# Options Report
# Part A
## CP1021 Strengthening the Grid in North Dublin

September 2019

EIRGRID

# 1 Table of Contents

# 2 Introduction

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

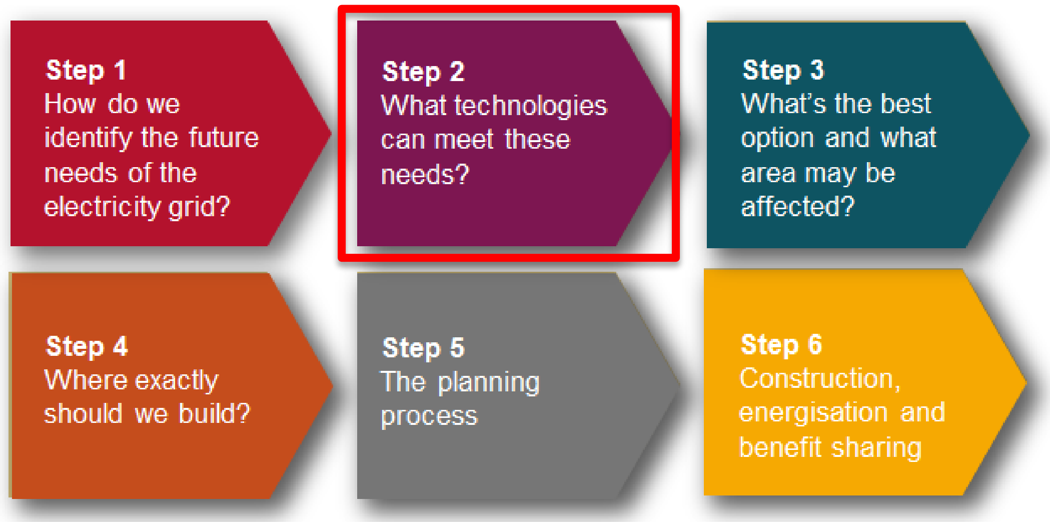


**Figure 1** *High Level Project Development Process*

The transmission network problem was identified and described in previous Step 1 and was documented in the Need Report.

The Options Report Part A (this document) is a deliverable for Step 2. In Step 2, a technology overview will be carried out. This will determine the aspects that will be considered when creating any options. All the viable and technically acceptable options created will be shown in a list that is called 'the long list'. This list will be refined in a two-part approach with the aim to establish a shorter list of best performing solution options to bring forward for further investigation in Step 3. The outcome from the first part of refinement of the long list in Step 2 is presented in the Options Report Part A (this document) and the outcome of the second part of refinement of the list is presented in Options Report Part B.

The need, in this case, involves a transmission network problem relating to the transfer of power across the existing 220 kV transmission network from the Woodland 400 kV

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

station to the north Dublin area. The issues encountered involve the capacity of the transmission system in the area.

# 3 Process followed and criteria

## 3.1 Description of process

The need to improve the transmission network is identified in Step 1. Following on from that step, the process of identifying viable and technically acceptable technology solution options starts. This involves a rigorous process spanning over two steps namely, Step 2 and Step 3. The outcome of Step 2 is a list of best performing solution options which will be taken to Step 3 for further investigation and evaluation. At the end of Step 3 we will have a best performing solution option which will be developed for construction and energisation.

Step 2 can further be broken down into a two-part approach, namely Part A and Part B. This report (Options Report Part A) details the findings of the first part (Part A) of the refinement of the long list. Part B will involve a second refinement of the options list and the findings of this assessment will be presented in the Options Report Part B at the end of Step 2. Between Part A and Part B stakeholder engagement will take place. The stakeholder engagement is project specific and generally at this stage in the development process it is intended to engage with national and regional stakeholders. A project specific web-site will be set up and relevant material about the project will be published. Figure 2 provides an overview of the process and different tasks in Step 2, excluding stakeholder engagement.  A more detailed description of the individual tasks is provided below.

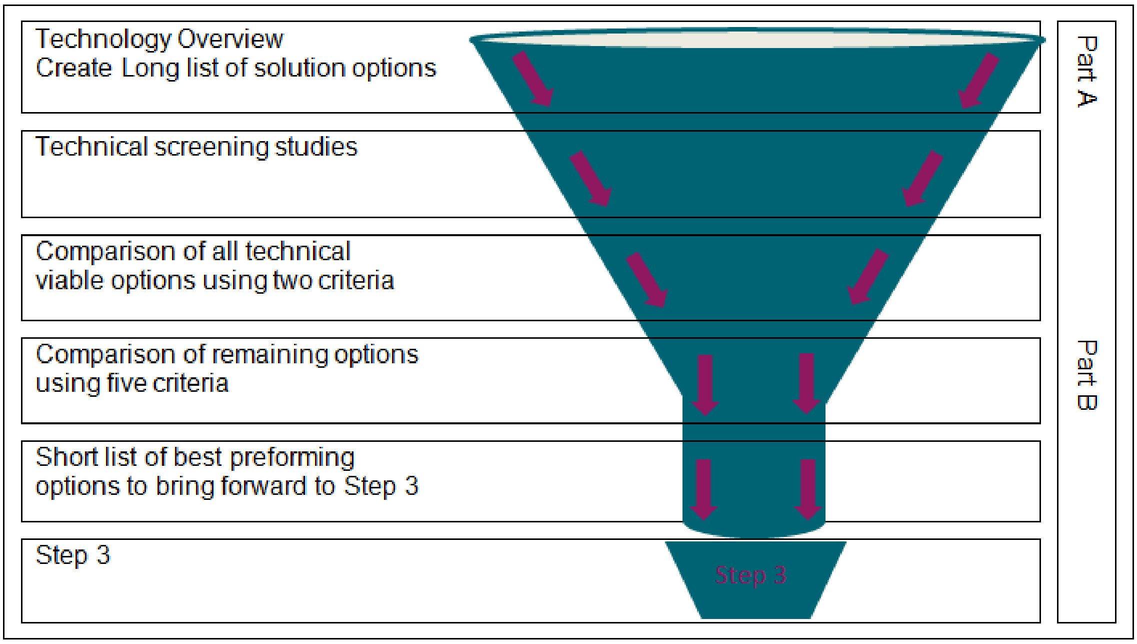


**Figure 2** *Illustration of the process of developing of options in Step 2*

#### 3.1.1 Part A

The initial development of viable and technically acceptable options starts with the Technology Overview. This involves consideration of technical aspects which will form the basis of developing the solution options, such as technologies, suitable voltage levels and potential connection points of the solutions. The reasoning and justification for any choices and decisions are outlined. This is discussed in section 4.1 Technology Overview in more detail. The findings of the technology overview are then used to create a long list of viable and technically acceptable solution options.

The second task involves high level technical screening studies of the identified solution options to determine if they have a potential to solve the identified need. The solution options will also be assessed on their technical ability, relative to each other, to solve the identified problem. This is discussed in section 4.2.1 Technical screening studies. Further more detailed technical analysis will be carried out later in Part B in Step 2 to determine technical details of options.

The third task involves a multi-criteria comparison of the solution options in the long list using two criteria namely, technical performance and economic performance. This task may involve reducing a vast number of solution options to a more refined list of options to be further investigated. This is discussed in Section 4.3 Comparison of solution options.

#### 3.1.2 Part B

The option list is further refined, this time using a multi-criteria comparison against five criteria. The five criteria are technical performance, economic performance, environmental, deliverability and socio-economic aspects. Each remaining option is assessed against the five criteria. At the end of Step 2 the outcome of this assessment will be available in the Options Report Part B.  The outcome of Step 2 is a shorter list of solution options which will be taken to Step 3 for further investigation and evaluation.

## 3.2 Criteria used for comparison of options

As described in previous section the multi-criteria comparison is carried out twice in Step 2. The first time (Part A) the performance matrix is used only two criteria are compared namely, technical performance and economic performance. The second time (Part B) the performance matrix is used five criteria are compared, namely technical performance, economic performance, environmental, deliverability and socio-economic. Descriptions of the all criteria are outlined below.

### 3.2.1 Technical performance

Technical performance in Part A is based on high level technical screening studies of the identified solution options. This will determine if they have a potential to solve the identified need. The solution options will also be assessed on their technical ability, relative to each other, to solve the identified problem. In this case the initial technical screening study is based on the worst contingencies identified in load flow as part of the need analysis.

The need analysis showed that:

- During winter and summer peaks the worst situation arises when a generator located at Huntstown (HNC) is unavailable. The worst single contingencies identified are one of the 220 kV circuits from Clonee – Woodland or Corduff – Woodland. (N-1 test).
- At summer peak, which happens during the maintenance season, a maintenance and trip combination contingency of the Clonee – Woodland and Corduff – Woodland 220 kV circuits is worst. (N-1-1 test).
- At winter peak if the second huntstown generator (HN2) is also unavailable for any reason the worst contingency is the loss of the Corduff – Woodland 220 kV circuit. (N-G-1).

The different options will be compared against identified indicators of the technical performance based on the need identified. This is further discussed in Section 4.2.1 Technical screening studies.

The second time (Part B) the technical performance is assessed the criteria is based on compliance with Transmission System Security and Planning Standards (TSSPS) and policies. Minimum technical requirements based on these have to be met to qualify an option for consideration, but options which extend technical performance margins beyond minimum acceptable levels are favoured over others. Operational flexibility will also be assessed. This will capture the complexity involved in operational switching and risks to operation during maintenance. The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated will also be taken into account.

### 3.2.2 Economic performance

Economic performance in Part A will be based on high level estimated capital costs for each option for comparison purposes. The primary source for cost estimates have been developed with input from the Transmission Asset Owner (TAO) and are based on desktop designs and costings for similar works. Where costs were not available for a particular technology, the best most recent estimate will be used.

Economic performance in Part B will be based on estimated Total Project Cost (TPC) for comparison purposes. The TPC will comprise both estimated capital costs and an estimated cost for the Transmission System Operator (TSO) element for development the options. The primary source for cost estimates will be developed with input from the Transmission Asset Owner (TAO) and are based on desktop designs and costings for similar works. Where costs were not available for a particular technology the best, most recent estimate will be used.

#### *3.2.3 Environmental*

This criterion is used in Part B. Environmental issues are considered at a high level such as potential interactions with Natura 2000 sites (Special Areas of Conservation-SAC, or special Protection Areas-SPAs or other designated sites that may be in the zone of influence for the various options. Impacts on existing land use and landscape including cultural heritage is compared for the various options.

#### *3.2.4 Deliverability*

This criterion is used in Part B. Deliverability captures timelines as well as engineering and planning risks which could extend delivery timescales and costs.

#### *3.2.5 Socio-Economic*

This criterion is used in Part B. This criterion will consider the general location of the subject site of the proposed solution options and adjacent lands with regards to the nature of typical social impacts. This assessment is carried out in accordance with EirGrid's SIA Methodology.

## 3.3 Scale used to assess each criterion

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

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

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

# 4 Long list and comparison of options

## 4.1 Technology Overview

This overview forms the pillars from which the solution options to resolve the identified need are developed. For the technology overview, EirGrid's approved technology toolbox has been used. To determine the possible solution options a number of aspects are considered. A brief discussion regarding these aspects and the decisions made are outlined below.

Prior to developing options for the identified need, it is important to analyse and understand the need. The need in this case, involves a strengthening of the network in the north Dublin region to facilitate increased demand in north Dublin and variability in generation output in Dublin.

New large scale energy users are concentrated around north Dublin. These large energy users are located near the existing transmission stations at Clonee, Corduff, Finglas and Belcamp. There are a limited number of circuits to supply these stations and a dependence on generation to manage power flows is likely as the large energy users avail of their Maximum Import Capacity.

Added to this, four large generators are connected in Dublin at Finglas, Corduff, Shellybanks and Irishtown stations respectively, and the East-West Interconnector is connected at Woodland. The generators can be used to supply load in north Dublin and to offset flows from Woodland towards Corduff, Finglas, and Belcamp. However these generators are likely to be overtaken in the merit order by newer more efficient conventional generators and increasing levels of renewables. Both these categories of generators are likely to belocated outside of Dublin and power will have to be transported into the north Dublin region where it is needed around Corduff, Finglas and Belcamp station.

The need assessment indicated that solutions with the best potential to solve the need are likely to involve connection points between the Woodland station in county Meath on the western side of the constrained area, and new, or existing, station along the constrained path towards the generator connection stations in central Dublin. Connecting these nodes will strengthen nodes in its vicinity and strengthen the path for power flowing into Dublin. The best performing solution needs to integrate with the existing network and provide a platform for the future expansion of the transmission network.

### *4.1.1 Technologies*

The development of options may involve additional circuits or equipment which would allow for the more efficient use of existing transmission infrastructure on the system. EirGrid is committed to making best use of existing assets before considering investing in new assets. The 'do-nothing' option has been considered and shown in the needs assessment in Step 1 to retain reliance on generation in Dublin to offset power flows from Woodland towards Corduff, Finglas, and Belcamp.

Reconfiguration of the existing network, or possible use of powerflow management devices such as series reactors or phase shifting transformers, to ensure best use of the existing assets has also been examined in developing the needs assessment. During that assessment all practical network reconfigurations were tested to ensure any spare capacity on existing circuits could be used to alleviate the need.

New capacity will be required to accommodate additional demand connections and to allow flexibility in the market based optimal dispatch of generation in the Dublin area.

#### ***4.1.1.1 New Circuit Capacity.***

High Voltage Alternating Current (HVAC) will be considered for all of the reinforcement options. HVAC is the same technology used in the existing network and would integrate well. Some of our options will look at uprating existing infrastructure.

High Voltage Direct Current (HVDC) technology was not considered for the reinforcement of the area due to the high cost for a relatively short length circuit, and the lack of flexibility for future connections into the new reinforcement.

In terms of new circuits, both HVAC underground cable (UGC) and overhead line (OHL) options will be considered. It should be noted that previous analysis has indicated that long lengths (more than 10 km) of AC 400 kV underground cable cannot be accommodated in the Irish transmission system. There are technical reasons why a longer AC underground cable cannot be accepted. The reasons include voltage control problems and electromagnetic transient phenomena associated with the capacitive characteristics of high voltage underground cables. The issues associated with long cables can only be determined by specialised system analysis and these studies are planned to be carried out if an AC cable option is brought forward to Step 3.

We have included a number of AC underground cable solution options along with AC overhead line options in the long list. The majority of the long list of options is at 220kV levels, with some options incorporating 400 kV circuits to help identify benefits that 400 kV circuits could provide. The cable options will be assessed on the same terms as the other options in Part A. If the cable options remain after the first refinement of the list their technical suitability and acceptability will be investigated further in Part B and in Step 3 if required.

Partial AC undergrounding of any overhead line solution using short lengths of underground cables will be considered as part of mitigation measures in Step 3 and/or Step 4.

#### *4.1.1.2 Associated Additional Network Equipment.*

Due to the electrical characteristics of underground cable circuits (they have a lower electrical impedance than overhead lines) they would carry a large share of the flow in a corridor of parallel overhead line circuits. Power flow management devices could be required to manage the flow along the new underground cable circuit within the thermal limits of the cable. Detailed analysis of requirements for power flow management will be covered in Step 2B, if required. Power flow management devices include series reactors, phase shifting transformers, or power electronic based technology, to manage the power flow through the new cables.

#### *4.1.1.3 Offshore Circuit Routes.*

The majority of the identified connection points, 220 kV stations and other strong nodes, are all located far inland. However one of the solution options which proposes to link Poolbeg, Carrickmines and Belcamp stations on the east of Dublin may require an offshore cable solution. The use of a partial offshore cable solution has not been specifically identified for the other solution options. The reason is that the onshore cable elements required to get to the coast would alone be longer than an entirely onshore cable option. In the event that subsequent detailed routing of cable options increases the route length sufficiently, the use of partial offshore cable will be reconsidered.

### *4.1.2 Voltage level*

For the development of the options the voltage levels 220 kV and 400 kV will be considered. The magnitude of the need identified, namely thermal overloads on 220 kV circuits, indicates that a reinforcement using the voltage levels of 220 kV and 400 kV at a minimum is required. Using a 110 kV reinforcement would not contribute with the capacity required and is not considered appropriate.

### *4.1.3 Connection points*

The identified network problems indicate issues with loss of high voltage circuits, in particular the two existing 220 kV circuits between Woodland and Corduff. The loss of one of these 220 kV circuits will force most of its power flow on to the remaining circuit. This will cause overloads on this remaining circuit. Similarly the concurrent loss of the

220 kV lines between Corduff - Woodland or Corduff – Clonee - Woodland will cause overloading on the Finglas to Poolbeg circuit.

Possible connection points for solution options include connections between the 220 kV stations at Woodland and Corduff, and these stations have been the focus of the options developed. Other strong connection points to be considered are Finglas, Belcamp, Poolbeg, Inchicore, Maynooth, Carrickmines and Castlebagot. A potential future new 220 kV station at Steelstown, between the towns of Rathcoole and Naas, was also considered. Figure 3 highlights the identified possible connection points which will be used when creating the potential options.

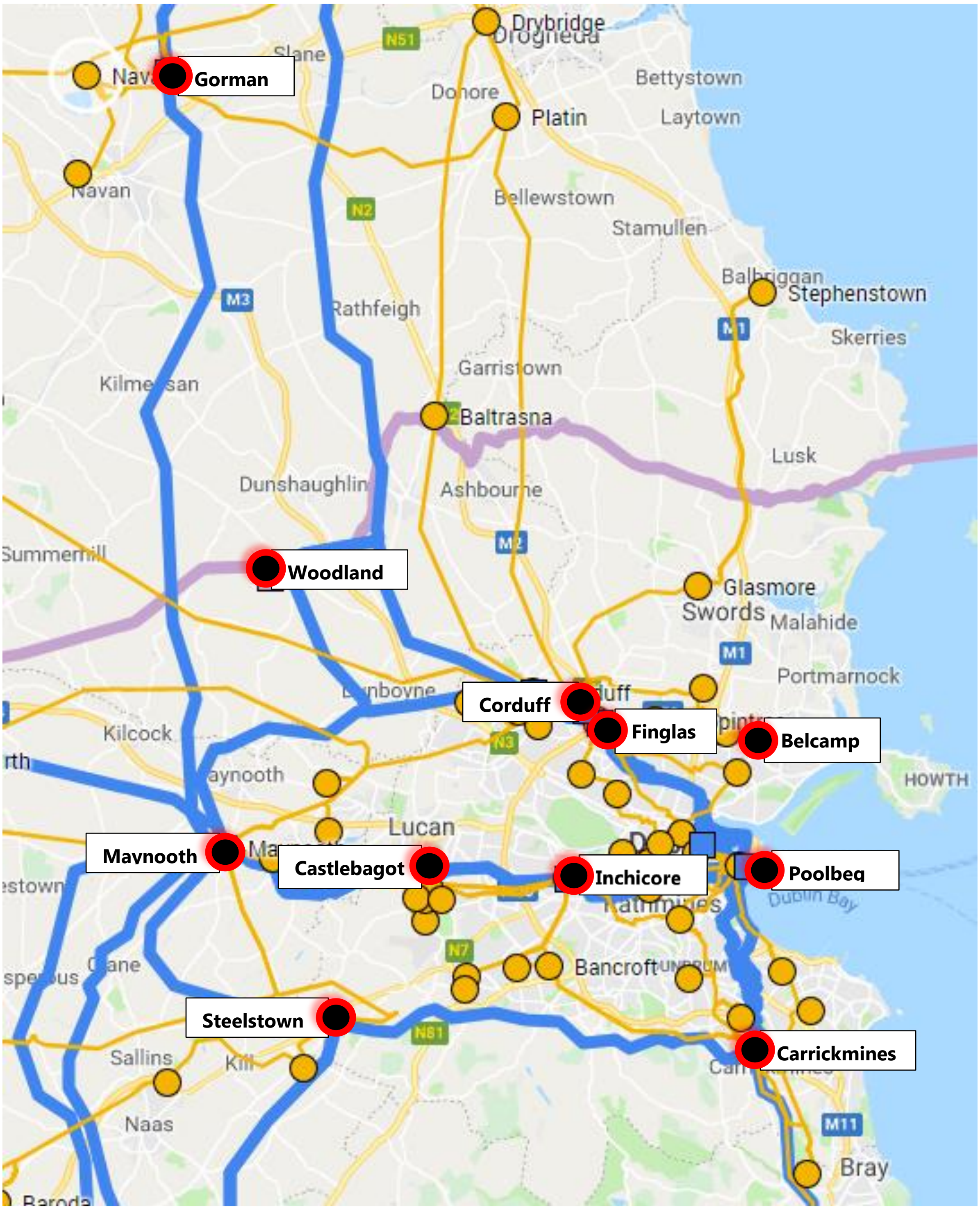


**Figure 3** *Some the possible connection points for solutions*

## 4.2 Assessment of solution options in long list

The long list of solution options was established using the connection points, voltage levels and technologies described in previous section. Knowledge of the identified need and engineering judgement was also used when the long list was created. The long list consists of 21 technically viable and feasible solution options and they are listed in Table 2.

The solution options identified in the long list were assessed based on two criteria namely, technical performance and economic performance. The aim of this assessment is to be able to compare the options and reduce the number of solution options that would be brought forward for more detailed evaluation. The following sections of this report describe how these assessments were carried out and the outcome. The effect on each criterion parameter is presented along the following scale.

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

| Long List | |
|---|---|
| 1 | Corduff - Woodland new 220 kV UGC circuit |
| 2 | Corduff - Woodland new 220 kV OHL circuit. |
| 3 | Corduff - Woodland new 400 kV UGC circuit |
| 4 | Corduff - Woodland new 400 kV OHL circuit |
| 5 | Corduff - Gorman new 220 kV OHL circuit |
| 6 | Corduff - Poolbeg new 220 kV UGC circuit |
| 7 | Corduff - Inchicore new 220 kV UGC circuit. |
| 8 | Corduff - Maynooth new 220 kV UGC circuit. |
| 9 | Corduff - Castlebagot new 220 kV UGC circuit |
| 10 | Corduff - Carrickmines new 220 kV UGC circuit. |
| 11 | Corduff - Poolbeg - Carrickmines 220 kV UGC circuit. |
| 12 | Corduff – Steelstown (New station) new 220 kV UGC circuit |
| 13 | Corduff - Castelbagot – Steelstown (New station) new 220 kV UGC circuit |
| 14 | Belcamp - Woodland new 220 kV UGC circuit. |
| 15 | Belcamp - Woodland new 220 kV OHL circuit. |
| 16 | Belcamp - Woodland new 400 kV UGC circuit. |
| 17 | Belcamp - Woodland new 400 kV OHL circuit. |
| 18 | Finglas - Woodland new 220 kV UGC circuit. |
| 19 | Finglas - Woodland new 220 kV OHL circuit. |
| 20 | Finglas - Woodland new 400 kV UGC circuit. |
| 21 | Finglas - Woodland new 400 kV OHL circuit. |

**Table 1** *List of the high level technical screening study options in Step 2 Part A for options in long list*

#### *4.2.1 Technical screening studies*

The technical performance of options, at this stage, is based on high level technical screening studies to determine if the options have a potential to solve the identified need. The solution options will also be assessed on their technical ability relative to each other. The aim of the high level technical screening studies is to reduce the number of solution options that would be brought forward for more detailed evaluation.

The high level technical screening studies are based on assessing the worst contingencies identified as part of the need analysis. The need analysis showed that the key technical issue to be considered as part of developing the solution options was thermal overloads.

It was decided to use this issue as the indicator for the technical performance of the options in the long list. This enabled an assessment of each option's technical ability to solve the identified issues in a concise way. It also allowed a comparison of each option's technical ability relative to each other.

Three basic subcriteria were used to compare the technical performance of the options. These were:

1. Overloads remaining after adding potential solution option
2. Effect of potential solution options on power flows
3. Additional network capacity provided by potential solution options

##### ***4.2.1.1 Overloads remaining after inclusion of solution options***

This subcriterion examined each solution option's ability to remove the post contingent overloads identified in the needs analysis. Each solution option was added to the network, in turn, to determine if overloads remained on the circuits identified in the needs analysis, or if the new circuit in the solution option was overloaded. Solution options that most reduced the number of overloads,  performed best.

##### ***4.2.1.2 Effect of solution options on power flows***

This subcriterion examined the solution options to identify if they change the loading of the circuit that was recorded in the needs analysis. Each solution option was added to the network, in turn, to determine the effect on the circuit. A reduction in the circuit loadingwas considered beneficial, and solution options performed better the more the loading on the circuit was reduced.

#### *4.2.1.3 Additional Network Capacity provided by solution options*

The third subcriterion analysed the additional network capacity added by the solution option without the need for additional power flow controlling equipment. This was done by comparing the balance of power flows on the existing and new circuits for each solution option in turn. If the circuits are more balanced additional equipment may not be required to help balance the flows. This will allow the best use of existing and new circuits without the need for additional equipment.

### *4.2.2 Short Circuit analysis*

In the needs assessment the expected short circuit current level for the different generation and demand scenarios was calculated.  These levels were compared against those for the different solution options identified due to the knowledge that the North Dublin area has existing high short circuit levels. The short circuit level was analysed to develop an understanding of the effect each solution option may have on them. The short circuit level impact was not considered as an indicator of technical performance because the difference in impact between solution options was not large enough to compare.

### *4.2.3 Hight level technical screening studies*

Each solution option in the long list was modelled in the winter and summer peak 2025 network situations and the worst contingencies identified in the needs assessment were applied. The impact that the solution options made on the thermal overloads was recorded and compared with a reference case. The reference case represents a network with no solution option included.

Table 3 highlights the high level technical performance of the options based on thermal overloads, compared to the reference case.

| Options | | Overloads remaining after adding solution option | Effect of potential solution option on power line | Additional capacity/Balance of flows | Overall Technical Performance |
|---|---|---|---|---|---|
| 1 | Corduff - Woodland new 220 kV UGC circuit | | | | |
| 2 | Corduff - Woodland new 220 kV OHL circuit. | | | | |
| 3 | Corduff - Woodland new 400 kV UGC circuit | | | | |
| 4 | Corduff - Woodland new 400 kV OHL circuit | | | | |
| 5 | Corduff - Gorman new 220 kV OHL circuit | | | | |
| 6 | Corduff - Poolbeg new 220 kV UGC circuit | | | | |
| 7 | Corduff - Inchicore new 220 kV UGC circuit. | | | | |
| 8 | Corduff - Maynooth new 220 kV UGC circuit. | | | | |
| 9 | Corduff - Castlebagot new 220 kV UGC circuit | | | | |
| 10 | Corduff - Carrickmines new 220 kV UGC circuit. | | | | |
| 11 | Corduff - Poolbeg - Carrickmines 220 kV UGC circuit. | | | | |
| 12 | Corduff - Steelstown (New station) new 220 kV UGC circuit | | | | |
| 13 | Corduff - Castelbagot - Steelstown (New station) new 220 kV UGC | | | | |
| 14 | Belcamp - Woodland new 220 kV UGC circuit. | | | | |
| 15 | Belcamp - Woodland new 220 kV OHL circuit. | | | | |
| 16 | Belcamp - Woodland new 400 kV UGC circuit. | | | | |
| 17 | Belcamp - Woodland new 400 kV OHL circuit. | | | | |
| 18 | Finglas - Woodland new 220 kV UGC circuit. | | | | |
| 19 | Finglas - Woodland new 220 kV OHL circuit. | | | | |
| 20 | Finglas - Woodland new 400 kV UGC circuit. | | | | |
| 21 | Finglas - Woodland new 400 kV OHL circuit. | | | | |

**Table 2** *Result of the high level technical screening studies in Step 2 Part A for options in long list*

#### *4.2.4* Economic performance

Economic Performance in Part A in Step 2 is based on estimated capital costs for each option for comparison purposes. **Error! Reference source not found.**4 summaries the estimated capital cost for the long list of options and provides a colour code relative to each other for comparison purposes.

| | Options | Economic Performance |
|---|---|---|
| 1 | Corduff - Woodland new 220 kV UGC circuit | |
| 2 | Corduff - Woodland new 220 kV OHL circuit. | |
| 3 | Corduff - Woodland new 400 kV UGC circuit | |
| 4 | Corduff - Woodland new 400 kV OHL circuit | |
| 5 | Corduff - Gorman new 220 kV OHL circuit | |
| 6 | Corduff - Poolbeg new 220 kV UGC circuit | |
| 7 | Corduff - Inchicore new 220 kV UGC circuit. | |
| 8 | Corduff - Maynooth new 220 kV UGC circuit. | |
| 9 | Corduff - Castlebagot new 220 kV UGC circuit | |
| 10 | Corduff - Carrickmines new 220 kV UGC circuit. | |
| 11 | Corduff - Poolbeg - Carrickmines 220 kV UGC circuit. | |
| 12 | Corduff - Steelstown (New station) new 220 kV UGC circuit | |
| 13 | Corduff - Castelbagot - Steelstown (New station) new 220 kV UGC | |
| 14 | Belcamp - Woodland new 220 kV UGC circuit. | |
| 15 | Belcamp - Woodland new 220 kV OHL circuit. | |
| 16 | Belcamp - Woodland new 400 kV UGC circuit. | |
| 17 | Belcamp - Woodland new 400 kV OHL circuit. | |
| 18 | Finglas - Woodland new 220 kV UGC circuit. | |
| 19 | Finglas - Woodland new 220 kV OHL circuit. | |
| 20 | Finglas - Woodland new 400 kV UGC circuit. | |
| 21 | Finglas - Woodland new 400 kV OHL circuit. | |

**Table 3** *Economic Performance of options in long list*

## 4.3 Comparison of solution options

Table 5 provides a summary of the combined performance of each option against the two evaluation criteria (Technical Performance and Economic Performance).

| Options | | Technical Performance | Economic Performance | Combined Performance |
|---|---|---|---|---|
| 1 | Corduff - Woodland new 220 kV UGC circuit | | | |
| 2 | Corduff - Woodland new 220 kV OHL circuit. | | | |
| 3 | Corduff - Woodland new 400 kV UGC circuit | | | |
| 4 | Corduff - Woodland new 400 kV OHL circuit | | | |
| 5 | Corduff - Gorman new 220 kV OHL circuit | | | |
| 6 | Corduff - Poolbeg new 220 kV UGC circuit | | | |
| 7 | Corduff - Inchicore new 220 kV UGC circuit. | | | |
| 8 | Corduff - Maynooth new 220 kV UGC circuit. | | | |
| 9 | Corduff - Castlebagot new 220 kV UGC circuit | | | |
| 10 | Corduff - Carrickmines new 220 kV UGC circuit. | | | |
| 11 | Corduff - Poolbeg - Carrickmines 220 kV UGC circuit. | | | |
| 12 | Corduff - Steelstown (New station) new 220 kV UGC circuit. | | | |
| 13 | Corduff - Castelbagot - Steelstown (New station) new 220 kV UGC circuit. | | | |
| 14 | Belcamp - Woodland new 220 kV UGC circuit. | | | |
| 15 | Belcamp - Woodland new 220 kV OHL circuit. | | | |
| 16 | Belcamp - Woodland new 400 kV UGC circuit. | | | |
| 17 | Belcamp - Woodland new 400 kV OHL circuit. | | | |
| 18 | Finglas - Woodland new 220 kV UGC circuit. | | | |
| 19 | Finglas - Woodland new 220 kV OHL circuit. | | | |
| 20 | Finglas - Woodland new 400 kV UGC circuit. | | | |
| 21 | Finglas - Woodland new 400 kV OHL circuit. | | | |

**Table 4** *Multi criteria assessment based on two criteria in step 2 Part* A

In terms of technical performance, those options which added to the connectivity of Corduff station by terminating there but started at stations around the city, namely Castlebagot, Poolbeg, Carrickmines, and Steelstown, were not effective in meeting the need identified in Step 1.

Options which add capacity parallel to the existing path between Woodland, Corduff, Finglas, and Belcamp performed best. Of the options that add parallel capacity, those that start at Woodland 400 kV station and terminate at Finglas, Corduff or Belcamp 220 kV stations, or at new 400 kV stations at those sites, perform best. Those terminating at Finglas performed marginally better. Those terminating at Belcamp do not have a direct influence on the power flows on the Finglas – North Wall 220 kV circuit.

The analysis found that the 220 kV underground cable options would require additional powerflow management devices to avoid the new cable circuit carrying the majority of powerflow in the corridor and being heavily loaded, or overloaded, as soon as it is installed. Detailed analysis of the requirement for power flow controlling devices will be carried out in Step 2B. That analysis may determine a fixed device such as a series reactor, or a flexible device such as a phase shifting transformer, or a Flexible AC Transmission (FACTs) device with similar capabilities, to be appropriate.

Previous analysis has indicated that long lengths of AC 400 kV underground cable cannot be accommodated in the Irish transmission network. Although previous analysis identified issues we have for completeness included AC underground cable solution options in the long list at 400 kV and 220 kV. The cable options are assessed on the same terms as the other options in the high level screening studies in Part A. AC cable solutions will require very detailed specific technical analysis to determine if they are technically feasible. These detailed specific technical analyses will be carried out in Step 3 if the cable options remain. Partial AC undergrounding of any overhead line solution using short lengths of underground cables will be considered as part of mitigation measured in Step 3 and/or Step 4.

The economic performance has a dependence on the length of the proposed new circuit. Long circuits perform economically less favourably compared to the options which have a shorter length. New circuits at 400 kV were shown to be more expensive than the 220 kV candidate solutions due to the additional transformer requirements and higher circuit costs.

## 4.4 Proposed solution options to be brought forward

The proposed options that will be taken through for further investigation are marked with the colours **Cream** and/or **Light Green**, in **Error! Reference source not found.**5. The proposed options can be influenced by stakeholders if reasonable justification is provided for modification of the proposed list of options. Based on the analysis to date, below is a proposed refined list of solution options to be brought forward for more detailed evaluation in Part B:

- New Corduff – Woodland 400 kV OHL Circuit
- New Corduff – Woodland 400 kV UGC Circuit
- New Corduff – Woodland 220 kV OHL  Circuit*
- New Finglas – Woodland 220 kV OHL Circuit
- New Finglas – Woodland 400 kV UGC Circuit
- New Finglas – Woodland 400 kV OHL Circuit
- New Belcamp – Woodland 400 kV OHL Circuit**

*The option of a New Corduff – Woodland 220 kV UGC circuit did not emerge from the refinement of the long list due to a poorer technical performance of the UGC option.

** The option of a New Belcamp – Woodland 400 kV UGC circuit did not emerge from the refinement of the long list due to the additional capital cost of the cable component.

If the New Corduff – Woodland 220 kV OHL circuit option or New Belcamp – Woodland 400 kV OHL circuit option proceeds through Step 2B and Step 3 a variation of those options using underground cable will be evaluated in line with EirGrid's commitment to evaluate UGC when OHL options are brought through the Framework.

# 5 Conclusion of Step 2 Part A

After completing a technology overview, a long list of 21 viable and technically feasible solution options was presented. The solution options identified in the long list were assessed based on two criteria namely, technical performance and economic performance.

The aim of the assessment in Part A is to be able to compare the options and reduce the number of solution options that would be brought forward for more detailed evaluation. Based on the analysis to date, below is a proposed refined list of solution options to be brought forward for more detailed evaluation in Part B:

- New Corduff – Woodland 400 kV OHL Circuit
- New Corduff – Woodland 400 kV UGC Circuit,
- New Corduff – Woodland 220 kV OHL  Circuit,
- New Finglas – Woodland 220 kV OHL Circuit,
- New Finglas – Woodland 400 kV UGC Circuit,
- New Finglas – Woodland 400 kV OHL Circuit,
- New Belcamp – Woodland 400 kV OHL Circuit.

The proposed list of options can be influenced by stakeholders if reasonable justification is provided for modification of the refined list.

All options involve a new connection commencing at Woodland 400/220 kV station and reaching in towards the Nothern outskirts  of Dublin.

In Part B the remaining options will be assessed under five criteria;

- Technical Performance
- Economic Performance
- Deliverability
- Environmental
- Socio-economic

This assessment will allow the refined long list to be further reduced to create a shorter list to bring forward to Step 3.