with county planning policies, as new structures are proposed and there is a preference for new transmission connections to be underground. Perceived and actual impacts on land values may present significant constraints both in rural and urban areas. With careful routeing of OHL in consultation with communities and landowners, the risk of impacts would be reduced.

There is little scope for installing OHL in public roads however as there is for UGC so almost all of the land use would be 3rd party lands. New OHL corridors would require limited and temporary land take for construction, with short access tracks from local roads being used, wherever possible. Permanent land take would be limited to the footprint of the OHL pylons. There would however be a small number of significant impacts on particular parcels of land during the operational phase due to potential land use restrictions.

8.5.4 Landscape and Visual

There is a high (**Dark Blue**) risk of significant impacts on landscape and views as a result of this option. The potential for significant visual impacts in particular is identified and these would be permanent. Whilst sensitive landscapes, viewpoints and main settlements would be avoided where possible the length of this route and the high number of viewpoints which may be affected as a result means the risk of significant visual impacts remains high.

8.5.5 Cultural Heritage

There is a moderate to high (**Blue**) risk of significant impacts on cultural heritage as a result of this option. There would be a combined impact of the potential to encounter unknown archaeological assets during construction and the potential to impact the setting of built heritage assets during operation. Of these two potential impacts, however, the more significant impacts would be likely to arise on the setting of heritage features during operation. The increased length of this option and the subsequent requirement of a greater number of pylons and the potential for impacting the setting of more historic assets means there is a higher risk of significant impacts from this option than for Option 1.

8.5.6 Noise and Vibration

There is a low to moderate (**Green**) risk of significant impacts from noise and vibration as a result of this option. The construction of a new OHL and associated pylons would be likely to generate noise and vibration, most notably from works for pylon foundations. This noise impact would be temporary. There may also be some low levels of noise associated with the OHLs during operation. There is likely to be a greater impact in the area of Woodland substation due to its rural nature.

8.5.7 Climate Change

There is a moderate to high (**Blue**) risk of significant impacts to and from climate change as a result of this option. The OHL would be vulnerable to predicted future climate impacts associated with storms and winds and increased rainfall. Damage done could be difficult to repair as a result of increased flooding. This is a long-term risk and one that is predicted to increase over time. This would impact security of supply. This is an increased risk compared to option 1 because of the increased length of the route. The volume of material required to construct an OHL between Woodland and Finglas is significant and carries with it associated embodied energy. This would be greater than for Option 1.

8.5.8 Summary of Environmental assessment of the Woodland – Belcamp 400 kV OHL option

The greatest risks to the environment from this option are on Biodiversity and Landscape and Visual, owing to the high number of water bodies in the study area, the likelihood of having to come off-road to cross them in the more rural areas and the number of roadside ditches present. For other environmental aspects the risks are low to moderate that this option would cause significant impacts; for all topics any risk would be during construction and therefore of a temporary nature. UGC are in accordance with local planning policy ambitions and are more resilient to the impacts of climate change. As a result, this option has an overall low to moderate risk of significant impacts on the environment (**Green**).

Topic	Option 3 (New Belcamp to Woodland 400kV OHL)
Biodiversity	
Soil and Water	
Planning Policy and Land Use	
Landscape and Visual	
Cultural Heritage	
Noise and Vibration	
Climate Change	
Combined Environmental Performance	

Table 41 Summary of Environmental assessment of the new Belcamp - Woodland 400 kV OHL option

8.6 Socio-Economic

This assessment was carried out by Jacobs and a summary of their findings are presented in this report.

8.6.1 Traffic and Transport

There is a moderate to high (**Dark Green**) risk of significant impacts on Traffic and Transport as a result of this option. The greatest impacts to Traffic and Transport would be during construction as a result of construction traffic using local and regional roads as haul routes and accessing points to construction compounds or other construction installations. Such an occurrence could lead to driver and pedestrian delay; increased fear and intimidation for pedestrians, especially where there are no footpaths along the roads being used; and potentially severance of communities, community facilities and businesses if any roads need to close. Whilst impacts are temporary and comprise of construction traffic only, with no lengthy road closures anticipated, construction over a period of two years in an area as densely populated and congested as the study area would have a potentially significant impact on local traffic. In the wider study area to Belcamp there are four motorways and Dublin Airport. Construction traffic would be using these and regional roads. The longer route to Belcamp as compared to Option 1 to Finglas increases the risk of significant impacts.

8.6.2 Amenity

There is a high (**Dark Blue**) risk of significant impacts on amenity as s a result of this option. When considering the relative impacts identified for each of these topics in the assessment and then combining them, consideration is also given to the temporary or permanent nature of the impacts: Landscape and views are at a high risk of significant impacts and this is a permanent impact.; traffic impacts would be temporary only, albeit over a long period of time; noise impacts would occur in both construction and operation but are not considered to be significant. The longer route to Belcamp as compared to Option 1 to Finglas increases the risk of significant impacts compared to that option. As a result, and taking a precautionary approach, the combined assessment considers that there is a high risk of impacts on amenity.

8.6.3 Health

There is a low to moderate risk (**Green**) of significant impacts on health as a result of this option. Potential impacts relate to stress and anxiety associated with Traffic impacts, amenity impacts and 'nuisance' emissions such as noise. No significant impacts are anticipated from noise there is a moderate to high risk of amenity impacts which could lead to stress and anxiety, Concerns relating to EMFs relating to electrical transmission lines can also lead to increased stress and health issues. EirGrid's design standards require all OHLs to operate existing public exposure guidelines from ICNIRP and as such there should be no direct impact from EMFs; despite this EMFs are likely to remain a concern for local communities. This has been demonstrated in a number of public consultations. As a result, there remains a low to moderate risk to health as a result of this option.

8.6.4 Local Economy

There is a low (**Cream**) risk of significant impacts on the economy as a result of this option. In terms of employment, during construction the workforce would be relatively small in the context of the local and regional economy; it is likely to require specialist labour which may not be available locally. In operation there would be limited scope for employment opportunities. In terms of expenditure, there would be positive impacts on the local and regional economy, but this would be relatively low in magnitude. Specialist equipment is likely to be required from outside of the study area. In terms of potential impacts on the operation of Dublin Airport, beyond those related to road congestion, it is not considered there would be a significant impact. Development in the vicinity of airports is subject to a number of restrictions and an OHL would be subject to the same, to ensure the safe and continued operation of the airport.

8.6.5 Utilities

There is a low (**Cream**) risk of significant impacts to third party utilities as a result of this option. Above and below ground utilities are the same as those described for option 1, with the addition of more 110kV and 220kV connections. At Belcamp 220kV substation there is a 200kV UGC connection to Finglas and some local 110kV UGC connections. In addition to these, there are many 38kV and lower voltage OHLs criss-crossing the study area. Third party utility surveys will be undertaken prior to excavation for pylon foundations, thereby removing the risk of impacting underground cables, water supply pipes, private water sources or wastewater treatment systems.

8.6.6 Summary of Socio-economic assessment of the Finglas – Woodland 400 kV OHL option

The greatest risks from a socio-economic perspective from this option are to amenity. Risks to the economy and utilities are low; Traffic and Transport and health risks are considered to be moderate and moderate to low respectively. The risk to amenity is as a result of the significant.

Topic	Option 3 (New Belcamp to Woodland 400kV OHL)
Traffic & Transport	
Amenity	
Health	
Economy	
Utilities	
Combined Socio-Economic Performance	

Table 42 Summary of socio-economic performance for the new Belcamp - Woodland 400 kV OHL option

8.7 Summary of the assessment for the Woodland to Belcamp 400 kV OHL option

This option would involve constructing a new 400 kV OHL between Woodland 400 kV and Belcamp 220 kV substations. This option is the best performing option in none of the criteria compared to the other options. The environmental and socio-economic criteria are the worst performing compared to other options, given the specific environmental and visual sensitivities of the areas surrounding Belcamp 220 kV substation.

Having considered all of the five criteria, the outcome of the multi-criteria assessment indicates that the new Woodland to Belcamp 400 kV OHL option (Option 3) does not perform very well, and it has been given a high impact (**Dark Blue**) on its overall performance.

Topic	Option 3: BEL – WOO 400 kV OHL
Technical Performance	
Economic Performance	
Deliverability	
Environmental	
Socio-economic	
Combined Performance	

Table 43 Overall assessment outcome for the new Belcamp - Woodland 400kV OHL option

9 New Belcamp to Woodland 400kV Underground Cable

This section describes the assessment of the new Belcamp – Woodland 400 kV UGC option against the five criteria, and their sub-criteria as described in Section 4.2. Each criterion is described in separate sections and a summary of the overall performance of the option is provided in Section 7.7.

The assessments for the environmental and socio-economic criteria have been carried out by Jacobs, and a summary of its findings are presented in this report. Jacobs' detailed reports of these assessments can be found on our website and the links can be found in Section 2.1.

Due to the nature of UGC, additional investigations were carried out to better inform the assessment from a feasibility and technical point of view. There are certain aspects that we need to understand before an UGC option can be deemed feasible. For instance, the power carrying capacity (rating) of the cable is dependent on how it is laid in the ground.

These investigations included a high-level feasibility study to determine if indicative feasible routes (which achieve adequate capacity ratings) can be found in the road network in the study area and what type of obstacles the cables may have to cross. Jacobs carried out this assessment and its detailed report (321084AJ-REP-002 Rev A03 – Cable Feasibility Report) can be found on our website – see Section 2.1 for the link.

Also, other technical behaviours of UGCs had to be examined to avoid the cables causing damage to other electrical equipment once installed. These investigations included cable integration studies and indicative reactive compensation requirements, harmonic filter requirements, and temporary overvoltage assessments (TOV).

PSC carried out these assessments and its detailed report (Capital Project 1021 East Meath to North Dublin Grid Upgrade Cable Studies, EIR-014270, Rev 3, 7th June 2022) can be found on our website.

Further investigations will have to be carried out in relation to these issues if any of the underground cable options are brought forward to Step 4 to reflect the actual route and parameters of the cable option.

9.1 Description of option

This option involves a transmission network reinforcement centred on strengthening the network between the existing Belcamp 220 kV substation in County Dublin and Woodland 400 kV substation in County Meath. This consists of:

- Construction of a new 400 kV underground cable linking a new 400 kV busbar at the existing Belcamp 220 kV station to Woodland 400 kV station. For the purpose of this investigation, we have assumed the length of the cable to be approximately 45 km;
- At the existing Belcamp 220 kV station a new 400 kV C-Type busbar, and one 400/220 kV transformer will be built. The new 400 kV station development must be capable of accommodating a future second 400/220 kV transformer and future additional 400 kV circuits, and expansion of the substation to an enhanced ring busbar.
- At the existing Belcamp 220 kV station, a new 220 kV transformer bay will be required to connect the new 400/220 kV transformer.
- At the existing Woodland 400 kV station a new line bay will be required to connect the new circuit.
- Reactor compensation of c.100 MVAr at each station end of the new cable circuit will be required. The size of the reactor will be verified in further cable integration studies when circuit route and cable type are selected in later steps of the Six Step process.

9.2 Technical Performance

9.2.1 Compliance with health and safety standards

Please refer to Section 4.2.1 for a detailed description. The new Belcamp – Woodland 400 kV UGC option will be compliant with the relevant safety standards and is considered to have a low (**Cream**) risk of not complying with health and safety standards.

9.2.2 Compliance with Security and Planning Standards

The security standards of the transmission network are defined in the following:

- The Transmission System Security and Planning Standards (TSSPS); and
- The Operational Security Standards (OSS).

These standards will ensure that the system is planned and operated in a manner which adheres to system security and integrity, and reliability of supply criteria.

The new Belcamp– Woodland 400 kV UGC option proposed will comply with the relevant system reliability and security standards referenced above. Although the option will meet the minimum technical requirements, certain aspects may differentiate the option's technical performance compared to other options. A high-level summary of the technical aspects considered and investigated is presented below.

The need analysis indicated that, without mitigation, single contingencies (the unexpected loss of a circuit or piece of equipment), of either of the existing 220 kV circuits between Woodland and Corduff or Clonee, would lead to power flows in excess of the capacity of the remaining of the two circuits. The analysis indicated that generation redispatch to increase conventional generation in North Dublin would be required to mitigate the overloads. This issue was shown to worsen as demand in Dublin increases.

When the new Belcamp – Woodland 400 kV UGC option is added to the system model, the analysis indicates an improvement in these issues by removing the expected overloads between Woodland and Corduff or Clonee.

An assessment was undertaken into keeping the transmission network within standards following a loss of plant and equipment while another is out for planned maintenance. Maintenance is carried out annually during March to October. For planned outages, some re-dispatch of generation is allowed, but this should be kept to a minimum to ensure the most cost-effective generation is dispatched.

The assessment determined the worst case to manage was planned maintenance on the new Belcamp – Woodland 400 kV UGC. This requires generation redispatch within allowed limits to manage a subsequent unplanned loss of transmission equipment. Without redispatch the issues identified in the need assessment would be experienced, with the unplanned loss of the Corduff – Woodland 220 kV circuit leading to a loading of 146% on Clonee - Woodland. This is an improvement on the issues indicated in the needs assessment, which showed that during a maintenance and trip combination the Clonee – Woodland circuit could expect an overload of 172% depending on dispatch conditions.

When all aspects are considered, the new Belcamp – Woodland 400 kV UGC option is considered to have good compliance when assessed against the above standards and hence has been given a low impact (**Cream**) in the assessment.

9.2.3 Reliability performance

This criterion has been assessed using three inputs namely unplanned outages, planned outages and the time it takes to repair the circuit. The collective impact of these provides an indication of the annual availability of the asset. The reliability and outages of the station equipment associated with the circuit is assumed to be same for all options and is therefore not included in this analysis.

The statistics for reliability are based on EirGrid's and international failure statistics, the mean time to repair and the availability in days per 100 km per year for UGC. It has been assumed that the new Belcamp – Woodland 400 kV UGC circuit will be approximately 45 km in length for the purpose of this assessment.

Unplanned Outages*:*

As mentioned in Section 8.2.3, almost all faults on OHLs are of short duration as a result of transient faults. If an auto-reclose function is provided for the protection of the OHL, it will restore the circuit shortly after the fault. Auto-reclose is not available for faults on UGC and as such faults are considered to be long-lasting and will not be re-energised until an investigation has been undertaken. Consequently, when a cable fault occurs, finding a fault location and resolving it can result in prolonged circuit outages. As such, cable circuits have a lower availability than OHLs because of the prolonged outage times in the event of a fault.

There is only 1 km of existing 400 kV UGC in Ireland. This length of 400 kV UGC is too small a sample for determining meaningful performance statistics.

Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity (approximately 144 km) of 400 kV and 220 kV UGC under our control along with international failure statistics for cables[29]. Taking the fault statistics of this existing 144 km of UGC for the period 2004 to 2020, and the international failure for XLPE land cables from 220 kV to 400 kV, gives a projected fault rate of 0.27 Unplanned outages/100km/year.

[29] Cigre, TB379 Update of service experience of HV underground and submarine cable systems, 2020

Parameter	Average statistics for 400 kV & 220 kV UGC combined
Reliability (Unplanned outages/100km/year)	0.27
Mean time to repair (days)	25 – 45 Days[30]
Unavailability due to disturbance (days/100km/year)	7 – 12 days

Table 44 Average failure statistics for a 100km 400kV or 220kV UGC

Table 45 shows the statistics for reliability, the mean time to repair faults, and the unavailability for 220 kV and 400kV cables (based on international failure statistics for cables[29]). These statistics, given that they apply to XLPE[31] cables, are taken to be applicable for this option.

Planned outages:

Planned outages are normally associated with routine maintenance. The typical routine maintenance outage duration for 400 kV cables taken from our maintenance policies is 2-3 days per annum (dependent on the number of joint bays and cable sections). Each year an operational test is performed, and periodically an ordinary service. These maintenance outages equate to a total unavailability of 0.84%, or c.2.5 days per annum.

Combination of the planned and unplanned outages:

The combination of the planned and unplanned outages the Belcamp – Woodland 400 kV UGC option and the total annual unavailability are set out in the table below and adjusted to reflect the length of the proposed option.

[30] Dependant on installation method and number of joint bays
[31] XLPE cable means cross linked polyethylene

	Belcamp – Woodland 400 kV UGC (45 km)
Reliability (Unplanned outages/circuit length(km)/year)	0.121
Mean time to repair (days)	25 – 45 days
Unplanned outages (Combined) Unavailability due to disturbances (days/circuit length(km)/year)	3.1 – 5.5 days/annum
Planned Outages	2.5 days
Total Annual Unavailability	5.6 – 8 days/annum
Difficulty/risk scale	

Table 45 Average failure statistics for a 45km 400kV UGC

The average failure rate and time to repair for the new Belcamp – Woodland 400 kV UGC option is deemed to be high when compared to the OHL alternative. The availability of this option as a result of outages is in the range of 97.8-98.5% at best and unavailability could potentially be greater than a month per annum. Based on this assessment, the reliability criterion for the new Belcamp – Woodland 400 kV UGC is considered to be at a moderate performance (**Dark Green)**.

9.2.4 Headroom

The new Belcamp – Woodland 400 kV UGC option accommodates a similar amount of large-scale demand in the Dublin and Mid-East region compared to the other options. Underground cable options were noted to provide marginally better headroom due to their lower overall electrical impedance, and circuit options that terminate at Finglas were shown to perform marginally better than those terminating at Belcamp due to Finglas substation being connected to all the existing 220 kV circuit between Woodland and North Dublin.

The assessment indicates that the new Belcamp – Woodland 400 kV UGC option creates headroom (increases the amount of additional large-scale demand that could be accommodated) of approximately 275 - 325 MW compared to no reinforcement, depending on which scenario is analysed.

The new Belcamp – Woodland 400 kV UGC option performs well in the headroom criteria compared to the other options and is deemed to have a moderate (**Dark Green**) performance in terms of headroom.

9.2.5 Expansion or extendibility

The new Belcamp – Woodland 400 kV UGC will provide a future new circuit and as such there are opportunities for further expansion of the transmission network using this circuit as a platform in the future. In the event that another connection along the cable route is required, these cable options may make the opportunity for expansion and extendibility more challenging and difficult compared to if an OHL technology was used.

There are a number of aspects which make this more challenging. The cable circuit is relatively long and requires bespoke reactors at each end of the of the cable to limit the impact during energisation of the cables and also during normal operation as the reactors will make sure that the voltage does not deviate outside planning standards.

If the length of the cable is changed then these reactors would have to be resized and new reactors purchased. In the event that the cable is associated with harmonic filters, then additional studies would have to be undertaken to ensure that the filters are properly tuned for any new cable length and size. This could mean that some purchased equipment would become redundant in the future, if the cable option chosen is altered. There may also be limitations on route options for diversions or connections to the new circuit in the road network (cables are preferably accommodated in roads to have easier access to the asset for maintenance and repair).

The new Belcamp – Woodland 400 kV UGC option has a target thermal capacity[32] equivalent to the existing 400 kV circuits. Assessments of cable types available to maximise the capacity of the new circuit are under way at the time of this report. The result of these assessments will be an input to analysis in later steps of the Six Step process. The route selected will also be analysed for thermal pinch points, such as crossing roads or waterways or other cable circuits, that limit the capacity of the new circuit allowing mitigations to be developed where possible.

The planned expanded Belcamp site will have sufficient space for the initial 400 kV busbar and transformer required, as well as any future needs for an expansion to the busbar and any additional 400/220 kV transformers or further 400 kV circuits.

[32] Thermal capacity of existing 400 kV OHL is a winter rating of 2963 A and summer rating of 2506A based on conductor 2 x 600 mm2 ACSR CURLEW at 80°C,

After considering all aspects in this criterion, all cable options provide a worse base for any further expansion of the transmission network compared to OHL technology.

The implications of the opportunity for expansion and extendibility is more challenging and difficult compared to OHL technology and new Belcamp – Woodland 400 kV UGC option will have a high (**Dark Blue**) impact in terms of difficulty to accommodate potential for future expansion. expansion.

9.2.6 Repeatability

Underground Cable (UGC) technology for 220 kV and 400 kV voltages is already in use in the Irish transmission system, but on a smaller scale compared to OHL. Every time an UGC option is proposed as a solution, each cable option will have to be studied on its own merits. Bespoke network design would have to be considered for each option that would take account of necessary harmonic distortion introduced by any cable or if voltage limiting equipment is required to accommodate the cable options into the transmission network.

In terms of repeatability, it is recognised that there may be limitations in the network in regards to accommodating cables. The impacts of the above points are usually greater the higher the operating voltage of the cable used.

Similarly, substations using both Air Insulated and Gas Insulated switchgear are already used extensively in the Irish transmission system and so will not introduce additional system integration, operational, and maintenance complexity that would affect the repeatability of the technology on the Irish transmission system.

As such, it is considered that the new Belcamp – Woodland 400 kV UGC option has high to moderate risk of not meeting the repeatability criteria (**Blue**).

9.2.7 Technical operational risk

Underground cable and Air or Gas insulated substation switchgear are technologies that are tried and tested internationally and in Ireland. However, the nature of cable technology means that when cables are used over long lengths they require a bespoke design to be able to be accommodated into the network while remaining within the technical network design standards.

The voltage level and the considerable length will influence the technical operational risk in regards to cable options. Special energising and switching procedures will be required to manage any of the UGC options in an operational environment.

These aspects and additional equipment required to accommodate the underground cable will increase the technical operational risk. The new Belcamp – Woodland 400 kV UGC option is considered to have a high to moderate (**Blue**) impact in relation to technical operational risk.

9.2.8 Conclusion of technical performance

This option is considered to perform adequately when all of the technical sub-criteria are considered and hence has been given a moderate to high impact (**Dark Green**) in the assessment.

Summary of technical performance of the new Belcamp – Woodland 400 kV UGC option	
Health and Safety Standard compliance	
Security & Planning Standard compliance	
Reliability performance	
Headroom	
Expansion or Extendibility	
Repeatability	
Technical Operational risk	
Combined Technical Performance	

Table 46 Summary of technical performance of the new Belcamp - Woodland 400 kV UGC option

9.3 Economic Assessment

The economic performance of the options is represented using our colour scale with the individual performance of an option assessed relative to the performance of the other solution options.

9.3.1 Input cost to the economic appraisal

9.3.1.1 Pre-engineering cost

The pre-engineering costs are estimated to be €11 million. In the economic appraisal, a contingency provision of 5% has been applied to this amount.

The phasing of the pre-engineering costs is as follows:

Phasing of Pre-Engineering Spend – New Belcamp – Woodland 400 kV UGC					
2022	*2023*	*2024*	*2025*	*2026*	*2027*
21%	52%	14%	14%	8%	0%

Table 47 Phasing of pre-engineering spend for Belcamp - Woodland 400 kV UGC

9.3.1.2 Implementation cost

The capital investment required to deliver the new Belcamp – Woodland 400 kV UGC option is estimated to be €486 million. A provision for Transmission System Operator (TSO) related implementation cost and landowner payments, proximity allowance and local community fund has been included in this cost. In the economic appraisal, a contingency provision of 10% has been applied to this amount. The estimated implementation cost is categorised into its general components and is summarised in Table 48.

Categorised implementation cost – New Belcamp – Woodland 400 kV UGC	
Cost category	Implementation cost (€m)
Underground cable	357.8
Stations	76.7
Other (flexibility & proximity payments and other allowances)	7.5
SUB-TOTAL	442.0
Contingency (10%)	44.2
TOTAL	486.2

Table 48 Categorised implementation cost for Belcamp - Woodland 400 kV UGC

The phasing of the implementation costs is as follows:

Phasing of implementation spend – New Belcamp – Woodland 400 kV UGC										
2026	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
15%	30%	40%	15%	0%	0%	0%	0%	0%	0%	0%

Table 49 Phasing of implementation cost spend for new Belcamp - Woodland 400 kV UGC

9.3.1.3 Life-cycle cost

This sub-criterion consists of three separate inputs incurred over the useful life of the option, namely operation and maintenance cost, electrical losses and replacement cost.

The equipment associated with the new Belcamp – Woodland 400 kV UGC option is expected to be maintained in accordance with the well-established existing practices. The operation and maintenance cost varies over the assets' life time and as such three periods of approximate costs are assumed. Table 50 displays rounded figures to the nearest thousand. No replacement cost is assumed as the equipment has a life expectancy of 50 years which is line with the period for the economic assessment.

Life-cycle cost for New Belcamp – Woodland 400 kV UGC		
Annual Operation and maintenance cost (€k)	0-20 year period	€286k
	21-40 year period	€206k
	41-50 year period	€286k
Annual Electrical losses cost (€M)	€3.8M	
Replacement cost	€78M	

Table 50 Life-cycle cost for the Belcamp - Woodland 400 kV UGC

9.3.1.4 Cost to Single Electricity Market

As described in Section 4.2.2, Economic performance criteria, the cost to the Single Electricity Market represents the cost for the periods when the reinforcement is unavailable. The unavailability is based on the reliability performance of the option. This is a cost to the single electricity market and is calculated as a combination of the benefit in production cost saving (project benefit) and reliability performance of the option.

The reliability performance of the option is taken from Section 7.2.3 Reliability. The production cost savings assessment used the TES 2019 scenarios and as such a range of annual production cost savings are used in the assessments as the different scenarios have different demand and generation patterns. Table 51 show the input for this criterion.

Cost to Single Electricity Market for Belcamp – Woodland 400 kV UGC option	
Annual Production cost saving (Benefit) (€m/annum)	Range €-1.2m to €17.8m
Annual unavailability of option during which benefits cannot be attributed	Unavailable for 8 days, available 97.81%
Annual Cost (saving) to SEM	Range €-1.2m to €17.4m

Table 51 Cost to single electricity market for the new Belcamp - Woodland 400 kV UGC

9.3.1.5 Economic performance for the new Belcamp – Woodland 400 kV UGC option. When all of the above costs and savings are considered, the economic result of the new Belcamp – Woodland 400 kV UGC option indicates a poor result compared to the other options and hence is considered to have a moderate to high (**Blue**) impact on the economic result. To be able to differentiate between competing options in a measured way and to check the options' performance in different credible future energy scenarios, a robustness and sensitivity test was carried out. The objective is to identify the option that is impacted the least in its economic result for a range of credible future energy scenarios. This robustness test indicates a stable performance compared to the other options independent from which future energy scenario is used in the assessment.

After considering both the economic result and the robustness test, the new Belcamp – Woodland 400 kV UGC is considered to provide a poor economic performance in comparison with the other options hence has been given a moderate to high impact (**Blue**) in the assessment.

Summary of economic performance of the new Belcamp – Woodland 400 kV UGC option	
Economic result	
Robustness	
Combined Economic Performance	

Table 52 Summary of economic performance of the new Belcamp - Woodland 400 kV UGC option

Deliverability

9.3.2 Implementation timelines

The expected timeline for the implementation of the 400 kV single circuit cable option is a period of 7.75 years in total. This is subject to and following statutory consenting for the structures and associated access routes. This time frame can be divided into two phases.

The first phase for all options is based on 4.5 years for the outline design, environmental assessment and the planning and permits process.

The second phase for the 400 kV single circuit cable option totals 3.25 years and includes detailed design, procurement of materials and construction works. This assumption includes time for the design to be confirmed, landowner consents being obtained by EirGrid and materials ordered in the first 1.5 years of this period. The design works, material procurement and construction period for the works required in the existing stations will be incorporated into the timeline.

The new 400 kV bays at Woodland 400 kV and Belcamp 220 kV substations are estimated to take 1.5 years.

The UGC option has the shortest timeline of all of the options. The impact of the implementation timelines on the project is assessed to be moderate (**Dark Green**) for this option.

9.3.3 Project plan flexibility

Routes for the cable options will be developed in Step 4 of our grid development process should they be brought forward to that step. The cable route would be developed in line with EirGrid standard practices. It is established practice in grid development that transmission cables should be constructed in the existing public road network if possible.

This is to make access and maintenance to the cable easier once the project is constructed.

One consideration in the selection of suitable roads to accommodate the cable options is the width of the required cable trench. All the cable options will require a 4-metre-wide trench and a working strip area wide enough to accommodate the required machinery. The road network in the study area will provide some flexibility in the identification of the best performing route. The use of Horizontal Directional Drill (HDD) technology to cross existing rivers, rail and roads will provide flexibility to avoid crossing point constraints.

Once the emerging preferred route has been submitted for planning consent, there is limited flexibility as we would need to work within the constraints of the site development boundary (otherwise known as the redline) of the route and the technical limitations of the cable route such as bending radius and fixed joint bay locations of the cable.

This option considered to have a moderate to high (**Blue**) impact on the project plan flexibility.

9.3.4 Risk to untried technology

In general, cables are increasingly used in transmission systems across the world and the mitigations to technical issues that arise with the technology are well known, and generally tried, and tested. In an Irish context, the first 220 kV XLPE cable was installed in 1984, and there are a number of recent projects on the Irish transmission system using this technology.

Another consideration in terms of untried technology is the use of long sections of UGC. This can lead to many technical issues which require specialised technical studies to determine if it is technically feasible to use a particular length of cable. Although, these studies have been carried out in Step 3 they will have to be repeated in Step 4 if any cable option is progressed to take account of the actual cable route determined. All cable options will require shunt reactors at either end of the cable to compensate the cable capacitance to keep the voltage within standards under normal operation.

Although shunt reactors are in place in the transmission system today, the size of the required shunt reactors for some of the UGC options is large and there is limited experience with these types of installations. The cable option may also require installation of filters in several substations in the network to mitigate any harmonic voltage distortions. The location of the filters cannot be determined until the design of the cable is known and this poses a risk for UGC options.

The installation of long lengths of 400 kV XLPE UGC became possible in the late 1990s with the development of a suitable cable joint for connecting lengths of such cable together. Nevertheless, EirGrid's experience with 400 kV cable is limited, with only a very small amount currently installed on the network.

Another aspect in relation to the UGC option is that Horizontal Directional Drilling (HDD) technology will very likely have to be used to cross specific obstacles within the study area, such as rivers and motorways, for short lengths of the cable route. This poses another risk to the UGC options as it is an expensive methodology, requiring the use of specialist equipment.

The risk to untried technology for the 400 kV single route cable option is considered to moderate to high (**Blue**).

9.3.5 Dependence on other projects (outages)

The UGC options involves a number of elements which would require planned outages.

The required work in both Woodland 400 kV and Belcamp 220 kV substations would need proximity and commissioning outages. In Woodland, the work is in relation to the construction of the 400kV bay, which is included in CP1194 Woodland 400 kV redevelopment project. In Belcamp, a new 400 kV GIS substation and associated station elements will be required in order to connect the new UGC.

The dependence on other projects for Option 4 is considered to have a moderate to high (**Blue**) level of impact.

9.3.6 Supply chain constraints, permits, wayleaves

For the new 400 kV UGC option, there may be significant supply chain constraints. This relates to the procurement and delivery of significant lengths (approx. 40km) of 400 kV UGC, the required filters and other associated large-scale equipment and testing apparatus. Cumulatively, this could result in significant supply chain constraints.

Permitting is likely to be challenging, with the provision of 400 kV UGC infrastructure in a suburban area of the Greater Dublin Area, irrespective of final design and location. It is confirmed, for the purpose of this analysis, that cable trenches will need to be approximately 4m in width; in addition, it is envisaged that an 8m working width corridor will be required adjacent to the cable trench, thereby requiring an overall cable alignment width (permanent and temporary) of approx. 12m.

There are no roads within the receiving environment that could accommodate this width of construction corridor without significant temporary and/or permanent alteration, such as the removal of ditches, boundary vegetation, front gardens, walls and piers etc.

Moreover, such roads would have to be closed for a considerable period of time, with potentially significant implications for traffic movements for both local access and commuter traffic. Overall, this would result in an impact of some significant scale and extent along the entire width of any UGC route.

It is currently considered that the UGC options, due to their size, scale and likely impact, are likely to require planning permission. If statutory consent is required, it is likely to be the subject of an application directly to An Bord Pleanála (ABP) as Strategic Infrastructure Development (SID). It is considered likely that, given the nature and extent of the development and its potential environmental and community impact, as well as the potential public interest in the proposed development, ABP would hold a full Oral Hearing in respect of a new 400 kV UGC development.

There is the potential for the UGC circuits to occur cross-country – i.e. away from public roads. This brings its own significant challenges in terms of landowner engagement and concerns, environmental and land use impacts – in particular the inability to undertake certain types of agricultural activity thereon.

It is assumed that significant engagement with landowners with properties along public roads would be required in the delivery of a new 400 kV circuit, for such purposes as surveying, siting and construction. These landowners may be new to accommodating electricity infrastructure on their landholdings. New temporary and permanent easements would be required to facilitate construction of the new circuit. Based on recent precedent in terms of the provision of new high-voltage UGC transmission infrastructure, there is the potential for significant landowner opposition to this option.

Having regard to all the above, this option is considered to have a moderate to high (**Blue**) impact in relation to the Supply Chain Constraints, Permits and Wayleaves criterion.

9.3.7 Conclusion of deliverability performance of Option 4

There are five sub criteria considered when the overall deliverability performance is assessed. The UGC options have the best implementation timelines when compared to the other options under consideration. This is a benefit to these options as implementation timelines for any network reinforcement are important to be able to assure that the transmission network will be in compliance with security standards and that all consumers have a secure electricity supply.

It is likely that all of the UGC options would require planning permission or statutory consent, due to their size, scale and likely impact on the receiving environment. They would preferably be accommodated in the public road network and would require a 2.1

m cable trench and an additional working strip, thereby requiring an overall cable alignment width (permanent and temporary) of up to 12 metres in certain places. This could have significant impacts and may impact deliverability of these UGC options. Road closures and potentially significant implications for traffic movements for both local access and commuter traffic would be a factor for all the UGC options during construction

For a new 400 kV UGC from Woodland to Belcamp, implementation timelines is the least impact with all other sub criteria performing similarly. When all of these deliverability aspects are considered, this option is deemed to have a moderate to high impact (**Blue)** from a deliverability point of view.

Topic	Option 4 (New Woodland to Belcamp 400kV UGC)
Implementation timelines	
Project plan flexibility	
Risk of untried technology	
Dependence on other projects	
Supply chain constraints, permits, wayleaves etc.	
Combined Deliverability Performance	

Table 53 Summary of deliverability performance of the new Belcamp - Woodland 400 kV UGC option

9.4 Environmental Assessment

9.4.1 Biodiversity

There is a moderate (**Dark Green**) risk of significant impacts on biodiversity as a result of this option. In the absence of mitigation, the greatest effects on biodiversity would be during construction, where despite cables primarily being laid in public roads, there is potential for impacts on hedgerows, tree lines and aquatic ecosystems; other habitats and species may also be disturbed or fragmented during the construction phase and effects could be permanent in some cases. There is also the potential for permanent loss of mature trees along the route, especially where roads are very narrow or where the UGC is required to cross fields and hedgerows off-road. The increased length of this route compared to Option 1 results in an increased risk of significant impacts to biodiversity.

9.4.2 Soils and Water

There is a moderate (**Dark Green**) risk of significant impacts on soils and water as a result of this option. The greatest impacts would be during construction. The risk to water bodies from silt and spillages during the construction process would be moderate as there are a number of waterbodies in the Study Area which would need to be crossed; it would not always be possible to use existing bridges for this purpose and in these cases, it would be necessary to go off-road and use other crossing techniques such as open cut trenches. There is also the potential for impacts on roadside ditches during construction. The risk is within the same category as for Option 2, despite being longer as the risks for Option 2 already take into account the potential for a large number of off-road crossing requirements which are more likely to be required along rural roads than in the urban areas close to Belcamp.

9.4.3 Materials Assets - Planning Policy and Land Use

There is a low to moderate (**Green**) risk of significant impacts on planning policy and land use as a result of this option. This option supports the ambitions of local planning policy for new transmission infrastructure to be underground where possible. There is the potential for the sterilisation of land where a UGC crosses third party lands, however that would be limited as a result of the preference to use public roads. This preference also reduces the level of land take required, except at the connections into Woodland and Belcamp: here there is the potential that the cable would have to be installed across third party land, requiring significant temporary land take during construction. This land take would be limited during operation, although a permanent wayleave and some restriction of agricultural practices above the UGC is likely.

9.4.4 Landscape and Visual

There is a moderate risk (**Dark Green**) of significant impacts on landscape and views as a result of this option. The impacts would be greatest during construction, but this impact would be temporary in nature. During operation, the impacts would be limited. There would be visible joint boxes periodically along the UGC route, although these would be quite small. There may also be some requirement for third party land take and permanent loss of mature trees and hedgerows at points along the route and connections to the substations. The increased length of this option compared to option 1 increases the number of joint boxes and the potential for losses of mature trees and hedgerows along the route

9.4.5 Cultural Heritage

There is a moderate (**Dark Green**) risk of significant impacts on cultural heritage as a result of this option. The impacts on cultural heritage from the UGC would be greatest during construction, both in terms of ground disturbance and impacts on the settings of heritage assets. The crossing of third-party lands at the substations presents a greater risk to heritage assets, especially unknown archaeological assets, than installation in the regional road network. During operation, there is also some potential for impacts on the setting of heritage assets from the joint boxes required along the UGC route. There are also a number of heritage features in very close proximity to the west of Belcamp substation that present constraints.

9.4.6 Noise and Vibration

There is a low to moderate (**Green**) risk of significant impacts from noise and vibration as a result of this option. Potential noise and vibration impacts from the UGC would be during the construction phase and would result from the trench works, particularly in areas of hard-standing, such as along roads. However, the baseline noise environment along roads is higher than that of rural areas, and as such, the impact is not likely to be significant. There may be a slightly greater impact at Woodland substation due to the rural nature of the area, but appropriate noise screening will be provided to minimise any noise nuisance. No impacts are anticipated during the operational phase, as the cable will be buried.

9.4.7 Climate Change

There is a moderate (**Dark Green**) risk of significant impacts on and from climate change as a result of this option. UGCs are reasonably resilient to the impacts of climate change, such as storms, wind and rain, although changes in ground temperature and reduced moisture may have impacts on the efficiency of the cables. The volume of material required to construct an UGC between Woodland and Belcamp is significant and carries with it associated embodied energy. This would be greater than for Option 2.

9.4.8 Summary of Environmental assessment of Option 4

A number of environmental factors are at a moderate risk of significant impacts as a result of this option; this is because the impacts are similar to those for Option 2 where many of the factors were considered to be at low to moderate risk, however this option is longer and so this increases the risk of such impacts. For soil and water, the greatest risks are as a result of open cut crossing of water bodies and constructing trenches in roads with roadside ditches alongside. These are most likely to occur in the more rural western part of the study area and are of a similar magnitude to those identified for Option 2. The risk to soil and water remains moderate. For all topics any risk would be during construction and therefore of a temporary nature. UGC are in accordance with local planning policy ambitions and are more resilient to the impacts of climate change. As a result, this option has an overall moderate risk of significant impacts on the environment (**Dark Green**).

Topic	Option 4 (New Belcamp to Woodland 400 kV UGC)
Biodiversity	
Soil and Water	
Planning Policy and Land Use	
Landscape and Visual	
Cultural Heritage	
Noise and Vibration	
Climate Change	
Combined Environmental Performance	

Table 54 Summary of environmental assessment of the new Belcamp - Woodland 400 kV UGC option

9.5 Socio-economic Assessment

9.5.1 Traffic and Transport

There is a moderate to high (**Dark Green**) risk of significant impacts on Traffic and Transport as a result of this option. There are similar impacts as those outlined in Option2, given that it is EirGrid's preference to install UGC in the public road network. As a result, assuming an UGC rote would be largely in the public road, there are potentially very significant impacts on local and regional roads during its construction. Public roads in the Study Area vary in their widths, with some being only 4m wide. Where routeing is in more narrow roads, installation may necessitate whole road closures and diversions for short periods of time. In the wider roads, one carriageway may require to be closed, resulting in the need for traffic management measures. This would lead to driver and pedestrian delay; increased fear and intimidation for pedestrians, especially where there are no footpaths along the roads being used; and potentially severance of communities, community facilities and businesses if any roads need to close. There are also potential implications for businesses, with employees and goods experiencing delays. A UGC route to Belcamp from Woodland will need to cross three motorways/national roads and navigate a route around Dublin Airport which is a substantial constraint. There would be careful consideration of the use of public roads in the vicinity of the airport and early discussions carried out with the airport operators to ensure there would be no significant impact on airport operations as a result of this option. Notwithstanding this, the increased length of this option compared to Option 2 increases the risks of significant impacts.

9.5.2 Amenity

There is a low to moderate (**Green**) risk of significant impacts on amenity as a result of Option 4. As is set out in Section 6.6.2, amenity considers the combined impacts of traffic, views and noise during construction and views and noise during operation. There would be no impacts on noise and limited impacts on views in operation so only construction impacts are considered here. Noise impacts were considered to be low to moderate given the preference to use the public road network; whilst traffic impacts during construction may be significant, as described in Section 9.6.1, they are temporary in nature. In considering the combined amenity impact a greater weight is afforded to permanent impacts. As a result, the risk would be low to moderate that significant impacts on amenity would occur

9.5.3 Health

There is a low to moderate (**Green**) risk of significant impacts on health as a result of this option. Potential impacts relate to stress and anxiety associated with Traffic impacts, amenity impacts and 'nuisance' emissions such as noise. No significant impacts are anticipated from noise; there is a low to moderate risk of amenity impacts; although traffic impacts are moderate to high these would be temporary, Concerns relating to EMFs relating to electrical transmission lines can also lead to increased stress and health issues. There is no electric field above ground level of underground cables as the field is fully screened by the cable sheath. Magnetic fields from UGC drop rapidly with lateral distance. EirGrid's design standards require all OHLs to operate to existing public exposure guidelines from ICNIRP; recent studies (EirGrid 2014) show that surveyed existing underground cables are well below the ICNIRP reference level set to protect public health. Taking into account all of these factors, it is considered there would be a low to moderate risk of significant impacts to health as a result of this option.

9.5.4 Economy

Potential impacts on the economy from this option are considered to be positive but are of a low (**Cream**) risk, i.e. unlikely, to be significant for the local and regional economy. This is due to the likelihood that a small construction workforce is envisaged to be required to construct this option, and its atypical nature will also require construction workers to have particular skills and experience, making it harder for currently employed individuals to gain employment on the project. Similarly, supply-chain benefits are likely to positive but limited given the specialised nature of construction. During operation, potential impacts on the economy are anticipated to be positive (in the context of reinforcing the wider electricity network), albeit limited given the nature of the project.

9.5.5 Utilities

There is a moderate (**Dark Green**) risk of significant impacts on utilities as a result of this option. It is EirGrid's preferred approach for UGC solutions, to use the existing road network (burying cables within the roads themselves) rather than within greenfield agricultural lands. As such, there is a greater potential to encounter pre-existing underground utilities than may otherwise be the case were an offline route to be taken or an OHL constructed. There are likely to be a number of underground utilities in the regional and local road network between Woodland and Finglas substations, including other electricity cables, telecommunication cables, sewers, and public and private water supplies. Whilst any utilities that are required to be altered or diverted would be done so at a time when disruption to the public would be reduced insofar as possible, and any disruption would be of a short duration, there is a reasonable likelihood of encountering other utilities during construction. There is an existing aviation fuel line in the road to the immediate south of Belcamp substation which poses a significant constraint on the use of that road. The increased length of this option compared to Option 2 increases the risks of significant impacts.

9.5.6 *Summary of Socio-economic assessment of Option 4*

The greatest risk of this option, from a socio-economic perspective, is on Traffic and Transport. For other socio-economic topics the risk of significant impacts is considered to be moderate (utilities) low to moderate or low (economy). The impacts on traffic are not insubstantial, especially in the more urban areas of the study area; however, they are temporary in nature. As a result, this option has an overall moderate risk of significant impacts from a socio-economic perspective (**Dark Green**).

Topic	Option 4 (New Belcamp to Woodland 400 kV UGC)
Traffic & Transport	
Amenity	
Health	
Economy	
Utilities	
Combined Socio-Economic Performance	

Table 55 Summary of Socio-economic performance for the new Belcamp to Woodland 400kV UGC options

9.5.7 *Summary of the assessment for the Woodland to Belcamp 400 kV UGC option*

This option would involve constructing a new 400 kV UGC between Woodland 400 kV and Belcamp 220 kV substations. This option is the best performing option in the deliverability criterion compared to the other options. The economic criterion is the worst performing compared to other options, as this option is the longest route and UGC being more expensive than OHL.

Having considered all of the five criteria, the outcome of the multi-criteria assessment indicates that the new Woodland to Belcamp 400 kV UGC option (Option 4) does perform well, and it has been given a moderate impact (**Dark Green**) on its overall performance.

Topic	Option 4: WOO-BEL 400 kV UGC
Technical Performance	
Economic Performance	
Deliverability	
Environmental	
Socio-economic	
Combined Performance	

Table 56 Overall assessment outcome for the new Belcamp - Woodland 400kV UGC option

10 Conclusions

The East Meath – North Dublin Grid Reinforcement (Capital Project 1021) is a planned reinforcement of the electricity network between Woodland 400 kV substation in County Meath and either Finglas or Belcamp 220 kV substations in County Dublin. The project is in Step 3 of the six-step approach that we use when we develop and implement a solution to any identified transmission network problem.

The project is essential to enable the further integration of renewable energy in line with Government policy ambitions. It will further be a key enabler in meeting the growing demand for electricity in the east region.

The purpose of Step 3 is to decide on the Best Performing Option. In Step 3, there were four options investigated.

- Option 1: New 400 kV OHL between Woodland 400 kV Station and Finglas 220 kV Station;
- Option 2: New 400 kV UGC between Woodland 400 kV Station and Finglas 220 kV Station;
- Option 3: New 400 kV OHL between Woodland 400 kV Station and Belcamp 220 kV Station;
- Option 4: New 400 kV UGC between Woodland 400 kV Station and Belcamp 220 kV Station;

Each of these options has been assessed against the five criteria covering technical performance, economic performance, deliverability performance, environmental impacts and socio-economic impacts.

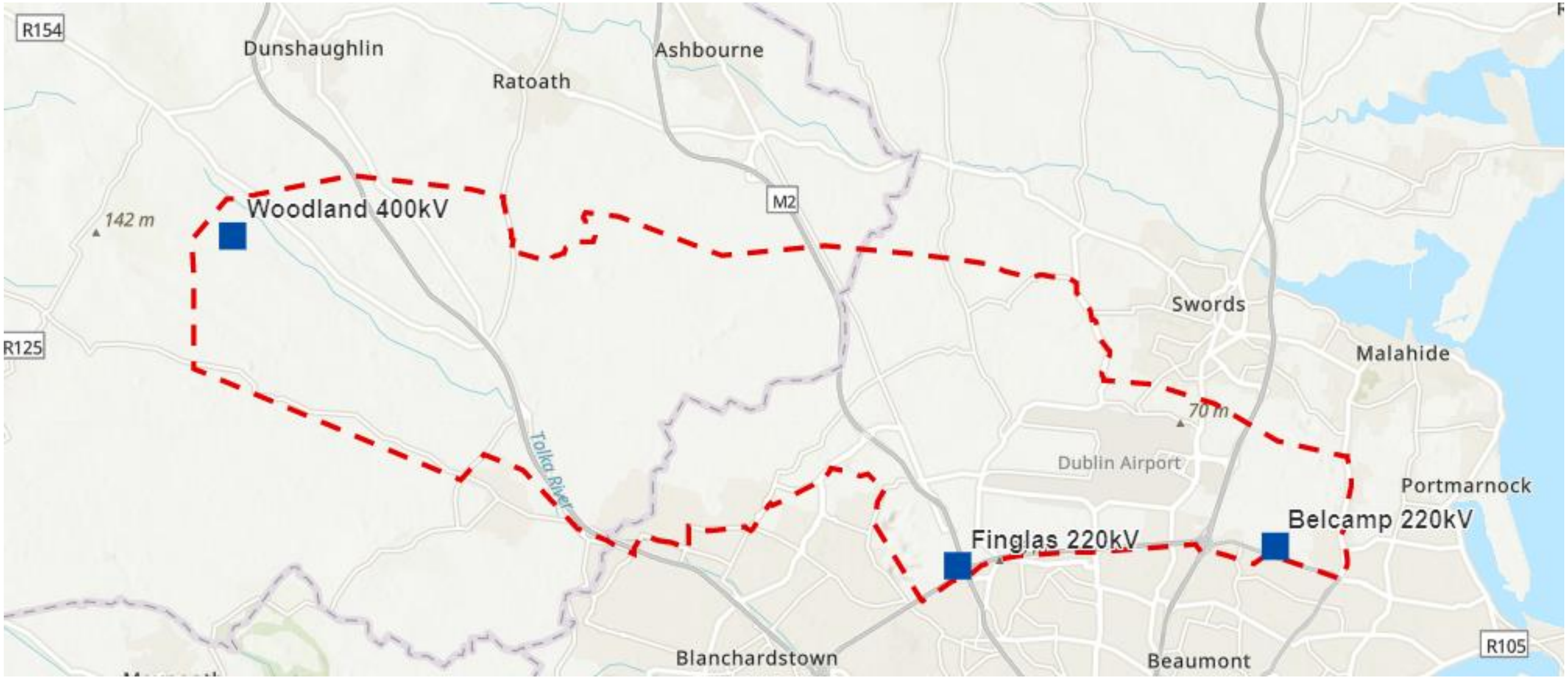
Based on the multi-criteria assessment, Option 4, the UGC to Belcamp, is the Best Performing Option (BPO).

This option will be brought forward to Step 4 of EirGrid's framework. A short-list of route options will be brough forward for public consultation later in 2022, all feedback will be considered before a cable route is confirmed.

Appendix 1 – Transmission map showing substation locations

An extract of the transmission map is presented below. The entire map can be found on our website in the following link
http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-Transmission-Map-January-2020.pdf

Belcamp 220 kV substation is located in north County Dublin along the R139. This substation is relatively new and is not shown in the transmission map yet. The substation's location is indicated for clarity.



Appendix 2 – Technical performance of options

Summary of Technical Performance of all options				
	Option 1 **FIN OHL**	**Option 2** **FIN UGC**	**Option 3** **BEL OHL**	**Option 4** **BEL UGC**
Health and Safety Standard compliance				
Security & Planning Standard compliance				
Reliability performance				
Headroom				
Expansion or Extendibility				
Repeatability				
Technical Operational risk				
Combined Technical Performance				

Appendix 3 – Economic performance of options

Summary of economic performance all options 2022 values					
	units	Option 1 FIN OHL	Option 2 FIN UGC	Option 3 BEL OHL	Option 4 BEL UGC
Pre-Engineering Costs	[€M]	10	10	10	11
Project Implementation Costs	[€M]	114	300	130	396
Project Life-Cycle Costs (Losses)	[€M] pa	46	82	63	108
Project Life-Cycle Costs (O & M) Presented in period of years (1-20), (20-40), (40-50)	[€k] pa	230 337 2623	247 193 247	327 493 2452	286 206 286
Project Life-Cycle Costs (Decommissioning & Replacement)	[€M]	N/A	60	N/A	78
Cost to SEM based on unavailability of reinforcement (TES Scenario used)	[€M] pa	Range 62 to 321	Range 74 to 384	Range -17 to 251	Range -20 to 298
Combined Economic Performance					

Summary of economic performance of all options				
	Option 1 FIN OHL	Option 2 FIN UGC	Option 3 BEL OHL	Option 4 BEL UGC
Economic Result				
Robustness				
Combined Economic Performance				

Appendix 4 – Deliverability performance of options

Summary of deliverability performance of all options				
	Option 1 FIN OHL	Option 2 FIN UGC	Option 3 BEL OHL	Option 4 BEL UGC
Implementation timelines				
Project plan flexibility				
Risk of untried technology				
Dependence on other projects				
Supply chain constraints, permits, wayleaves etc.				
Combined Deliverability Technical Performance				

Appendix 5 – Environmental performance of options

Summary of environmental performance of all options				
	Option 1 FIN OHL	Option 2 FIN UGC	Option 3 BEL OHL	Option 4 BEL UGC
Biodiversity				
Soils and water				
Planning policy and land use				
Landscape and views				
Cultural heritage				
Noise and Vibration				
Climate Change				
Combined Environmental Performance				

Appendix 6 – Socio-economic performance of options

Summary of socio-economic performance of all options				
	Option 1 FIN OHL	Option 2 FIN UGC	Option 3 BEL OHL	Option 4 BEL UGC
Traffic and Transport				
Amenity				
Health				
Economy				
Utilities				
Combined Socio-Economic Performance				