Best Performing Options Report
Step 3 of Grid Development Framework

North Connacht 110 kV Project

January 2018

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1 Introduction

1.1 Our Statutory Role

EirGrid is the national electricity Transmission System Operator (TSO) for Ireland. Our role and responsibilities are set out in Statutory Instrument No. 445 of 2000 (as amended); in particular, Article 8(1) (a) gives EirGrid, as TSO, the exclusive statutory function:

"To operate and ensure the maintenance of and, if necessary, develop a safe, secure, reliable, economical, and efficient electricity transmission system, and to explore and develop opportunities for interconnection of its system with other systems, in all cases with a view to ensuring that all reasonable demands for electricity are met and having due regard for the environment."

Furthermore, as TSO, we are statutorily obliged to offer terms and enter into agreements, where appropriate and in accordance with regulatory direction, with those using and seeking to use the transmission system. Upon acceptance of connection offers by prospective generators and demand users, we must develop the electricity transmission network to ensure it is suitable for those connections.

1.2 'Have Your Say' – Framework for Grid Development

EirGrid's process for developing identified transmission network problems into viable technical solutions, and further into construction and energisation, is known as the Framework for Grid Development ("The Framework"). It is described in our document *'Have Your Say'* published on EirGrid's website (www.eirgridgroup.com).

At a high-level, The Framework has six steps, as outlined below and in Figure 1. Each step has a distinct purpose and deliverables. The steps generally combine technical and other analysis with opportunities for public and stakeholder participation.

In summary:

- **Step 1:** We confirm the need for a project and its scale.

- **Step 2:** After considering a number of technical solutions, we narrow this down to the *Shortlist of Technology Options* – such as a new line and/or substation, or upgrades to existing lines.

- **Step 3:** We consider technology options in more detail. We also look at the broad study areas we may use for possible routes or site locations. We will also provide information on the methods we are using to analyse the technology options and study areas. We then narrow our analysis to a best performing option and its study area – the general area where we could locate the option.

- **Step 4:** We develop a detailed route or site. This will specify the location of any new equipment or infrastructure.

- **Step 5:** We will finalise a design scheme and obtain all necessary consents for the project. The relevant planning authority will decide if the project has permission to proceed, including setting conditions of permission, or modifying the proposal.

- **Step 6:** The project is progressed and handed over to ESB Networks, the Transmission Asset Owner (TAO) to construct and energise.

The North Connacht Project is currently in Step 3 of The Framework. Following the development of the *Shortlist of Technology Options* in Step 2, this *Shortlist of Technology Options* is further refined with the aim to establish at least one Technology Option that represents the best performing option(s). In Step 4, corridor options and eventually routes are developed and engaged on with the stakeholders in the study area.

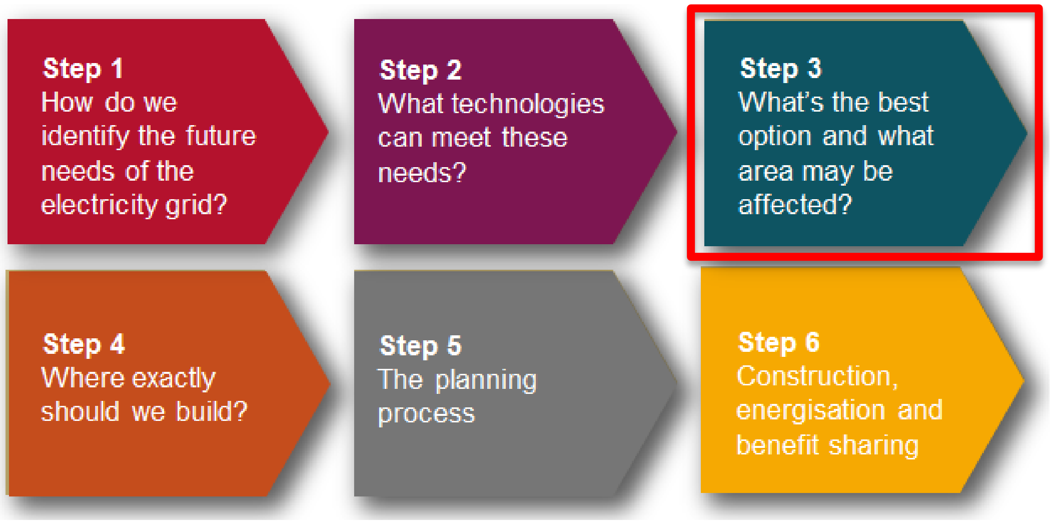

Figure 1: Overview of EirGrid's Framework for Grid Development

2 Project

2.1 Background

In September 2017, EirGrid announced plans to replace the former extra-high voltage (EHV) solution known as Grid West[1], with a smaller-scale development. The decision to replace that EHV project was made due to a significant reduction in the amount of wind generation in north Connacht to be connected onto the national transmission grid, from that originally identified under the Gate 3 group processing scheme in 2008.

In particular, the generation capacity of the so-called Bellacorick subgroup has now reduced from the initial Gate 3 figure of 647 MW in 2008 to 301 MW in 2017 (see Figure 2).

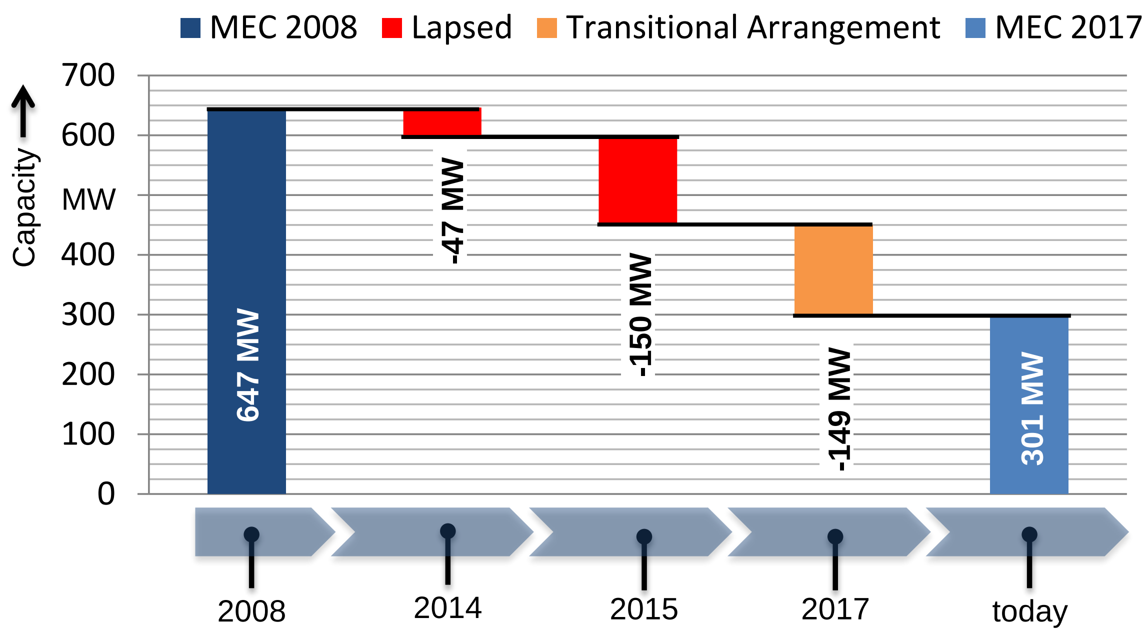

Figure 2: Development of Generation Capacity of Bellacorick Subgroup

In 2008 the anticipated wind generation formed the genesis and development of the Grid West project. Although there has been a significant reduction in anticipated wind generation capacity there still remains a need to connect generators with a total

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[1] http://www.eirgridgroup.com/the-grid/projects/grid-west/whats-happening-now/

combined capacity of 301 MW. This amount of additional generation is still significant; however, it can be met through the development of 110 kV electricity infrastructure, rather than requiring the EHV 220 kV, 400 kV or HVDC infrastructure that was proposed under Grid West.

Whilst such EHV infrastructure would meet the need for the level of generation currently expected, and in addition would provide a level of future-proofing for further increases in generation, no such further future generation has committed to connecting in the area. In the absence of such commitment, EirGrid has opted to focus on optimising the use of the existing 110 kV electricity infrastructure to minimise the need for new infrastructure.

The two existing 110 kV OHL circuits extending from the existing Bellacorick 110 kV substation (Bellacorick – Castlebar and Bellacorick – Moy) have already been, or are planned to be, uprated. This is as part of the overall grid development for exporting renewable generation from the north Connacht area. These works alone are not sufficient for the levels of renewable generation still proposed. It has been assumed that both of these uprates are completed as a starting position.

2.2 Project Need Confirmation

Prior to developing technology options, it is important to analyse and understand the need that is being addressed in Step 1. The pre Gate 3 generation capacity in the north Connacht area totals 174 MW. In addition, 401 MW of Gate 3 wind generation have agreements in place to connect to the grid. 301 MW of this Gate 3 generation is located in proximity of Bellacorick 110 kV substation (depicted as a red zone in the red square in Figure 3). Including the other generation of 163 MW with Firm Access Quantity (FAQ) and 14 MW without FAQ in the area, a total generation capacity of 752 MW is connected or anticipated to connect with Firm Access Quantities[2] (FAQ) in the future.

[2] http://www.eirgridgroup.com/customer-and-industry/general-customer-information/operational-constraints/

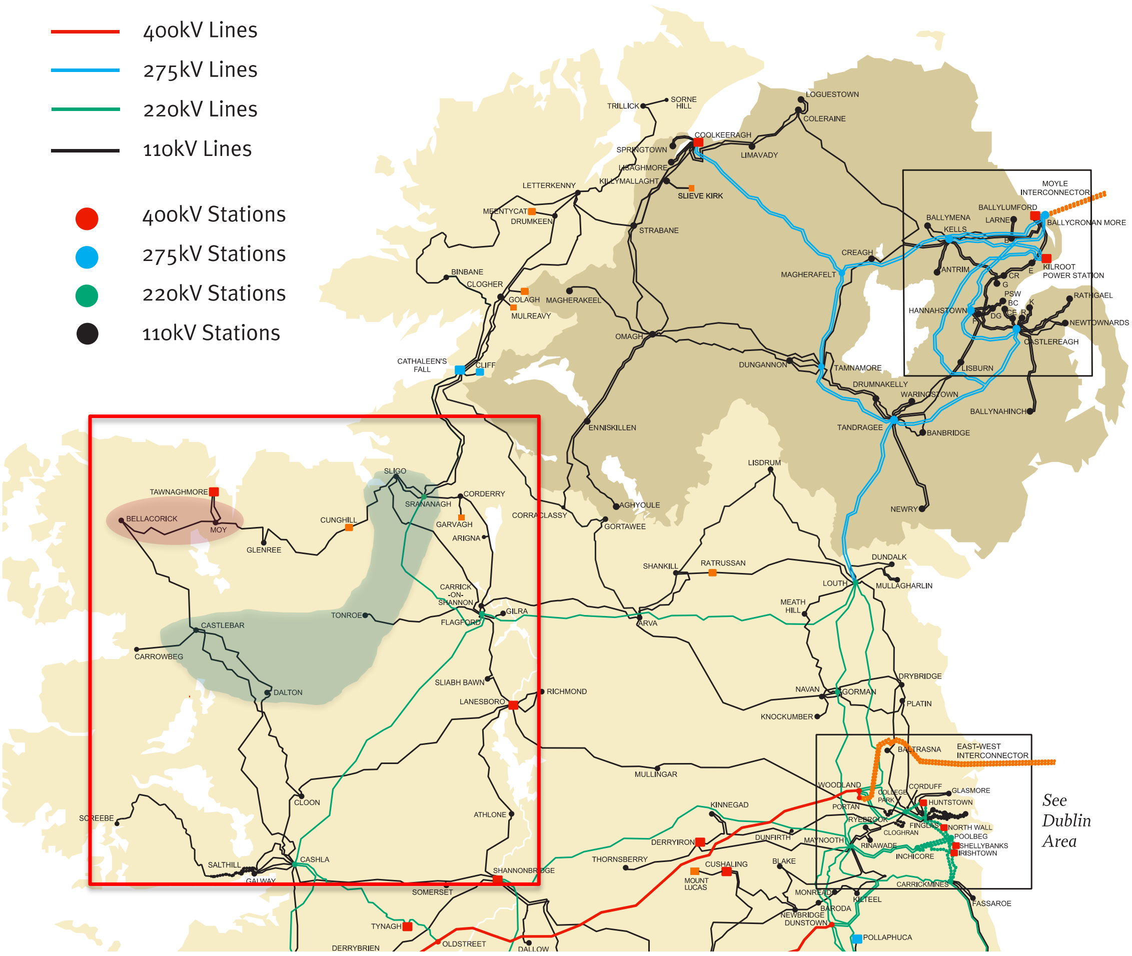

Figure 3: Transmission System Map[3] and High Level Study Area in North Connacht

The network issues which are caused by the planned connection of all generation in north Connacht area were identified in Step 1. It was assumed that the 301 MW of the Bellacorick subgroup generation will connect to the existing Bellacorick 110 kV substation. The total generated electricity (less the demand) in the north Connacht area has now to be moved to the south and east via the transmission system (depicted as a green zone in the red square in Figure 3). In situations with relative high wind (>80%),

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[3] http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Group-Transmission-System-Geographic-Map-Sept-2016.pdf

our studies have shown overloads for the unplanned loss of plant or equipment (known as an N-1 contingency) on the following circuits or station equipment:

- Glenree – Moy 110 kV;
- Castlebar – Cloon 110 kV;
- Bellacorick – Castlebar 110 kV;
- Cunghill – Glenree 110 kV;
- Cunghill – Sligo 110 kV;
- Cashla – Dalton 110 kV;
- Bellacorick – Moy 110 kV; and
- on Dalton 110 kV busbar;

By transmission standards, each item of plant or equipment is manufactured to operate within a statutory voltage range and to carry power flows up to a certain level. In a situation of the unplanned loss of plant or equipment, the power flow is redistributed. This could lead to a system voltage that is outside the statutory voltage range or to a power flow which exceeds the power carrying capability of plant or equipment. Both voltage violation and excess of power carrying capability are unacceptable. In north Connacht the loss of any circuit on the Moy – Glenree - Cunghill – Sligo or the Bellacorick – Castlebar route would result in the excess of manufactured capability of plant or equipment. These violations are in breach of EirGrid's Transmission System Security and Planning Standards[4] (TSSPS).

2.3 Developed Shortlist of Technology Options

In Step 2 of the Framework for Grid Development, the Longlist of Technology Options was developed based on the needs identified. The longlist was assessed on a high level against five criteria. As a result, the *Shortlist of Technology Options* was identified and brought forward in to Step 3 for more detailed assessment. The development schemes which are formed by the *Shortlist of Technology Options* and its associated uprates are listed in the Table 1 below.

[4] http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Transmission-System-Security-and-Planning-Standards-TSSPS-Final-May-2016-APPROVED.pdf

ID	Scheme	Method	High Level Work Packages
OHL-MT	**New Moy – Tonroe 110 kV**	Overhead Line (OHL)	New Build: 58 km Line Upgrade: 32 km Station Upgrade: 1
UGC-MT	**New Moy – Tonroe 110 kV**	Underground Cable (UGC)	New Build: 58 km Line Upgrade: 32 km Station Upgrade: 1
OHL-MS	**New Moy – Srananagh 110 kV**	Overhead Line (OHL)	New Build: 66 km Line Upgrade: 58 km Station Upgrade: 0
UGC-MS	**New Moy – Srananagh 110 kV**	Underground Cable (UGC)	New Build: 66 km Line Upgrade: 0 km Station Upgrade: 0

Table 1: Shortlist of Technology Options Identified in Step 2 – Options Report[5]

The following subsection details the work programme associated with each of the option.

2.3.1 Moy – Tonroe 110 kV OHL Option

New Build:

- New build of a 110 kV OHL circuit (430mm^2 ACSR @80°C) with an estimated length[6] of approximately 58 km
- Installation of new 110kV AIS line bay in Moy 110kV substation as part of the new circuit

Line Upgrade:

- Uprate of 110 kV OHL circuit from Tonroe to Flagford (430mm^2 ACSR @80°C) with a length of 32 km
- Uprate of 110kV AIS line bay in Flagford 110kV substation as part of the associated uprate

Station Upgrade:

- Redevelopment of the existing Tonroe 110 kV substation to AIS enhanced "C-Type" Outdoor Station (Strung Busbar) including two line bays, one transformer[7] bay and one spare bay.

[5] http://www.eirgridgroup.com/site-files/library/EirGrid/CP0816_NC_Step-2_Options-Report.pdf
[6] The estimated OHL length is defined as straight line length between terminating stations plus additional 25% for routing around constraints.
[7] The current Tonroe 110 kV substation includes an existing 110/38 kV DSO transformer.

2.3.2 Moy – Tonroe 110 kV UGC Option

New Build:

- New build of a 110 kV UGC circuit (1600mm² Al XLPE) with an estimated length[8] of approximately 58 km
- Two terminations of 1600mm² Al XLPE cable (at both cables ends)

Line Upgrade:

- Uprate of 110 kV OHL circuit from Tonroe to Flagford (430mm^2 ACSR @80°C) with a length of 32 km
- Uprate of 110kV AIS line bay in Flagford 110kV substation as part of the associated uprate

Station Upgrade:

- Redevelopment of the existing Tonroe 110 kV substation to AIS enhanced "C-Type" Outdoor Station (Strung Busbar) including two line bays, one transformer[9] bay and one spare bay.

2.3.3 Moy – Srananagh 110 kV OHL Option

New Build:

- New build of a 110 kV OHL circuit (430mm^2 ACSR @80°C) with an estimated length[10] of approximately 66 km
- Installation of new 110kV AIS line bay in Moy 110kV substation and Srananagh 110kV substation as part of the new circuit

Line Upgrade:

- Uprate of 110 kV OHL circuit from Castlebar to Cloon(430mm^2 ACSR @80°C) with a length of 32 km
- Uprate of 110kV AIS line bays in Castlebar 110kV substation and Cloon 110kV substation as part of the associated uprate

2.3.1 Moy – Srananagh 110 kV UGC Option

New Build:

- New build of a 110 kV UGC circuit (1600mm² Al XLPE) with an estimated length[11] of approximately 66 km
- Two terminations of 1600mm² Al XLPE cable (at both cables ends)
- Installation of new 110kV AIS line bays in Moy 110kV substation and Srananagh 110kV substation as part of the new circuit

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[8] The estimated UGC length is defined as straight line length between terminating stations plus additional 25% for routing along roads.
[9] The current Tonroe 110 kV substation includes an existing 110/38 kV DSO transformer.
[10] The estimated OHL length is defined as straight line length between terminating stations plus additional 25% for routing around constraints.
[11] The estimated UGC length is defined as straight line length between terminating stations plus additional 25% for routing along roads.

3 Methodology

3.1 Description of Process

This report details the findings of the more detailed evaluation of the *Shortlist of Technology Options* in Step 3. The evaluation of the options uses a multi-criteria comparison against five main criteria: Technical, Economic, Environmental, Socio-Economic and Deliverability. Each of these five criteria is divided again into sub-criteria which are listed in section 3.2. These sub-criteria are used in Step 3 to evaluate the *Shortlist of Technology Options* in more detail and to select at least one best performing option.

In order for us to populate each individual sub-criterion in the multi-criteria performance matrix, information can be obtained from various sources. The sources can be an in-house expert or an appointed consultant in the required area of expertise. In some areas information obtained in earlier steps or in a previous project, if applicable, were used and improved with more accurate information which has come to light during the process of development.

3.2 Criteria Used for Comparison of Technology Options

The range of sub-criteria used for the assessment of the *Shortlist of Technology Options* are listed and described under the heading of the five main criteria in the following sections.

3.2.1 Technical Performance

- *Safety Standards Compliance*: The project 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.
- *Security Standards Compliance*: The project should comply with the reliability and security standard defined in the Transmission System Security and Planning Standards and the Operation Security Standards.

- *System Reliability*: The average failure rates for the OHL or UGC can be calculated using, for example, estimated availability figures (unplanned outages/100km/year), Meant Time To Repair and the length of the line or cable. A more detailed calculation could also take into account failure rates of transformers, switchgear and other items.

- *Headroom*: Headroom describes the amount of additional generation/demand capacity that the transmission network is able to facilitate in the future without upgrades following implementation of the solution option.

- *Expansion / 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.

- *Repeatability*: This criterion examines whether this option can be readily repeated in the EirGrid network. For example, an OHL HVAC[12] option is very repeatable, but a partially underground HVAC option is less repeatable as there can only be a certain amount of underground HVAC cable in each area of the network.

- *Technical Operational Risk*: "Technical Operational Risk" aims to capture the risk of operating different technologies on the network.

3.2.2 Economic Assessment

- *Project Implementation Costs:* Costs associated with the procurement, installation and commissioning of the grid development and therefore includes all the transmission equipment that forms part of the project's scope.

- *Project Life-Cycle Costs:* These costs are incurred over the useful life of the reinforcement and include the foreseeable operational cost to ensure a viable option. This includes costs associated with operating expenditure (OPEX), maintenance, replacement, transmission losses, decommissioning, etc.

- *Project Benefits:* The benefit is determined by the reduction in applied constraints and the associated costs that consequently are avoided.

[12] HVAC: High Voltage Alternating Current

- *Cost to SEM:* Cost to SEM from development unavailability (Reliability) i.e. the loss of energy due to unavailability.

- *Contingency Costs:* Estimate of unforeseeable expenditure that an individual option may incur.

- *Pre-Engineering Costs:* Costs associated with the design and specification, corridor and route evaluation and management of the statutory planning application, including contingencies for such activities.

3.2.3 Environmental

- *Biodiversity, Flora & Fauna:* Assessment of the potential impacts on protected sites for nature conservation, habitats and protected species.

- *Soils and Water Impacts:* Potential impact on soils (geology, Irish geological heritage sites, etc) and water (water quality of surface waters and groundwater) .

- *Material Assets:* Impact on land use (forestry, farmland, bogs/peats, horticulture).

- *Landscape & Visual:* Assessment of landscape constraints and designations and the potential impact on visual amenity.

- *Cultural Heritage:* The potential for impacts on the cultural heritage resources.

- *Noise:* Potential for vibration and operational noise impact of lines and sub-stations, taking into account sensitive receptors.

3.2.4 Socioeconomic

Socioeconomic performance sub-criteria are:

- *Settlement & Communities:* The expected impact of a grid development option on towns, villages and rural housing, and the way of life of their communities, residents, workers and visitors.

- *Recreation & Tourism:* Impact on recreational activities (e.g. fishing, sports) and tourism during and after construction, that are not included in the other sub-criteria.

- *Landscape & Visual:* Assessment of landscape constraints and designations and the impact on visual amenity.

- *Cultural Heritage:* The impact on the recorded cultural heritage resource of a potential grid solution.

- *Aviation & Defence:* Impact on wireless services such as radars, radio communications, TV, flight paths, etc.

3.2.5 Deliverability

Deliverability sub-criteria are:

- *Implementation Timelines:* Relative length of time until energisation (assess significant differences).

- *Project Plan Flexibility:* Does the project plan allow for some flexibility if issues arise during design and construction?

- *Dependence on other Projects:* Does the project depend on the completion of other projects?

- *Risk of Untried Technologies:* Has the technology been used by EirGrid and ESBN in the past.

- *Supply Chain Constraints:* 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.

- *Permits & Wayleaves:* Various permissions and wayleaves required to proceed to construction.

Construction related impacts

- *Water Impact during Construction:* Ease/ difficulty of mitigation measures that may be required to prevent impacts on river crossings, lakes, and groundwater

- *Air Quality Impact during Construction:* Ease/difficulty of mitigation measures that may be required to reduce impacts from construction-related dust and traffic.

- Tr*affic & Noise Impact during Construction:* Noise and traffic disturbance and impacts that may occur during the construction phase and mitigation measures to reduce impacts.

3.3 Scale Used to Assess each Criteria

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

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

Dark Blue	Blue	Dark Green	Green	Cream

Table 2: Colour Scheme used for Criteria Ratings

This scale is qualified by text for example mid-level (Dark Green), low-moderate (Green), low (Cream) or high (Dark Blue). No quantitative evaluation occurs.

4 Option Evaluation

4.1 Technical Performance

The table below is a summary of technical performances.

	ID	OHL-MT	UGC-MT	OHL-MS	UGC-MS
	Type	OHL	UGC	OHL	UGC
	Scheme	Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Sranangh 110 kV	Moy – Sranangh 110 kV
Technical Sub-Criteria	Safety Standard Compliance	Green	Green	Green	Green
	Security Standards Compliance	Dark Green	Green	Blue	Dark Green
	System Reliability	Cream	Blue	Cream	Dark Blue
	Headroom	Dark Green	Dark Green	Blue	Blue
	Expansion / Extendibility	Dark Green	Blue	Dark Green	Blue
	Repeatability	Cream	Dark Green	Cream	Dark Green
	Technology Operational Risk	Cream	Green	Cream	Green
	Overall	Green	Dark Green	Dark Green	Blue

Table 3: Technical Performance

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

Dark Blue	Blue	Dark Green	Green	Cream

This technical assessment illustrates that the various options have different potential implications in regards with the various technical sub criteria. The options terminating in Tonroe 110 kV substation score better than the options terminating in Srananagh in regards to security standards compliance and headroom. In terms of system reliability, repeatability, expansion / extendibility, and technology operational risk, the OHL score better than their UGC counterpart.

Overall, Moy – Tonroe 110 kV OHL performs the best with a low-moderate impact on technical performance (**Green**). Overall, the Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV OHL perform equally with a moderate impact (**Dark Green**). The Moy – Srananagh 110 kV UGC performs with a moderate-high impact (**Blue**) on technical performance.

The evaluation of each option made under each technical sub criterion is elaborated further in the following sections.

4.1.1 Safety Standard Compliance

As all options propose using tested and approved technology, they also comply with relevant safety standards such as those from the European Committee for Electrotechnical Standardisation (CENELEC). The materials used comply with IEC or CENELEC standards.

Due to different station arrangements, the stations may be slightly different as follows:

There are three ways to install the required line bay for the new circuit in Moy 110 kV substation (near Ballina). Two of these require installation of the bay for the new circuit in a so-called back-to-back arrangement with existing 110 kV equipment. Due to proximity, this has an impact operational flexibility.

Tonroe 110 kV substation (in Ballaghaderreen) has no 110 kV busbar. Currently, the existing Flagford 110 kV OHL circuit connects directly onto the 110/38 kV transformer. This transformer feeds the local 38 kV distribution system. The technology options terminating in Tonroe 110 kV substation will require a new busbar. The new busbar would be installed aligned with EirGrid Busbar Configuration Policy[13] as AIS Enhanced "C-Type" Outdoor substation (Strung Busbar). Designated Working Areas (DWA) may come into play during the busbar installation and may require the Flagford 110 kV bay to

[13] EirGrid's Busbar Configuration Policy (October 2015)

be switched out or diverted to a mobile bay[14] to allow the construction works to take place.[15]

Srananagh substation was initially built in 2005/2006. The substation has voltage elements at 220 kV and 110 kV. There are five locations for additional bays at 110 kV. The typical safe working consideration would apply to complete the line bay installation. DWA measures may come into play during the 110 kV line bay installation and a DWA outage may be required on the 220/110 kV transformer and during construction of the new bay.[16]

Table 4: Safety Standard Compliance Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Safety Standard Compliance				

All options may require DWA outages due to proximity during construction and maintenance work. Hence, all options are rated as low-moderate in regards with risk for safety issues (**Green**).

4.1.2 Security Standards Compliance

The security standard compliance was assessed for three operational scenarios. Table 5 lists the assumptions in regards with the load, wind generation and non-wind generation for the study area[17].

[14] This arrangement has been utilised previously during maintenance works on the transformer.
[15] Technical Report -- Tonroe 110 kV Substation
[16] Technical Report -- Srananagh 220/110 kV Substation
[17] Study Area contains the following 110 kV substation: Cloon, Dalton, Carrowbeg ,Castlebar, Bellacorick, Moy, Tawnaghmore, Glenree, Cunghill, Sligo, Srananagh and Tonroe

Table 5: Operational Scenarios for Study Area (see Figure 3 red box)

Type	Load [MW]	Wind Generation [MW]	Level of Wind Generation [% MEC]	Non-Wind Generation [MW]	Level of Non-Wind Generation [% MEC]
Summer Valley (SV)	41	517	65%	5	8%
Summer Peak (SP)	165	629	80%	17	29%
Winter Peak (WP)	219	677	86%	17	29%

For the detailed assessment, it is assumed that the transmission system without any of these options forms the reference case, if appropriate. The comparison with the reference case helps to illustrate the benefit of the each option.

4.1.2.1 Voltage

According to EirGrid's Transmission System Security and Planning Standard, the post-contingency voltage limits for the duration of contingency are 0.9 to 1.1 per unit or 99 kV to 121 kV. Further, for contingencies, the maximum step change between pre- and post-contingency voltages shall be no more than 0.1 per unit.

Power system analysis of all the solution options has shown the minimum post-contingent voltages are 0.98-0.99 per unit. The maximum post-contingent voltages were maintained at in a range of 1.07-1.08 per unit. The voltage limits are within the voltage limits of the planning standards.

In terms of voltage steps, all options perform similarly. For voltage step up both UGC options show a marginal improvement and lower voltage deviation in comparison with the respective OHL.

Each option shows an improvement in comparison to the reference case due to strengthening of the 110 kV network in area. All options comply with the post-contingent voltage levels provided by EirGrid's Transmission System Security and Planning Standard.

4.1.2.2 Thermal Limits

The needs assessment for the North Connacht 110 kV Project is summarised in section 2.2. It shows circuit loadings in the study area that are above the short-term emergency rating in the reference case.

Any of the Options in the *Shortlist of Technology Options* would establish a second pathway out the study area in the event of an outage or contingency along the path of Castlebar – Bellacorick – Moy – Glenree – Cunghill – Sligo 110 kV substation. As a result the high circuit loadings are reduced significantly in the event of outage or contingency, when compared to the reference case.

Establishing a third pathway out of the study area changes the network topology. This, in addition with the different circuit technologies used for the *Shortlist of Technology Options,* results in a significant change in power flows. The UGCs attract higher power flows due to their lower impedance, which releases more available power carrying capability in the existing 110 kV transmission infrastructure in the study area. Similar results can be achieved for the OHL options by installation of additional devices that help to divert the power flow to optimise the available capacity. In order to manage power flows in the study area more effectively, key innovative technologies like Distributed Series Reactance (DSR) could be used to dynamically adjust the impedance of the conductor. These technologies can be used to optimise the power flows and minimise requirements for additional future infrastructure up to a certain extent.

South of Bellacorick

Studies have shown that circuits in the study area along the paths of Castlebar – Cloon and Cashla – Dalton will experience high line loadings in the event of an outage or a contingency. Hence, various measures were considered in the analysis to reduce the line loading on these pathways. Two solutions are available: Increase the power carrying capability, or reduce the power flows on these circuits. Table 6 shows an overview of the available options to alleviate the issues.

Table 6: Mitigation to Reduce Line Loading or Increase Power Carrying Capability

Mitigation	Impact	Description
Upgrade of existing Dalton 110 kV Substation	Increase Rating of Castlebar – Dalton and Cashla Dalton circuits	Equipment in Dalton 110 kV substation limits line rating

Distributed Series Reactance (DSR)[18]	Reduce power flows on Castlebar – Dalton; Castlebar – Cloon; and Cashla – Dalton	Divert power flow in order to optimise use of available capacity on other circuits
Dynamic Line Rating[19]	Dynamic Power Carrying Capability	Dynamic rating depending on ambient conditions in order to maximise power carrying capability in realtime operations
Upgrade of circuits[20]	Increase Power Carrying Capability	Installation of a new conductor capable of carrying higher power flows.

East of Bellacorick

The additional pathway also increases the power flows towards the East. These power flows eventually accumulate with the flows from further North in Donegal. The Gate 3 generation in Donegal have not yet been connected but it is important to consider the implications of these generators in this long-term analysis.

As a result, the line loading of the Arva – Carrick-on-Shannon 110 kV circuit increases for all options. All options will be associated with mitigations[21] to alleviate overloads on Arva – Carrick-on-Shannon 110 kV circuit.

The options Moy – Srananagh OHL and Moy – Srananagh UGC result in increasing power flows along the route Corderry – Arigna T – Carrick-on-Shannon 110 kV substation. Due to the different characteristics of the UGC, the power flows on that particular route are slightly greater for the UGC option. In Summer Peak this may require further mitigations to alleviate the high loadings on Arigna T – Carrick-on-Shannon.

Both options Moy – Srananagh OHL and Moy – Tonroe UGC are associated with the least amount of required mitigation measures on circuits in the study area. Moy – Tonroe UGC option performs slightly better as mitigation measures such as generation constraints could be only required during the Summer Valley. Moy – Tonroe OHL and Moy – Srananagh UGC show high loadings on three circuits which have to be alleviated

[18] http://www.eirgridgroup.com/how-the-grid-works/innovation/enhanced-user-facilitatio/
[19] This requires the upgrade of the existing Dalton 110 kV substation.
[20] This requires the upgrade of the existing Dalton 110 kV substation.
[21] Such mitigation may be part of future grid development options at a regional level. None of these options are integral to the North Connacht 110 kV project and therefore are not included in this project.

by further measures. Hence, these two options perform less well than Moy – Tonroe UGC.

4.1.2.3 Short Circuit Levels

Interconnectional solution options result in an increase in connection between substations in the 110 kV network in study area. The short circuit levels increases for each option in the *Shortlist of Technology Options.* At the starting and terminating 110 kV substations the short circuit levels increase by a value in the range of 2 to 3 kA. In the adjacent substations, which are electrically close[22], the short circuit level increases by a value in the range of 1 to 2 kA.

Despite the increase in short circuit levels, the values for each option in *Shortlist of Technology Options* are below 90% of the equipment rating. Therefore, each option is compliant with EirGrid's Transmission System Security and Planning Standards.

4.1.2.4 Angle Differences / Dynamic Issues

Studies on the reference case have shown that certain contingencies in the study area could result in phase angles of greater than 40 degrees (maximum level of stress) on re-closing. This is in breach of EirGrid's Operating Security Standards - December 2011. The circuits that show phase angle differences above 40 degrees in the reference case are listed below:

- Cunghill – Sligo 110 kV
- Cunghill – Glenree 110 kV
- Bellacorick – Castlebar 110 kV

Of all the solution options, the maximum angle difference is exceeded for the Moy – Srananagh OHL option. The Moy – Tonroe OHL option did not exceed the allowable limit, but was close to the upper bounds.

[22] Stations which are directly connected by an OHL or UGC with each other.

In order to reduce the angle difference, the generation or demand level has to be adjusted in the area following an unplanned outage of the above listed circuits.

Due to the different characteristics of the UGC conductor, the angle difference is lower in comparison to OHL. Hence, both UGC technology options perform better than their respective OHL technology options.

4.1.2.5 EMT Limits

All options will be designed to meet the EMT limits as they have to comply with it. Mitigations are likely to be required for a new circuit of a length in a range from 58 to 66 km to meet the limits. The required mitigations for all options will be determined in the design phase of the best performing option in Step 4.

4.1.2.6 Summary

Table 7: Security Standards Compliance Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Security Standards Compliance				

Taking all these factors on security standards and compliance into account: The Moy – Srananagh 110 kV OHL performs worst with moderate-high impact (**Blue**). Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV UGC perform equally with a moderate impact (**Dark Green**). Moy – Tonroe 110 kV UGC has been shown to perform best in terms with a moderate-low impact (**Green**).

4.1.3 System Reliability

EirGrid's mandate is to maintain and develop a transmission system in Ireland that is safe, secure, reliable, economical and that has due care for the environment. The reliability and security of the electrical supply are effectively determined by the availability of the system. Since, when the electrical grid is unavailable, users do not have a reliable or secure supply.

The statistics for reliability is 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.

Figure 4 shows the comparison of annual expected unavailability of each option in hours per year.

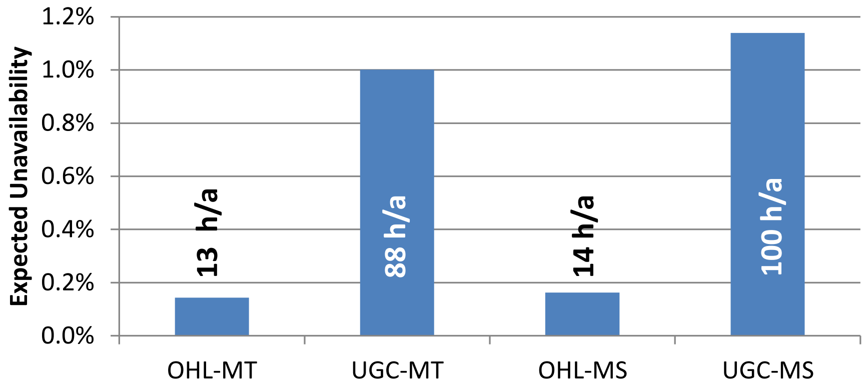

Figure 4: Annual Expected Unavailability of each Technology Options

Due to the shorter required circuit length, the options connecting Moy – Tonroe perform better than the respective Moy – Srananagh 110 kV. Furthermore, the OHL options surpass the UGC options due the lower unavailability rating.

Table 8: System Reliability Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
System Reliability				

Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL have low impact on system reliability (**Cream**). Moy – Tonroe 110 kV UGC has been shown to have moderate impact on system reliability (**Blue**). The Moy – Srananagh 110 kV UGC has been shown to have the highest impact on system reliability (**Dark Blue**).

4.1.4 Headroom

4.1.4.1 Generation

The proposed development schemes are able to facilitate the generation levels assumed in studies. These generation levels are based on historical trends. In Summer Peak, the 110 kV network is expected to be able to facilitate generation levels of up to 80% wind generation. In Winter Peak wind generation levels of 86% in the study area were applied and was shown to be able to be accommodated by the network in the area. These slightly higher levels in Winter Peak times can be accommodated due to higher electricity demand and power carrying capabilities of the circuits in winter.

The Summer Peak case is the limiting factor to increasing generation levels. Dependent on its size and operating regime additional generation capacity in the area would require further development of the network.

4.1.4.2 Demand

The security of supply levels were assessed at times of no local generation[23] in the study area and for the loss of a single item of plant or equipment (N-1) and contingency events during maintenance (N-1-1). These cases would form the worst-case scenarios[24] in terms of contingencies and electricity supply in the area. Transmission substations at 110kV are not designed for the purposes of supplying distribution demand of more than 90 MW[25].

The OHL and UGC development schemes connecting Moy – Tonroe introduce a second circuit connecting into Tonroe 110 kV substation. The second circuit secures the supply of electricity in the event of loss of either the existing Flagford – Tonroe 110 kV circuit or the new 110 kV Moy – Tonroe 110 kV circuit. Hence, these schemes allow an additional supply of electricity of up to 90 MW in any N-1 contingency event. Both Moy – Tonroe schemes perform better in this regard than the Moy – Srananagh schemes.

Due to all options connecting to Moy 110 kV substation, all development schemes improve the level of security of supply at Moy 110 kV substation. In the N-1 contingency event, the demand growth potential is up to 90 MW. In the worst case[26] of an N-1-1 contingency event, the Moy – Srananagh schemes perform slightly better because they still allow an electricity demand growth of up to an additional c.75 MW.

The worst-case N-1-1 contingency event for the Moy – Tonroe schemes is the contingency with the loss of both Bellacorick – Castlebar 110 kV and Tonroe – Flagford 110 kV. Hence, the maximum electricity demand growth potential must be reduced at Tonroe 110 kV substation which leaves the Moy – Tonroe schemes with a total demand growth potential of c.63 MW.

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[23] In order to maximum the import of electricity to meet the local demand.
[24] In order to achieve the maximum demand growth potential in the worst-case event, further reactive power compensation device may be required.
[25] EirGrid's Transmission System Security and Planning Standards 4.1.3
[26] Worst-Case N-1-1 Contingency: Bellacorick – Castlebar 110 kV and Moy – Srananagh 110 kV

The power carrying capability of the Moy – Glenree circuit 110 kV limits the demand growth in all contingencies, however this could be uprated if demand growth projections indicated a need.

The Tawnaghmore 110 kV substation is directly connected to Moy 110 kV substation by two 110 kV circuits. Hence, Tawnaghmore 110 kV substation will benefit from the increase of security of supply at Moy 110 kV substation. The risk of losing the two circuits connecting Tawnaghmore 110 kV substation due to failure or maintenance is expected to be low.

4.1.4.3 Summary

Table 9: Headroom Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Headroom				

The Moy – Tonroe 110 kV OHL and UGC options perform equally well with a moderate impact on headroom (**Dark Green**). The Moy – Srananagh 110 kV OHL and UGC options perform less well with a moderate-high negative impact on headroom (**Blue**).

4.1.5 Expansion / Extendibility

4.1.5.1 Moy 110 kV Substation

Moy 110 kV substation has currently two possible areas for the development of a new line bay in the existent substation compound. Either of these areas could be used for the new circuit connecting Moy with Tonroe / Srananagh 110 kV substation. This development will leave Moy 110 kV substation with space for one new bay for future development, for example to connect a further circuit.

4.1.5.2 Tonroe 110 kV Substation

Both schemes connecting Moy – Tonroe require the development of a 110 kV AIS Enhanced "C-Type" Outdoor substation (Strung Busbar) at the existing Tonroe 110 kV substation near Ballaghaderreen. The re-developed substation would have room for four line/transformer bays three of which are required to connect the existing equipment and the new circuit. Consequently, Tonroe 110 kV substation will have one bay for future development.

4.1.5.3 Srananagh 110 kV Substation

In Srananagh 110 kV substation there are currently two spare line/transformer bays available for further development of a new line/transformer bay. One of these could be used for the new Moy – Srananagh 110 kV circuit, either OHL or UGC.

4.1.5.4 Increase of Power Carrying Capability

The power carrying capability of circuits is limited by the heat (thermal losses) generated by the power flowing through the circuit. There are various options which could be applied to increase the power carrying capability:

- Reduce the current flow while maintaining the same capacity for power
- Increase the thermal capacity of the circuit

All the available options are mainly applicable for OHL technologies.

According to EirGrid's grid development technology toolbox, two options are available to increase the power carrying capability while making best use of existing infrastructure.

The first option is the use of High Temperature Low Sag (HTLS) conductors, which are able to operate at higher temperatures and hence facilitate a higher current at the same operating voltage resulting in a higher power flow. This type of conductor would replace the existing conductor and can often be installed on the existing pole-set infrastructure. The second option is to actively monitor[27] the atmospheric environment and its direct cooling effect on the conductors. This technology (Dynamic Line Rating) allows a dynamic power carrying capability depending on atmospheric operating conditions. For either option, the upgrade of existing equipment in substation and lines may be required to maximise the current carrying potential.

[27] Active monitoring of wind speed, sun radiation and ambient temperature.

Alternatively, the power carrying capability could be increased by the increasing the voltage levels and consequently reducing the current on the circuit. In terms of voltage increase, all options establish a new pathway to the next meshed substation Flagford or Srananagh 220/110 kV substation. Both substations would allow access to the 220 kV voltage level. In order to increase the voltage level from 110 kV to 220 kV new conductors would be required due to insulation and power flow requirements. The OHL options would require new insulators, conductors and depending on the weight and physical spacing of equipment, new pole sets / towers. Further a new 220/110 kV substation would be required in Ballina. If technically feasible, the effort and requirements associated with the increase of voltage would be considered to be equal to the development of a new 220 kV OHL circuit and a 220/110 kV substation in the area.

4.1.5.5 Summary

Table 10: Expansion / Extendibility Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Expansion / Extendibility				

The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options have been determined to perform equally with a moderate impact on expansion and extendibility (**Dark Green**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options have been determined to perform equally with a moderate-high negative impact on expansion and extendibility (**Blue**).

4.1.6 Repeatability

OHL circuits at 110 kV are already widely in use in the Irish transmission system with more than 4500 km of circuit length. No limits are envisaged in regards to repeatability of 110 kV OHL circuits on the Irish transmission system.

The total 110 kV UGC length in the Irish transmission system is c.400 km. The average 110 kV UGC length on the Irish transmission system is c.2 km with the longest circuit between the Galway and Knockranny 110 kV substations of c.23 km. The use of UGC with a length of 58 and 66 km, respectively, would be considered an untried technology on the Irish transmission system. Given the length of the UGC circuits and the strength of the 110 kV network it is considered likely that the amount of additional UGC may be limited in the area. Hence, there is a medium risk associated with the repeatability of UGC in area.

Table 11: Repeatability Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Repeatability				

The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options have been determined to perform equally with a low impact on expansion and extendibility (**Cream**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options have been determined to perform equally with a moderate-high negative impact on expansion and extendibility (**Dark Green**).

4.1.7 Technical Operational Risk

Table 12: Technical Operational Risk Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Technical Operational Risk				

OHL circuits are seen as a tried and tested technology. Hence, low technical operational risk is associated with OHL technology. The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options have been determined to perform equally with a low impact on technical operational risk (**Cream**).

UGC at this voltage are used at various points in the Irish transmission system mainly in urban areas like Dublin or to connect generators like wind farms into adjacent 110 kV substations. The UGC technology is considered as a tried and tested technology. Additional operational requirements, i.e. reactive power compensation and filter devices, increases the complexity for UGC operation. Hence, a low-medium technical operational risk is associated with the UGC technology. The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options have been determined to perform equally with a moderate-low negative impact on expansion and extendibility (**Green**).

4.2 Economic Assessment

The Discounted Cash Flow (DCF) analysis method is used to evaluate the economic merits of reinforcement options. It uses the concept of the time value of money that all future cash flows are estimated and discounted using an approved Weighted Average Cost of Capital (WACC) to calculate their equivalent present values. The method facilitates the consistent representation of all the value that is associated with each of the alternative reinforcements.

The WACC is taken to be the real societal discount rate, which is interpreted to be the Test Discount Rate specified by CRU. The WACC applied is 4.95%[28].

The duration of the evaluation is taken as the regulatory authority-approved useful life for transmission assets, i.e. 50 years[29].

The table below is a summary of the economic assessment made.

ID		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Type		OHL	UGC	OHL	UGC
Scheme		Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Srananagh 110 kV	Moy – Srananagh 110 kV
Economic Sub-Criteria	Implementation Costs				
	Life-Cycle Costs				
	Project Benefits				
	Cost to SEM				
	Contingency				
	Pre-engineering Costs				
	Overall				

Table 13: Economic Assessment

[28] Decision on TSO and TAO transmission revenue for 2016 to 2020, CER/15/296, 23rd December 2015

[29] Decision on TSO and TAO transmission revenue for 2016 to 2020, CER/15/296, 23rd December 2010. Page 52: "...an average life of 50 years is applied to transmission network assets".

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

Dark Blue	Blue	Dark Green	Green	Cream

This economic assessment illustrates that the various options have different potential implications in regards with the various economic sub criteria. Overall, the options are mostly equal over most of the sub-criteria but implementation costs. Here, the OHL options perform better than the UGC options due to lower implementation costs. The Moy – Tonroe 110 kV OHL options performs best in this regard, despite the additional implementation cost for a new 110 kV substation in Tonroe near Ballaghadreen, due to the shorter length of the new circuit, and shorter length of the associated circuit uprates.

Overall, Moy – Tonroe 110 kV OHL performs the best with a low-moderate impact on economic performance (**Green**). Overall, the remaining options, Moy – Tonroe 110 kV UGC, Moy – Srananagh 110 kV OHL and Moy – Srananagh 110 kV UGC perform equally with a moderate impact (**Dark Green**).

The evaluation of each option made under each economic sub criterion is elaborated further in the following sections.

4.2.1 Project Implementation Costs

The project implementation costs are the costs associated with the procurement, installation and commissioning of the reinforcement and therefore includes all the transmission equipment that form part of the development scheme. The project implementation cost are estimates and adequate for the comparison of these options. Estimated circuit length is based on past experience given the stage in development in the framework process. This is defined as straight line length between terminating stations plus additional 25% for routing around constraints. The implementation cost estimates are based on the latest version of standard development costs.

The estimated implementation costs are categorised into their general components and are summarised in Table 14 below:

Table 14: Summary of Project Implementation Costs

Cost Category		Project Implementation Costs			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Overhead Line	€M	16.2	-	18.5	-
Underground Cable		-	45.8	-	52.1
Station		8.2	8.8	3.8	2.5
Associated Uprates		9.0	9.0	16.2	0.0
Other					
Flexibility Payments and Proximity Allowance		3.6	0.7	4.1	0.8
Sub-Total	**€M**	37.0	64.3	42.6	55.4
Contingency	10%	3.7	6.4	4.3	5.5
Total	**€M**	40.7	70.7	46.9	61.0

The direct comparison of the options shows that the implementation costs of UGC are higher by a factor of two to three than the OHL implementation cost. As the implementation costs are depending on the length of the circuit, the Moy – Tonroe OHL option, as the shortest OHL circuit, has the lowest implementation costs of all options.

Currently there is only one circuit connecting in to the 110 kV substation at Tonroe. The existing 110 kV substation equipment is limited and cannot facilitate a new circuit. In order to be compliant with EirGrid's Busbar Configuration Policy the options terminating in Tonroe 110 kV substation are associated with the development of a 110 kV AIS Enhanced "C-Type" Outdoor substation (Strung Busbar). The re-developed substation will be able to facilitate two line bays, one transformer bay and space for a future bay. Two further line bays are required, one in Moy 110 kV substation for the new circuit and another in Flagford 220/110 kV substation on the 110 kV voltage level to meet the power carrying capability of the uprate between Flagford-Tonroe. These station works total implementation costs of €8.2 million.

In addition, the Moy – Tonroe 110 kV UGC option requires two cable terminations at ends of the UGC. This adds implementation costs of €0.6 million to the station implementation costs.

The existing Flagford-Tonroe 110 kV circuit has currently a power carrying capability of 98 MVA. This circuit has to be reinforced to meet the power carrying capability of the new circuit connecting Moy and Tonroe 110 kV substation. The estimated implementation costs for this reinforcement are € 9.0 million.

The Moy – Srananagh 110 kV OHL requires four new line bays for the new circuit and the uprate of Castlebar-Cloon. While the Moy – Srananagh 110 kV UGC does not require the additional uprate of Castlebar-Cloon, it requires only two new line bays for the new UGC circuit but two terminations on both side of the UGC. The station works associated with Moy – Srananagh 110 kV UGC totals therefore €2.5 million.

The Moy – Srananagh OHL option requires the uprate of Castlebar–Cloon. The uprate has a length of approximately 58km. The associated implementation costs are estimated to €16.2 million.

In the table above, the category "Other" is comprised of provisions for flexibility payments and proximity allowance amounting in a range from €0.7-0.8 million for UGC and €3.6-4.1 million for OHL. Due to more frequent land access associated with the OHL, the costs are higher than for UGC.

A contingency provision of 10% is included to account for the likelihood that costs may increase.

The Moy – Tonroe OHL option is associated with the lowest estimated implementation cost. The Moy – Tonroe UGC options has the highest implementation costs and is approximately 70% more expensive than its OHL options. The Moy – Srananagh options are both within the range of the options connecting Moy and Tonroe 110 kV substations.

Table 15: Project Implementation Costs Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Project Implementation Costs				

Taking all these factors on project implementation costs into account: The Moy – Tonroe 110 kV UGC performs worst with a high impact (**Dark Blue**). Moy – Srananagh 110 kV UGC performs with a moderate-high impact (**Blue**). Moy – Srananagh 110 kV OHL performs with a low-moderate impact (**Green**). Moy – Tonroe 110 kV OHL has been shown to perform best in terms with a low impact (**Cream**).

4.2.2 Project Life-Cycle Costs

4.2.2.1 Maintenance and Operational Expenditures

The incremental maintenance costs are those costs incurred to ensure that the appropriate level of reliability and availability in the new circuit is maintained over its useful life.

The approach taken is to represent the maintenance costs as an annualised costs provision that is based on standard rates per equipment type provided by ESB Networks[30].

The annual maintenance costs are summarised in the Table 16 below.

Table 16: Summary of Maintenance Costs

Maintenance Category		Maintenance Costs			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
OHL	€M	0.51	-	0.58	-
UGC		-	0.04	-	0.04
Station		1.24	1.24	0.33	0.33
Present Value	€M	1.75	1.28	0.91	0.37

The present value of the cost of maintenance highly depends on the technology and terminating station 110 kV substation. While OHL are exposed to the environment, visual patrols will be carried out on a regular basis which constitute a substantial share of the maintenance costs. The maintenance costs associated with UGC technology are on the contrary less labour intensive and therefore lower.

Due to the redevelopment of Tonroe 110 kV station, the Moy – Tonroe options are associated with a present value of station maintenance costs of c.€ 1.24 million. The Moy – Srananagh options are associated with €0.33 million for the two additional bays on both sides of the new circuit. The additional expenditures are associated with the

[30] ESB Networks, Transmission Maintenance Unit Charges (confidential), Rev 5, May 2017

benefit to security of supply and demand growth potential in the area of Ballaghaderreen (see section 4.1.4.2). The Moy – Srananagh UGC option totals a present value of approximately €0.37 million over useful life.

4.2.2.2 Cost of Transmission Losses

Electrical losses refer to the electrical energy consumed by the transmission system as it transmits electricity. The more efficient a transmission reinforcement, the lower the electrical transmission losses it incurs. The efficiency of transmission of electricity increases with the voltage level used. All the proposed development schemes are at the voltage level of 110 kV. Hence, the increase in efficiency would be considered marginal in comparison to the total incurring annual transmission system losses.

The annual transmission losses for each option are extrapolated based on the transmission losses occurring in the network studies carried out. The results show that the both UGC options perform more efficient in comparison to its OHL counterparts. The Moy – Tonroe 110 kV UGC option shows the lowest estimated transmission losses among *the Shortlist of Technology Options.* The transmission loss estimates are based on an average single market price of approximately €45.81[31] per MWh in 2017.

Table 17 details the difference in transmission losses and the present value of the additional costs for transmission losses. Moy – Tonroe 110 kV UGC option as the most efficient among the *Shortlist of Technology Options* represents the reference case.

Table 17: Comparison of Transmission Losses and associated annual Cost

Maintenance Category		Transmission Losses and associated annual Costs			
		OHL-MT	UGC-MT (Reference)	OHL-MS	UGC-MS
Change in Transmission Losses	GWh / a	9.4	0	8.7	4.7
Present Value	€M	7.9	0	7.3	3.9

[31] Average Single Market Price in 2017 (Source: Single Electricity Market Operator (SEMO))

As outlined in section 4.1.2.2, the UGC has a different characteristic to the OHL that results in a more efficient usage of the existing power carrying capability in the study area. This leads to more efficient power flows in the study area, which is also reflected by the change in transmission losses shown in the Table 17 above. The OHL options however can be adapted to achieve more efficient power flows in the study area. In order to reduce the transmission losses for the OHL options, the characteristics of OHL has to be modified artificially by the application of additional innovation projects[32] (see section 4.1.2.2).

Without any further devices, the Moy – Tonroe OHL and Moy – Srananagh OHL options are associated with estimated additional costs in transmission losses of €7.3-7.9 million over the useful lifetime in comparison to the Moy – Tonroe UGC option. Moy – Srananagh UGC results in estimated additional transmission losses of €3.9 million over the useful lifetime.

4.2.2.3 Replacement Cost Including the Cost of Decommissioning:

The useful life is the same as the evaluation period of 50 years[33] for the options and as a result, no replacement or decommissioning costs are considered for these options.

4.2.2.4 Summary

Table 18: Project Life-Cycle Costs Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Project Life-Cycle Costs				

Taking all these factors on project life-cycle costs into account: The Moy – Tonroe 110 kV UGC performs the best with low impact (**Cream**). Moy – Srananagh 110 kV UGC performs with low-moderate impact (**Green**). The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform equally with a moderate impact (**Dark Green**).

[32] http://www.eirgridgroup.com/site-files/library/EirGrid/SmartWires-EirGrid-SmartValve-Pilot-Report.pdf

[33] Decision on TSO and TAO transmission revenue for 2016 to 2020, CER/15/296, 23rd December 2010. Page 52: "...an average life of 50 years is applied to transmission network assets".

4.2.3 Project Benefits

The benefit of a project can be measured by the amount of generation that are 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 carried out by EirGrid's energy market experts. 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 project benefits is based on the assumption that each constrained unit has to be procured at the single electricity market in order to meet the electricity demand in the All-Island electricity system. While the cost of electricity would be considered more expensive than the constrained cost of electricity, 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. The network without any new circuit and the same installed generation capacity and electricity demand forms the reference case.

Table 19 details the change in constraints associated with all options.

Table 19: Reduction in Constraints and Associated Annual Savings

Cost Category		Project Benefits			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Constraints Reduction	GWh / a	322	340	315	331
Annual Savings in Generation Costs	€M / a	13.9	14.6	13.7	14.4

Because of the different characteristics, the UGC options lead to a more balanced power flow on the pathways out of the study area. The characteristics act to attract more powerflow onto the UGC which means that the available capacity is used more effectively by UGC. Hence, the constraints reductions associated with the UGC tend to be a factor of c.4-5% greater in comparison to the OHL options. In order to achieve similar effects for the OHL, the characteristics of OHL have to be modified artificially by the application of additional innovation devices[34] (see section 4.1.2.2).

The options OHL-MT and UGC-MS with Tonroe 110 kV substation as the terminating substation are associated with a slightly greater constraints reduction than the options OHL-MS and UGC-MS with Srananagh 110 kV substation as terminating substation. The options with the extension to the Tonroe 110 kV substation connect directly into Flagford 220/110 kV substation which functions as a collector substation and allows power flows to travel towards the East and South-West. The power flows of the options OHL-MS and UGC-MS accumulated with the power flow from North in Srananagh 220/110 kV substation. Hence, the constraint reduction associated with the option OHL-MT and UGC-MT tend to be by the factor of 1-2% higher than its OHL-MS and UGC-MS counterpart.

The present values of the estimated annual savings in generation costs due to the constraints reduction over the useful life of transmission assets is estimated for the four options. Table 20 shows the calculated present values.

Table 20: Present Value of Constraint Cost Savings

Cost Category		Value of Constraint Cost Savings			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Present Value	€M	270	285	264	278

The value of constraint cost savings is highly dependent on the development of the Irish generation portfolio and therefore associated with a level of uncertainty. The calculated present value is influenced by conservative market prices and is only considered an indicative value in terms of constraint cost savings. Hence, the relative performance of the options to each other is used for this assessment which is expected to be similar regardless the market prices.

The cost savings of the UGC options perform over the useful lifetime relatively better by a factor of c.4-5% than its respective OHL options. The lower impedance characteristic of the circuit rather than the power carrying capability is reason for this result. Hence, a

[34] http://www.eirgridgroup.com/site-files/library/EirGrid/SmartWires-EirGrid-SmartValve-Pilot-Report.pdf

similar effects could be achieved for the OHL by the installation of further device to optimise the power flows in the study area. Consequently, the UGC options perform better in this regards than the respective OHL options.

Table 21: Project Benefits Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Project Benefits				

The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally well with low-moderate impact on project benefits (**Green**). The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform equally with a moderate impact (**Dark Green**).

4.2.4 Costs to SEM

The benefits that are realised from the connection of the planned wind generation arise from renewable generation sources displacing conventional generation. This contributes to a change to the overall production costs incurred.

For periods when the reinforcement is unavailable, the renewable generation that the reinforcement connects to the power systems would be interrupted and would be replaced with the alternative generation from the electricity market. The average daily monetary project benefit attributed to the renewable generation connected to the power system is calculated to be €38k - €40k (see Table 20). If the circuit is unavailable during a period of particularly high wind availability then the real costs which are associated with the circuit unavailability tend to be higher. Likewise if the circuit's unavailability was during a low wind generation period, the costs would be lower. However, for the purposes of this study at this step in the process, the use of this average figure is considered adequate.

The present value of the estimated costs to SEM associated with the unavailability of the new North Connacht 110 kV circuit are listed in Table 22 over the period of the useful life for transmission assets. The cost to SEM is calculated as a combination of projects' benefit (see section 4.2.3) and reliability (see section 4.1.3).

Table 22: Costs to SEM due to Unavailability

Cost Category		Costs to SEM due to Unavailability			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Present Value	€M	0.4	2.6	0.5	3.2

The higher availability of OHL results in higher power export capability over the year and lower associated cost to SEM due to unavailability. The cost to SEM associated with UGC are by a factor of 5-6 times higher than its respective OHL option.

Table 23: Costs to SEM Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Costs to SEM				

The Moy – Tonroe 110 kV UGC and Moy – Sranangh 110 kV UGC perform equally with a moderate impact (**Dark Green**). The Moy – Tonroe 110 kV OHL and Moy – Sranangh 110 kV OHL perform equally better with a low-moderate impact on cost to SEM (**Green**).

4.2.5 Contingency Costs

In the absence of a detailed route or site being selected it is not possible to develop specific contingency allowances. For the purposes of the evaluation, typical desktop contingency allowances are provided for in accordance with standard engineering practices. These provisions are the result of standard assumptions being made regarding complexity and site specific conditions.

Capital costs estimates include a contingency. The contingency allowance for the project reinforcement costs are assumed to be 10% of the project implementation costs. The pre-engineering costs include contingency provision of 10% to account for the risk that the amount may vary.

Other cost elements (i.e. losses, reliability) are based on historical data and, as such, no specific contingency to these elements has been provided for.

Table 24: Contingency Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Contingency				

The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a moderate impact (**Dark Green**). The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform equally better with a low-moderate impact on contingency costs (**Green**).

4.2.6 Pre-Engineering Costs

The pre-engineering costs refer 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 listed below.

Cost Category		Pre-Engineering Costs			
		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Pre-Engineering Costs	€M	15.6	12.0	15.6	12.3

The difference in estimated pre-engineering cost between the OHL and UGC options is as a result of the different extent of landowner and stakeholder engagement. This is considerably higher for OHL options. Furthermore, community funds and gain are only applicable to OHL options which widens the cost difference between the UGC and OHL technologies.

Table 25: Pre-Engineering Costs Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Pre-Engineering Costs				

The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options perform equally with a moderate impact on pre-engineering costs (**Dark Green**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options perform equally with a low-moderate impact on pre-engineering costs (**Green**).

4.3 Environment

The table below is a summary of a high-level assessment of the various options in terms of environmental performance. This high level environmental assessment focused on the primary constraints in the wider study area. The assessments are focused in particular on the likely impacts (short and long term) on biodiversity, soils and water, landscape and visual, cultural heritage, and the potential impact of construction works and operation of the circuit on noise. The assessment is based on the known effects of this scale of infrastructure on the environment while taking into account the sensitivities in the wider study area. Potential corridors have not been developed /assessed as part of this assessment, thus the focus is on the wider study area. It should be noted that mitigation measures are not taken into account as part of this assessment, thus the assessment is a worst case analysis, highlighting the issues that would require consideration in further development of the project options.

ID		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Type		OHL	UGC	OHL	UGC
Scheme		Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Srananagh 110 kV	Moy – Srananagh 110 kV
Environmental Sub-Criteria	Biodiversity/flora and fauna				
	Soil & water				
	Material Assets				
	Landscape and visual				
	Cultural Heritage				
	Noise				
	Overall				

Table 26: Environment

More significant/difficult/risk				Less significant/difficult/risk
Dark Blue	Blue	Dark Green	Green	Cream

This high level assessment illustrates that the various options have different potential impacts on the various environmental sub criteria. Both OHL options score similarly with the Moy – Srananagh circuit scoring worst for landscape and visual. Both UGC options score similarly, with potential impacts on soils and water in these sensitive catchments a significant issue for consideration. Overall, on balance, a 'moderate' environmental impact is predicted for the various options. However, the sub criteria for the various options score quite differently for certain environmental issues and these need to be taken in account in the next steps of project development.

The evaluation of each option made under each environmental sub criterion is elaborated further in the following sections.

4.3.1 Biodiversity

The North Connacht study area is highly constrained in terms biodiversity. In general, the main ecological features within the overall North Connacht study area include:

- Designated sites for nature conservation (i.e. Special Conservation Areas, SAC, Special Protection Areas –SPAs and non-designated bog and peatland habitats (E.g. Ox Mountains SAC, Lough Hoe bog SAC, River Moy SAC, Killala Bay/Moy estuary SAC/SPA, Ballysadare Bay SAC/SPA);
- Designated and non-designated Lakes (E.g. Lough Conn and Lough Cullin SPA, Lough Gara SPA) which are of importance for supporting wintering and breeding birds
- Designated and non-designated Rivers (E.g. River Moy SAC, Unshin River SAC, Yellow River, Owengarve River).
- Peatlands, Forestry, and woodland habitats.

Any option considered for the North Connacht project will need to be developed on the principle of avoidance of European Sites wherever possible. The exception to this may be where river crossings are required.

The main advantage of UGC in terms of biodiversity is that it rules out the potential for bird collisions totally. Negative interactions with birds is a key consideration in the development of any OHL and requires studies and mitigation measures to ensure significant impacts are avoided. Therefore, overall, considering the operational lifespan of the circuit, UGC would be less of risk based on the current level of information on bird populations and movements (given the proximity SPA sites/ possible migration routes) of and in the absence of mitigation measures.

However, the construction of an UGC in this study area requires careful consideration of impacts on sensitive habitats such as peatlands and wetlands. The risk of habitat loss, destruction or disturbance of species is not offset completely as land take additional to the road will be required for joint cable bays etc. There is a risk of contamination of watercourses during construction, and crossing of SPAs and SACs within the road network may, in some cases, require working in very close proximity to protected habitats or species. Management of soils and in particular peat must be considered and indirect impacts such as alterations to wetland habitats due to drainage induced by a cable trench may require detailed assessment.

The Moy to Tonroe sub-study area in North Connacht is an ecologically sensitive area. The proposed project (OHL or UGC) has the potential to directly impact European sites (SAC/SPA), in particular the River Moy SAC. The sub-study area also extends into a small section north-west of Ballina listed as a sensitive location for Freshwater Pearl Mussel.

In addition to the Lough Conn and Lough Cullin SPA, the Moy to Tonroe sub-study area also partially extends into the Lough Gara SPA on the Co. Roscommon and Co. Sligo border just east of the Tonroe 110 kV substation. This SPA is designated for Whooper Swan and Greenland White-fronted Goose, both species identified as high risk for collision with OHLs. Internationally important numbers of both species regularly use Lough Gara. There are two active raised bogs, classified as priority habitats, located within the Moy to Tonroe sub-study area; Callow Bog SAC and Tullaghanrock Bog SAC In addition to the Natura 2000 designated sites (SACs and SPAs) there are 12 sites of national importance designated as pNHAs within the Moy to Tonroe sub-study area, 3 of which are also designated as SACs. There are no NHAs located within the sub-study area.

There are significant ecological features to consider in the development of any transmission circuit in this area

The area of North Connacht within which the Moy to Srananagh scheme is located, is highly constrained in terms of sensitive ecological receptors. The area is mainly defined by the Ox Mountains and blanket bog habitat (Lough Hoe Bog SAC).

The Moy to Srananagh sub-study area surrounds and partially extends into the Killala Bay/Moy Estuary SAC which is designated for habitats such as; Tidal Mudflats and Sandflats, Atlantic Salt Meadows, and Fixed Dunes (Grey Dunes) and species such as; Common (Harbour) Seal and Sea Lamprey. Fixed Dunes are considered a priority habitat of this SAC. The Killala Bay/Moy Estuary SAC overlaps with the Killala Bay/Moy Estuary SPA .

The Moy to Srananagh sub-study area also surrounds and partially extends into the Ballysadare Bay SAC. This SAC overlaps with Ballysadare Bay SPA (004129) and adjoins Unshin River SAC

In addition to Natura 2000 designated sites (SACs and SPAs), the sub-study area is also constrained by Margaritifera Sensitive Areas. These sensitive areas generally overlap with the Ox Mountains. There are also 18 sites of national importance designated as pNHAs within the Moy to Srananagh sub-study area, 10 of which overlap with designated SACs.

The Moy to Srananagh sub-study area is highly constrained by ecologically sensitive areas. The proposed project has the potential to directly impact two Natura 2000 sites; the River Moy SAC and the Unshin River SAC. Therefore, there are significant ecological features to consider in the development of any transmission circuit in this area.

Table 27: Biodiversity Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Biodiversity				

Taking all these factors on biodiversity into account: The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options perform equally with a moderate-high negative impact (**Blue**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options perform equally with a moderate impact on biodiversity (**Dark Green**).

4.3.2 Soil and Water

A preliminary examination of soils within the area was undertaken for this assessment. This is based on soils maps sourced from the Geological Survey of Ireland (GSI), geological constraints (e.g. karst areas) and the presence of bogs within each area. All potential scheme options cross areas of peat which requires further consideration as the project develops in terms of routing.

The Moy-Tonroe OHL and UGC options are within sensitive water catchments, dominated by the influence of the River Moy and the Lakes, Lough Conn and Lough Cullin.

Lough Conn and Lough Cullin are two of the largest lakes in the area and together form the Lough Conn and Lough Cullin SPA. The River Moy and its tributaries are designated SAC and is considered Irelands Premier salmon river.

The Moy-Tonroe options are also influenced by the River Moy and also the Owengarve in Co. Sligo. Lough Gill, Lough Easky and Lough Talt are particularly important in terms of public water supply, while Lough Arrow is used as a raw water source in a number of Group Water Schemes serving a wide rural hinterland. These four lakes, two of which are within the study area, are targeted for particular attention in terms of water quality monitoring, due to their scale and economic and social significance as a raw water source for drinking water supplies.

All options score in the moderate to high risk range for soils and water, with the Moy Tonroe UGC scoring the worst for this sub criteria due to levels of peat that may require to be managed in any excavations combined with the sensitivities of the River Moy and its wider catchment.

Table 28: Soil and Water Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Soil and Water				

Taking all these factors on soil and water into account: The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options perform equally with a moderate impact (**Dark Green**). The Moy – Srananagh 110 kV UGC performs with a moderate-high impact (**Blue**). The Moy – Tonroe 110 kV UGC option perform worst with a high impact (**Dark Blue**).

4.3.3 Material Assets

This high-level assessment is primarily based on land use and the typical impacts that could be expected for a 110 kV OHL and for an UGC option. A 110 kV line is supported by pole sets and an angle mast is required where the line changes direction. These structures do not require significant land take and over the operational phase of the OHL should not impact significantly on land use and farming operations in particular. Both OHL options required upgrading of other transmission lines which will involve some level of land use disruption.

The general land use of the Moy-Tonroe options study area is characterised by a mixed land use pattern of peat bogs and agricultural lands with significant areas of natural vegetation and transitional woodland scrub. There are also significant areas where pasture/ improved grasslands represent a major land use.

The general land use of the Moy-Srananagh options study area is characterised by agricultural land of varying quality, from moorland to poor pasture with significant areas of natural vegetation and forestry on the higher elevations. The area is notable for its scenic routes particularly on the coastal R297 from Enniscrone to Dromore West, part of the Wild Atlantic Way. An amenity trail, the Sligo Way, extends from the Glenmore river valley west towards south west of Lough Gill passing Collooney.

Overall, the potential impacts on land use and material assets for both OHL options are considered to be similar, being of moderate significance. This takes into account potential disruption during the construction phase and also, ongoing minor effects of farming practices that would be required in working around twin pole sets or angle towers.

The construction phase of the UGC option within the local road network could cause considerable disruption to local roads and adjacent land use as additional land take is required along the route to facilitate joint bays for the cable. The installation of an UGC would result in temporary impacts to local roads and road users, are thus considered a moderate impact risk for both UGC options.

Table 29: Material Assets Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS

Material Assets				

Taking all these factors on material assets into account: All options perform equally with a moderate impact (**Dark Green**).

4.3.4 Landscape and Visual

The Moy-Tonroe sub-study area falls within sensitive landscapes as defined in the Landscape Appraisal of County Mayo.

The Landscape Appraisal of County Mayo shows that this sub-study area falls predominantly into Landscape Protection Policy Area 4. A portion of this sub-study area, in the areas around Foxford, have been classified as of higher sensitivity to change and protected by Landscape Policy Area 3.

There are a number of Protected Views, Scenic Routes, Scenic Views and Highly Scenic Views in areas between Lough Conn and Foxford and further east, there are significant numbers of walking routes. The Development Plan and associated "Development Impact-Landscape Sensitivity Matrix" includes for an assessment of Power lines, an electrical infrastructure project has high potential to create adverse impacts on the existing landscape character in policy area 3 and medium to high potential to create adverse impacts on Policy area 4.

The landscape appraisal of County Mayo does not distinguish between different types/ voltages of OHLs. A 400kV OHL, supported on steel towers (pylons) will have a much greater visual impact than a 110kV line supported predominantly on wooden pole support structures. Routing at the detailed design stage also play significant part in reducing the potential visual impacts of a 110kV OHL option. However, in the absence of routes for the various options, a precautionary assessment has been presented (moderate impact). The construction and operation of an UGC is not without impacts at the local landscape level. Features such as hedgerows, stone walls, treelines etc. may require permanent removal to facilitate the installation of a cable trench or cable joint bays which may alter local landscape features.

The Moy-Srananagh sub-study area is located mainly within County Sligo and contains a number of the county's scenic routes as identified in the County Development Plan and a number of proposed scenic routes in the Draft Sligo County Development Plan 2017 –

2023. These are located around Sligo Bay and Ballysadare Bay. The long distance walking route The Sligo Way also cuts through a large portion of the study area.

The Sensitive Rural Landscape designation which is outlined in the Draft Sligo County Development Plan 2017-2023 Landscape Characterisation Map covers a significant part of this study area, particularly around Easkey Bog and Ballysadare. The Landscape Characterisation Map also indicates a number of Visually Vulnerable Areas, particularly, the Ox Mountains range. The development of any circuit in this region would need to consider these landscape features and an OHL would be constrained to some degree by coastal influences to the north and the Ox Mountains dominating the study area to the east.

The Development Plan and the associated "Development Impact-Landscape Sensitivity Matrix" includes for and assessment of Power lines, an electrical infrastructure project has medium to high potential to create adverse impacts on the existing landscape character in policy area 4 and high potential to create adverse impacts on the existing landscape character in policy areas 3. As outlined for the Moy-Tonroe option, the Development plan does not distinguish between different voltages and a 110kV OHL will have less significant landscape and visual impacts than an higher voltage transmission line (e.g. 220kV/400kV), Routing at the detailed design stage also play significant part in reducing the potential visual impacts of a 110kV OHL option. However, in the absence of route for the various options, a precautionary assessment has been presented.

Therefore, the OHL option for Moy Srananagh 110kV scores poorly with a higher risk rating in comparison to the other options.

Table 30: Landscape and Visual Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Landscape and Visual				

Taking all these factors on landscape and visual into account: The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options perform equally best with a low-moderate impact (**Green**). The Moy – Tonroe 110 kV UGC options perform with a moderate impact (**Dark Green**). The Moy – Srananagh 110 kV OHL performs worst with a moderate-high impact (**Blue**).

4.3.5 Cultural Heritage

In terms of archaeological and historical resources the wider study areas of the options (Moy-Tonroe and Moy Srananagh) is rich in sites of national and local importance. Routing of the circuit (as the project progresses, whether OHL or UGC) will play a key role in avoiding known cultural heritage assets and overall the various options score similarly as having potentially moderate impacts on Cultural Heritage assets including setting. This is based on the current knowledge base and in the absence of mitigation.

In an international context the most significant site in north Mayo is the Céide Fields and North West Mayo Boglands near Ballycastle, a candidate World Heritage site appearing on the Tentative list. Although lying outside the study area, the site is relevant due to its nature and extent comprising a Neolithic landscape of megalithic burial monuments, dwelling houses and enclosures within an integrated system of stone walls spread over $12km^2$.

The general study area of the Moy Tonroe options includes sites of national importance and numerous Religious sites. Archaeological monuments, over 1,000 recorded archaeological monuments, protected structures and structures listed in the NIAH within the study area with concentrations in the urban areas of Ballaghaderreen, Swinford and Foxford all require consideration in the development of any circuit (OHL or UGC) in this area. The area is also rich in Demesnes, mainly concentrated around the areas of Swinford, Ballina and Ballaghaderreen.

The general study area of the Moy-Srananagh options also includes Nationally important sites such as Megalithic tombs (e.g. (MA030-073--) outside Ballina, Carricknagat Megalithic tombs (Nat mon. No. 277, SL021-062----, SL021-104), Cabragh wedge Tomb (Nat mon. No. 523, SL019- 171001)) and Rosserk Abbey. Regionally there are conspicuous concentrations of monuments around Ballysadare Bay, Owenmore River Valley and the Moy estuary.

Archaeological monuments, over 2,000 recorded archaeological monuments, protected structures and structures listed in the all require consideration in the development of any circuit (OHL or UGC) in this area. The area is also rich in Demesnes. The best preserved with ‘Main features substantially present - with some loss of integrity’ are Temple House, Annaghmore, Markree and Tanrego House.

Given the richness of this Cultural Heritage baseline, the emphasis for future assessment will be to proceed with due regard to these resources, reducing insofar as possible any potential direct or indirect impacts on their physical remains or setting within the landscape. While excavations associated with UGC could have impacts on below ground cultural heritage, the more permanent impact of an OHL may have impacts on the setting of cultural heritage features and therefore needs careful consideration in the routing of such an option.

Table 31: Cultural Heritage Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Cultural Heritage				

Taking all these factors on material assets into account: All options perform equally with a moderate impact (**Dark Green**).

4.3.6 Noise

All options would result in some noise impacts during construction and there will be ongoing operational noise. All options have a low-moderate impact under this criterion.

The construction stages of a potential UGC or OHL may result in temporary noise effects (and possibly vibration) at any nearby sensitive receptors (e.g. residential, community), Given more excavation is required for an UGC option and that an UGC is likely to be constructed along public roads, the consequent noise impact may be greater than that for the OHL option.

Construction noise and vibration impacts are temporary. If works are required in close proximity to sensitive receptors, they will be short-term as construction progresses along the route. There is no noise from the operation of an UGC.

OHLs have the potential for construction and operational noise impacts and effects on a limited number of localised residential receptors. Once constructed, OHLs may produce audible noise from transmission line corona, generating an audible hum; this noise effect is very localised, audible directly underneath or within 50m of the line. On a dry day, this "hum" is barely audible and is most noticeable when the conductors are wet e.g. in foggy or wet weather conditions. Aeolian noise can also be generated by OHLs, caused by wind passing through the conductors. Both scenarios are temporary and do not result in a significant impact on sensitive receptors.

Table 32: Noise Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Noise				

Taking all these factors on noise into account: All options perform equally with a low-moderate impact (**Green**).

4.4 Socioeconomic

The table below is a summary of socioeconomic performance.

	ID	OHL-MT	UGC-MT	OHL-MS	UGC-MS
	Type	OHL	UGC	OHL	UGC
	Scheme	Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Srananagh 110 kV	Moy – Srananagh 110 kV
Socio-Economic Sub-Criteria	Settlements & Communities				
	Recreation & Tourism				
	Landscape & Visual				
	Cultural Heritage				
	Aviation & Defence				
	Overall				

Table 33: Socioeconomic

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

Dark Blue	Blue	Dark Green	Green	Cream

Overall, both the Moy-Tonroe 110kV UGC and the Moy-Srananagh 110kV UGC option perform equally and are the best performing options. Comparatively, the UGCs present less risk and has a less significant impact than the OHL options in the context of all sub-criteria, lessening the socio-economic impacts generally. The Moy-Tonroe 110kV OHL option performs moderately and is the next best performing option. The option which presents the most risk and may have a significant impact is the Moy-Srananagh 110kV OHL option. The risk and significance of the impact on the Moy-Srananagh 110kV OHL option is evident in its performance under: settlements & communities; recreation & tourism landscape & visual criteria.

In order to populate each criterion in the multi-criteria performance matrix, information is obtained from various sources and in particular desktop studies and field visits. The Social Impact Assessment process and feedback received at the Stakeholder Engagement (see Section 5) has influenced this analysis. Given the early stage of this project some information obtained may become out of date as the project progresses and should be reviewed regularly to ensure its accuracy or added to as more accurate and detailed information becomes available during the process. It should also be noted that stakeholder engagement is an iterative task and further engagement in this step may have a bearing on the socio-economic analysis in this report.

A summary of each sub criteria is provided below:

4.4.1 Settlements and Communities

This study area is considered a predominantly rural area with areas both under strong urban influence and structurally weak. This study area, in parts, exhibits characteristics such as proximity to the immediate environs or close commuting catchment of a large town and evidence of considerable pressure for development of housing due to proximity to such urban areas. The main settlements encompass significant levels of single rural dwellings also, predominantly in linear form along the road network. Apart from the residential community, other communities considered include the agricultural, equine and commercial community's active in the study area.

Several large infrastructural projects have been planned within or approximate to the study areas, many are energy related including the EirGrid Grid West Project, Corrib Gas Project and numerous wind farms. The Grid West Project has left a social legacy for infrastructure development, particularly in the Moy-Tonroe study area. The design of pylons and their visual impact on the landscape generally was of concern for stakeholders. The social impact and legacies of this project may have a material impact on any proposals for future large projects in the area.

On both the Moy-Tonroe options (OHL and UGC), this risk and legacy is offset to a certain extent when considering the technical assessment of the headroom (see Section 4.1.4.2) which shows that there is an increase in the security of supply for demand customers at Tonroe 110 kV Station near Ballaghaderreen, Co. Roscommon as it is currently connected to the grid by only one existing 110 kV connection. A second circuit into the area would facilitate a future increase in electricity demand for Ballaghaderreen, Co. Roscommon and similarly Ireland West Airport at Knock, Co. Mayo which is in close proximity. This would provide a positive socio-economic impact to the area which may benefit directly from increased commerce and industry activity, and indirectly in terms of potential job creation and benefits to the local economy generally. In terms of future development of demand/generation connections, OHL options provide a higher level of flexibility than UGC options.

Table 34: Settlements and Communities Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Settlements and Communities				

Both UGC options had moderate-low risk under this sub-criteria and will have a similar impact regardless of the route. The Moy-Srananagh OHL option performed least favourably, largely because of interactions it may have with Ballina, Co. Mayo and the Sligo environs at Ballysadare, Co. Sligo. The Moy-Tonroe 110kV OHL option performs moderately given the security of supply at Tonroe 110kV Station provides a positive impact.

4.4.2 Recreation and Tourism

Recreation and tourism receptors approximate to the study area include natural, recreational and sporting amenities as well as social and community infrastructure. These facilities provide many cultural, social, economic and environmental benefits and provide a positive contribution towards quality of life. It is also recognised that the countryside, in which the study area is located, provides an important resource for tourism/recreation in itself. There are several scenic routes and prospects in the study areas. In the settlements and villages, there a numerous recreational areas established for the local communities.

Table 35: Recreation and Tourism Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Recreation and Tourism				

Both UGC options performed low in this instance and will have a similar impact regardless of the route. The Moy-Srananagh 110kV OHL option proved to have the most risk and is the most difficult option under this sub-criteria. The Moy-Srananagh 110kV OHL option may have a significant interaction with the Wild Atlantic Way and is located between the Ox Mountain Range and the coast, both sensitive areas of tourism/recreation value.

4.4.3 Landscape and Visual

The study area has a varied characteristics, including 'mountain coastal', 'lakeland', 'upland moor, heath and bog'; and 'Drumlins and Inland Lowlands'. In parts of the study area, OHL infrastructure has a high potential to create adverse impacts on the existing landscape character having regard to the intrinsic physical and visual characteristics of the landscape area. While it is generally a normal rural landscape there are sensitivities and visually vulnerable areas with numerous scenic routes and prospects. It may be unlikely that such impacts can be reduced to a widely acceptable level. On a local level, the potential landscape and visual impact to the study area needs to closely consider the intangible impacts on residents.

Both UGC options performed best with low risk for impacts on landscape and would have a similar impact regardless of the route. The UGC circuits would have a barely noticeable effect on views/visual amenity once operational although features such as hedgerows, stone walls, treelines etc. may require permanent removal to facilitate the installation of a cable trench or cable joint bays. This may alter local landscape features.

Table 36: Landscape and Visual Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Landscape and Visual				

The Moy-Srananagh 110kV OHL option proved to have the most risk and is the least preferred option under this sub-criteria. This is due to its interactions with the Wild Atlantic Way and the study area being located in a sensitive landscape between the Ox Mountain Range and the coast. These are visually vulnerable areas with scenic routes and prospects. While there are sensitivities and visually vulnerable areas on the Moy - Tonroe 110kV OHL option, it has been assessed as being of moderate risk to landscape , largely as a result of lower sensitivities experienced as it moves away from Lough Conn and past the Ox Mountains toward the Mayo and Roscommon border where the character of the landscape has better capacity to accommodate OHL infrastructure.

4.4.4 Cultural Heritage

The urban and rural areas in which the study area is located contain significant architectural and archaeological heritage. There could be a direct impact to these features as a result of any circuit coming in close proximity to cultural heritage. There could also be an indirect impact resulting from the visual effects of OHL infrastructure on the setting of these features. The features are documented in detail in: OSi Discovery Series 1:50,000; Historical Mapping including the Cassini 6 inch, Historic 6 inch, Historic 25 inch; Aerial Mapping / Google Streetview; Sites recorded in the National Inventory of Architectural Heritage; Sites recorded in the Archaeological Survey of Ireland; Other datasets available on the Heritage Council's Heritage Maps service

Table 37: Cultural Heritage Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Cultural Heritage				

The potential direct impact to cultural heritage is similar across options and will require detailed route planning in the subsequent steps of the project development. The performance of each option is distinguished largely as a result of the indirect visual impact of OHL infrastructure which can be difficult to mitigate particularly in a socio-economic environment. Cultural heritage is a most sensitive visual receptor, and the potential visual effects of an OHL increase with proximity to cultural heritage features. In considering this, both UGC presented a moderate-low risk and difficulty. The OHL options present more difficulty/risk than the UGC options due to the potential for visual impact and are scored as having moderate risk for cultural heritage.

4.4.5 Aviation and Defence

There are general restrictions on development in the vicinity of airports/aerodromes. It is a responsibility of the Irish Aviation Authority (IAA), when notified, to evaluate the impacts a proposal may have on the safe and efficient navigation of aircraft and to advise the Council of potential hazards to air navigation. The safeguarding requirements in the vicinity of civil aerodromes are principally set out as International Standards and Recommended Practices within 'Annex 14 of the Convention on International Civil Aviation', which is published by the International Civil Aviation Organisation (ICAO) and IAA.

Table 38: Aviation and Defence Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Aviation and Defence				

The primary constraint in the study area is Ireland West International Airport at Knock, Co. Mayo and smaller aerodromes facilitating mainly civilian operations. The study area for the Moy-Tonroe 110kV OHL option has interactions with Knock Airport and as a result performs moderately. The Moy-Srananagh 110kV OHL has no such constraint and performs moderately-low. Both UGC options are considered to have low risk in this instance and will have a similar low impact regardless of the route.

4.5 Deliverability

The table below is a summary of deliverability performances.

No		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Type		OHL	UGC	OHL	UGC
Scheme		Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Sranangh 110 kV	Moy – Sranangh 110 kV
Deliverability Sub-Criteria	Implementation Timelines				
	Project Plan Flexibility				
	Dependence on other Projects				
	Risk of Untried Construction Technology				
	Supply Chain Constraints				
	Permits and Wayleaves				
	Water Impact during Construction				
	Air Quality Impact during Construction				
	Traffic and Noise Impact during Construction				
	Total				

Table 39: Deliverability

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

Dark Blue	Blue	Dark Green	Green	Cream

This deliverability assessment illustrates that the various options have different potential implications with regard to the various deliverability sub criteria. The OHL options perform better or equal to the UGC options in nearly all sub criteria but permits and wayleaves. For OHL options, acceptance from landowners may be more difficult to achieve given the visual issues associated with the infrastructure and the land take required which may displace existing or future activities/development the landowner had intended on carrying out. The OHL options therefore perform better in the terms of project plan flexibility and the impact on water, air quality, traffic and noise during the construction.

Overall, Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL performs the best with a low-moderate impact on deliverability performance (**Dark Green**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a moderate-high impact (**Blue**).

The evaluation of each option made under each technical sub criterion is elaborated further in the following sections.

4.5.1 Implementation Timelines

The construction of transmission projects in the electricity transmission sector are typically implemented under an Engineer, Procure and Construct (EPC) or a Design and Build (D&B) form of contract. Both forms of contract require the Contractor to undertake at least the detailed design as well as the construction of the project. As a result the implementation timelines tend to be similar for either form of contract, as well as construction and commissioning of the project. Any major capital project goes through a number of distinct phases during its implementation. For EPC or D&B contracts, these stages can be categorised as follows:

- Specification, Tendering and Contract Award: Once Planning Consent has been secured for the project, the first stage is to prepare the specifications and tender documents to allow the project to be tendered by potential Contractors. Once the tenders are received and any post-tender clarifications resolved, the tenders are evaluated and the contract awarded.

- Design and Procurement: Once a signed Contract is in place, the successful Contractor commences the design required and initiates the procurement of all equipment and sub/contractors required for specialist skills. The Contractor will typically try to procure items with long-delivery times (long lead items) as early as possible, ahead of completion of the final design.

- Construction and Installation: The Contractor will then start works on site on a planned basis so as to coordinate the delivery of the major items to site with the completion of the civil and structural works required. The equipment is then installed onto the civil/structural infrastructure that has been constructed.

- Commissioning: On completion of the construction and installation works the project is commissioned. For major projects involving large complex equipment, commissioning is a complex process requiring significant planning a coordination with the network operations department to ensure that the integrity of the electrical grid is not compromised during commissioning of the new plant.

The following points should be noted to be different between the options and concerning the implementation timelines.

4.5.1.1 Moy - Tonroe 110 kV OHL Option

- The construction of the (approx. 58 km) 110 kV OHL option is expected to take approximately 18 months including commissioning. The works include the uprate of the bay in Moy 110 kV station and the construction of the OHL. This timeline is based on experience of construction of similar 110 kV circuits assuming that certain works could be completed in parallel with multiple crews.

- However associated with this option is a requirement to upgrade the existing substation in Tonroe. In terms of implementation timelines all consents, agreements, land procurements etc. would need to be obtained within the programme of the Overhead line works. For the purpose of this report it has been estimated that the upgrade to Tonroe 110 kV substation can be completed and energised in a 12 month period. For programme efficiencies the substation upgrade works will be carried out in parallel to the OHL works. Included in the 12 month duration is a 60 days commissioning period.

- This option also drives a 110 kV line uprate of Flagford-Tonroe. This work estimated to take 90 days and can be done either in advance of the commissioning of the new circuit if outages can be obtained, or following the commissioning of the circuit. This would extend out the timelines by one outage season so every effort will be made to liaise with the DSO in advance to secure the required outages.

- For the purpose of this report it has been estimated that the 110 kV bays in Flagford 110 kV station can be completed and energised in a 75 days period. These works will be undertaken as early as possible or in parallel with the line works to ensure completion prior to OHL works completion.

4.5.1.2 Moy - Tonroe 110 kV UGC Option

- The construction of the (approx. 58 km) 110 kV UGC option is expected to take approximately 18 months including commissioning. The works include the uprate of the bay in Moy 110 kV station, the cable terminations at both Moy and Tonroe 110 kV station, and the construction of the UGC. As above, this timeline is based on experience of construction of similar 110 kV circuits assuming that certain works could be completed in parallel with multiple crews.

- However associated with this option is a requirement to upgrade the existing substation in Tonroe. In terms of implementation timelines all consents, agreements, land procurements etc. would need to be obtained within the programme of the Overhead line works. For the purpose of this report it has been estimated that the upgrade to Tonroe 110 kV substation can be completed and energised in a 12 month period. For programme efficiencies the substation upgrade works will be carried out in parallel to the UGC works. This also includes a 60 days commissioning period.

- These timelines assume 6 crews operating concurrently; 4 crews to install ducting, 1 crew to pull and joint cables and 1 crew to install joint bays. This is also assuming that the local authorities will allow 5 independent crews work on regional roads concurrently, at weekends, and at night (where required) with traffic management plans, and safety measures in place.

- This option also drives a 110 kV line uprate of Flagford-Tonroe. This work estimated to take 90 days and can be done either in advance of the commissioning of the new circuit if outages can be obtained, or following the commissioning of the circuit. This would extend out the timelines by one outage season so every effort will be made to liaise with the DSO in advance to secure the required outages.

- For the purpose of this report it has been estimated that the 110 kV bays in Flagford 110 kV station can be completed and energised in a 75 days period. These works will be undertaken as early as possible or in parallel with the line works to ensure completion prior to UGC works completion.

4.5.1.3 Moy - Srananagh 110 kV OHL Option

- The construction of the (approx. 66 km) 110 kV OHL option is expected to take approximately 19 months including commissioning. The works include the uprate of the bays in both Moy and Srananagh 110 kV stations, and the construction of the OHL. As above, this timeline is based on experience of construction of similar 110 kV circuits assuming that certain works could be completed in parallel with multiple crews.

- This option also drives a 110 kV line uprate of Castlebar – Cloon. This work is expected to take 170 days (over two outage seasons if required) and can be done in advance of the commissioning of the new circuit and hence does not impact on the overall project timelines.

- For the purpose of this report it has been estimated that any of the 110 kV bays in Castlebar and Cloon 110 kV stations can be completed and energised in a 75 days period. These works will be undertaken as early as possible or in parallel with the line works to ensure completion prior to OHL works completion.

4.5.1.4 Moy - Srananagh 110 kV UGC Option

- The construction of the (approx. 66 km) 110 kV UGC option is expected to take approximately 19 months including commissioning. The works include the uprate of the bay in both Moy and Srananagh 110 kV stations, the cable terminations at both Moy and Srananagh110 kV station, and the construction of the UGC. This timeline is based on experience of construction of similar 110 kV circuits assuming that certain works (as outlined above) could be completed in parallel with multiple crews.

- These timelines assume 6 crews operating concurrently; 4 crews to install ducting, 1 crew to pull and joint cables and 1 crew to install joint bays. This is also assuming that the local authorities will allow 5 independent crews work on regional roads concurrently, at weekends, and at night (where required) with traffic management plans, and safety measures in place.

4.5.1.5 Summary

The construction of both 110 kV OHL timeline options were developed using established methods, assuming a number of contractors having sufficient resources, skills and experience to construct the OHL. The timelines developed for this section of the analysis includes an estimated time allowance for landowner engagement, access, and associated station works. This reduces the risk of programme over-runs, providing a higher degree for certainty to the construction timelines. However it must be noted that refusal of land access, and related escalation durations (mediation, legal etc.) has not been included in any of the above options.

In general, it is preferable to route underground high voltage cables along public roads to allow ease of access for monitoring and maintenance of the cable. Weekly surveys along the cable routes would need to be carried out to monitor any construction activities near the cable to ensure that no damage occurs to what would be a vital infrastructural asset. While cable faults are rare, when they do occur, prolonged access to the cable for a number of weeks (and maybe months) may be required to identify and repair any faults. For this reason, the estimates for construction and installation timelines have focused on routing the cable largely in existing public roads. This will result in an option that is easier to install and maintain.

Table 40: Implementation Timeline Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Implementation Timeline				

Taking all these factors on implementation timelines into account: All options perform equally with a moderate impact (**Dark Green**).

4.5.2 Project Plan Flexibility

If the construction and installation of the UGC in the existing public roads are not possible a cross-country cable route would be required. This would be associated with the construction of permanent access roads to allow maintenance crews access to the cable ducts with heavy machinery. This is because the cable drums and the rigs required to pull the cable are significantly heavier than the OHL towers, which are made of smaller lighter components that can be assembled on site. With regard to ground conditions, these were assessed on the basis of known areas of blanket bog, fen peat and cutaway bog and on the basis of general knowledge of ground conditions available from previous projects in the west of Ireland. In general, relatively poor ground conditions and areas of karst or of shallow rock can be expected in the study area. This could result in significant change in scope of work and would be associated with a delay in construction and installation timelines of either UGC option.

All options require the build of new infrastructure. Hence, all options will require permits and wayleaves to some extent or another. There is a public participation facet to the permitting which exposes risk to the implementation timelines. Wayleaving requires extensive relationship building with affected landowners which sometimes can be associated with additional time. Generally, UGC infrastructures are more accepted by the public due to its lower visual impact and the fact that public roads are generally used. Consequently, the additional direct and indirect impacts associated with OHL infrastructure as well as complex interactions could add to risk in the permit application process. Both OHL options have the same risk in terms of permits and wayleaving which may lead to extended implementation timelines.

Table 41: Project Plan Flexibility Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Project Plan Flexibility				

The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options perform equally with a high impact on project plan flexibility (**Dark Blue**). The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options perform equally with a low-moderate impact on project plan flexibility (**Dark Green**).

4.5.3 Dependence on other Projects

The proposed options do not depend on the completion of further projects other than the renewable generation development schemes that drive the need for the project.

Table 42: Dependence on other Projects Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS

Dependence on other Projects				

Taking all these factors on dependence on other projects into account: All options perform equally with a low impact (**Cream**).

4.5.4 Risk of Untried Construction Technology

At this point in time, all options propose the use of either 110 kV OHL or UGC technology. At a later stage in the development, a hybrid of OHL and UGC may also be considered.

The impact of the different technical solutions on the operation of the existing transmission network is of critical importance for EirGrid to provide a safe, reliable and secure electricity system. Any interaction between the technology proposed and the transmission network, which may compromise the operation of the existing system, is unacceptable unless it can be mitigated.

In the case of the 110 kV OHL and UGC options there is extensive experience of connections made using these technologies in the Irish transmission system and internationally. The interactions are well understood and can be accurately predicted using software available to network operators.

The use of long 110 kV UGC may lead to the requirement for shunt reactors and/or filters in one or both of the connecting stations. These shunt reactors would be used to compensate the cable capacitance. There is some experience in Ireland for procurement and installation of Air Core Reactors and interaction of this device with the transmission network can be predicted using software available to network operators.

Table 43: Risk of Untried Construction Technology Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Risk of Untried Construction Technology				

Taking all these factors on risk of untried construction technology into account: All options perform equally with a low impact (**Cream**).

4.5.5 Supply Chain Constraints

No constraints are envisaged on the material supply chain as the 110 kV OHL and UGC options include materials all part of ESB Term Contracts and therefore available with the contract agreed time lines.

Table 44: Supply Chain Constraints Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Supply Chain Constraints				

Taking all these factors on supply chain constraints into account: All options perform equally with a low impact (**Cream**).

4.5.6 Permits and Wayleaves

All options presented will be new infrastructure and will require permits and wayleaves to some extent or another – this elevates the risk for all options. There is a public participation facet to the permitting which often increases the risk to the option and wayleaving requires extensive relationship building with individual landowners, the risk to the option is often in the time required to achieve wayleaving.

Generally, it should be accepted that OHL infrastructure proves more difficult and creates risk in attaining permits. There are additional direct and indirect impacts associated with OHL infrastructure as well as complex interactions between impacts which adds to the risk when applying for permits. Both Moy-Tonroe and Moy-Srananagh 110kV OHL options can be considered to have the same risk and both do not perform as well as the UGC options.

The UGC options eliminate many of these difficulties and reduces the risk significantly in attaining permits. This is largely due to the elimination of visual impacts and preference from the public for EirGrid to pursue UGC options generally. Legally, there is also merit in pursuing an UGC option with permitting potentially being less onerous, if required at all. Although it should be noted, there is risk to this approach which should be addressed in more detail in Step 4. At this point in time, however, it is assumed that a permit, including Section 5 Declarations, will be required for all options. Both Moy-Tonroe and Moy-Srananagh 110kV UGC options can be considered to have the same risk and both perform the best, albeit moderately.

All options require that land be wayleaved so negotiation with landowners will be necessary to progress the options in a timely manner. Generally, the risk for wayleaving will be similar for all, however, the options perform differently when considering OHL and UGC options. For OHL options, acceptance from landowners may be more difficult to achieve given the visual issues associated with the infrastructure and the land take required which may displace existing or future activities/development the landowner had intended on carrying out. Similar to permitting, both Moy - Tonroe and Moy - Srananagh 110kV OHL options can be considered to have the same risk and both are therefore associated with a moderate-high impact. Whereas both Moy - Tonroe and Moy - Srananagh 110kV UGC can be considered to have the same risk and both perform the best, albeit moderately.

Several large infrastructural projects have been planned within or proximate to the study areas, many are energy related including the EirGrid Grid West Project, Corrib Gas Project and numerous wind farms. This Grid West Project created a significant social legacy for infrastructure development, particularly in the Moy-Tonroe study area. The design of pylons and their visual impact on the landscape generally was of concern for stakeholders. The opposition to the Grid West project may have arisen out of opposition to large wind farm projects in north Mayo. The upgrade of the grid in these study areas may be seen as solely facilitating further wind farm development in the area. The social impact and legacies of this project may have a material impact on permitting for future large projects in the area.

Table 45: Permits and Wayleaves Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Permits and Wayleaves				

The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL options perform equally with a moderate-high negative impact on permits and wayleaves (**Blue**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC options perform equally with a moderate-high negative impact on permits and wayleave (**Dark Green**).

4.5.7 Water Impact during Construction

The environmental issues that require consideration for water quality are presented in sections 4.3.1 and 4.3.2. This section address the construction issues related to potential water impacts that would need to be considered in delivering the project. There are two different types of water features considered in the water impact assessment, surface water and groundwater.

Surface water impact considers:

- River crossings; and
- Lakes.

Groundwater impact considers:

- Ground water;
- Karst features; and
- Groundwater vulnerability.

4.5.7.1 River Crossings and Lakes

At this stage of the project there is no selected route for the options yet and therefore it is difficult to assess the number and type of river crossings accurately. As detailed in section 4.3.2., all options are within sensitive water catchments including the River Moy, and Owenbeg, Unshin River in Co. Sligo. Loughs Conn and Cullin are significant features south of Ballina. Any option selected will require multiple crossings of rivers and streams including those designated SAC for protected aquatic species and habitats.

A UGC option would be constructed, along the public road network rather than cross-country. The sections where the UGC route would be expected to leave the public road network will be minimised, where possible. The UGC route would be expected to leave public road network where horizontal directional drilling is needed and where the road cannot accommodate join bays in the margins. Horizontal directional drilling may be required to avoid impacts on rivers and streams and to avoid any major existing services or structures, such as bridges or railway tracks, along the route.

Following the local road network means that the UGC options will inevitably require construction works close to rivers/streams. Potential impacts from these works may include increased sediment in surface water run-off. In particular, construction works in areas of peat could result in elevated suspended solids entering receiving water courses. Other construction related pollutants such as oil and lubricants are a risk to water quality.

Direct impacts on riparian habitats must also be considered. The effect of these potential impacts could be the deterioration of water quality downstream of the construction works and an indirect effect on downstream ecological habitats and species.

Due to the sensitivities of the watercourses in this wide study area, detailed mitigation measures will likely be required to be included in construction methodologies for works near surface water features (including horizontal directional drilling under rivers, streams and drainage ditches).

As the works will be localised and short-term, it is not anticipated that flow rates in rivers and lakes will be affected by either UGC option. In addition, any horizontal directional drilling will take place beneath river beds to avoid direct impact on the existing water channel at each location.

Similar considerations can be made for the OHL options but in this case the ground works are expected to be less than required for the UGC options. Routing and line design for an OHL option has the flexibility to take water course crossings into account allowing provision for buffer areas and positioning of structures away from sensitive locations. However, given the level of water features in the wider area and the sensitive nature of these rivers and streams, mitigation measures will be required to ensure water quality at the catchment level and not integrated into construction management plans.

4.5.7.2 Ground water

While there is no selected route at this stage of the project, the assessment of bedrock type is at a high level.

In any case part of the area where these possible circuits may be located is on karstified Pure Bedded Limestone, which is a regionally important aquifer (vulnerable to pollution). As the scale of works will be localised and short-term, it is unlikely that works associated with the UGC and OHL options will affect aquifer recharge. However, if groundwater is impacted by construction works or from repair works during the operational phase of the development, i.e. from the disturbance of peat in an area that results in elevated suspended solids entering the underlying aquifer, the effect may be that the quality of groundwater deteriorates and indirectly effects downstream water supplies and groundwater dependent ecosystems.

4.5.7.3 Karst Features

At this stage of the project there is no selected route for any option and therefore it is difficult to assess if the possible route pass through an area with some recorded karst features, including one potential turlough, enclosed depressions, springs and caves.

Karst features leave the underlying groundwater vulnerable to pollution and all construction works carried out in the vicinity of such features must be strictly monitored and controlled to protect the groundwater.

4.5.7.4 Groundwater Vulnerability

At this stage of the project there is no selected route for any option and therefore it is not possible to assess the vulnerability of the Groundwater.

4.5.7.5 Summary

Table 46: Water Impact during Construction Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Water Impact during Construction				

Taking all these factors on water impact during construction into account: The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform best with low impact (**Cream**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a low-moderate impact (**Green**).

4.5.8 Air Quality Impact during Construction

The construction of the UGC and OHL has the potential to impact on local air quality. During the operational phase of any option, there will be no emissions and therefore no impact on air quality. This assessment will focus on the emissions during construction phase.

During the construction of the proposed development, the construction works and the operation of construction plant and equipment will emit a number of pollutants of concern. The pollutants have defined ambient limit values set out in the Air Quality Standard Regulations. The construction works themselves are likely to give rise to emissions and pollutants including oxides, dust and particulate matter (particulate matter with an aerodynamic diameter of 10µm and 2.5µm are called PM10 and PM2.5 respectively), which can have an impact on sensitive receptors (both human and ecological) in the vicinity of the works.

The potential air quality impacts of the development to be considered are:

- Impacts of dust during the construction phase of the development; and
- Impacts of vehicle and plant emissions during the construction phases

During the construction phase, the UGC will be constructed along the public road network. This will take the cable past a number of houses, and has the potential to cause disruption along the public road network over an extended area.

The principal earthworks associated with the UGC are the excavation of a trench along the length of the construction site, and the typically subsequent backfilling once the cable ducts have been laid. It is expected that the active construction site close to any receptor at any given time will be less than 2,500m^2, and is therefore considered as a small dust emission class site (IAQM, 2014).

During the construction phase, the OHL support structures will be constructed mainly in open fields and not close to dwellings. The earthworks associated with masts foundation works will have an area of 25m^2 circa per foundation. The average distance between two consecutive support structures will be in the region of 150-170m circa; therefore It is expected that the active construction site close to any receptor at any given time will be less than 2,500m^2 and considered a small dust emission class site (IAQM, 2014).

Dust emissions during construction, for any UGC and OHL option, can give rise to elevated dust deposition and PM10 concentrations. These are generally short-lived changes over a few hours or days, which occur over a limited time period of several weeks or months. The active construction works at any one time along the UGC route are expected to be small in scale with low risk to any nearby houses, due to the nature of the works. With good site practice, the construction works will have an imperceptible impact on dust deposition rates and short-term PM10 concentrations at any nearby receptors.

The number of vehicle movements at each UGC-laying site associated with the UGC options may be significant due to the ground conditions and soil types (peat). The vehicles that access the site are likely to do so along fully paved public roads.

Residential properties are located along those roads, and are therefore susceptible to dust emissions from the track-out of material onto the road.

Apart from cross country sections, limited in number and extend, it is unlikely that there will be a need for machinery to work on unpaved haul roads. Facilities for the washing of vehicles and vehicle wheels might provide an appropriate means of minimising the potential for material to be transferred onto the local road network. However, the use of washing also leads to wetting of local roads near the access. Regular inspection of the local roads within 200m of the site access point(s) should be undertaken and street cleaning applied as necessary.

Also, the effect of track-out of material can be minimised by limiting the amount of material transferred onto local roads and by removal of any transferred material from the roads. The impacts associated with the track-out of material can be controlled such that it would have an imperceptible impact on dust deposition rates and on short-term PM10 concentrations at any nearby receptors.

The number of vehicle movements for site associated with the OHL options is likely to be low due to the scale and nature of the works required. In this case most of sites will be located in open field and access will be via temporary roads or using wide track machines. These machines could potentially have a high rate on dust deposit and PM10 concentration but considering the limited amount of material required for each site (mast foundation) the impact is expected to be imperceptible. The road vehicles transporting material to site would have an air impact similar to the UGC option and their impact can be mitigated using the same measures.

Overall, the effect on local air quality as a result of the works along the cable route and OHL route sites will be negligible.

Mitigation measures/ good practice against air pollution include:

- Agree lines of communication between local authority pollution control officer and contractor(s) prior to commencement of works and procedure for reporting dust events or complaints from local residents;
- Minimise drop heights and chutes where practicable;

- During extended periods of dry weather (especially over holiday periods) plan for additional mitigation measures to avoid wind-blown dust issues both within and outside normal working hours; and

- Avoid long-term stockpiles of material on site without application of measures to stabilise the material surface, such as application of suppressants or seeding.

The risk of amenity effects and the amount of mitigation effort required is strongly influenced by weather conditions at the time of the works. Measures to control dust generation, such as on-site dust suppression techniques and vehicle covers may be used as required, particularly in the vicinity of residential housing and access and egress points for haul routes of construction materials. A wheel wash facility must be provided at locations along the route, particularly where the cable route travels across country.

Table 47: Water Impact during Construction Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Water Impact during Construction				

Taking all these factors on water impact during construction into account: The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform best with low impact (**Cream**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a low-moderate impact (**Green**).

4.5.9 Traffic and Noise Impact during Construction

4.5.9.1 *Traffic*

The assessments of traffic impacts and effects should be made by considering first the construction methodology employed and then the locations along the cable or OHL routes where the potential exists for disruption to traffic. The likelihood of full or partial road closure should be assessed in consideration of availability of feasible diversion routes where these would be necessary due to the construction works.

Not having defined route options at this stage of the project do not allow for a full traffic and noise risk assessment.

For a project of this size, some disruption to traffic will inevitably occur during construction. However, EirGrid will work with local authorities and community groups to put traffic plans in place and to resolve any foreseeable problems.

Significant disruption to traffic is expected, for UGC options, at some locations during installation of the cable, as described below. Where the cable is routed along an existing road, it is envisaged that phased traffic management provisions or full road closures will be required in order to accommodate construction work.

Post installation, weekly surveys along the cable routes are anticipated. These are carried out to monitor any construction activities in the vicinity of the cable to ensure that no damage occurs to what would be a vital infrastructural asset. However, it is not envisaged that these surveys will have a significant impact on traffic.

In addition to the traffic disruption experienced during installation of the cable, it is possible that further traffic disturbance may be experienced in future if faults were to occur along the UGC. While cable faults are rare, they do occur. Prolonged access to the cable for a number of weeks (and maybe months) may be required to identify and repair any faults.

For UGC options the ducting installation procedure will help to minimise disruption to existing roads users. During construction, local access to houses and businesses will be maintained. The works will move at approximately 30 to 50 metres a day, meaning people can reasonably expect to have work directly outside their premises / house for limited periods of time only.

In order to minimise traffic impact where possible, the preferred UGC route should follows local roads. This will result in an option that is easier to install and maintain with an additional advantage in that the local roads, along which the cable will be laid, will be to some extent be upgraded.

For OHL options it is not expected to require many road closures due the fact mast and pole sets are installed in open fields, only during conductor string activity road crossed by the OHL will need to be closed for a limited period of time.

A detailed Traffic Management Plan (TMP) will be developed prior to construction in consultation with affected County Councils.

The TMP will be agreed in writing with the relevant planning authority prior to commencement of the development and will govern work practices on public roads and vehicle movements. The TMP will also provide a mechanism of notifying residents of the surrounding area of works and restrictions on public roads. The TMP will include details on traffic management and traffic control measures, temporary road closures, delivery of abnormal loads and provision for local access. Construction traffic related issues such as working hours, parking restrictions, access points onto the existing road network and construction worker travel and transport arrangements will also be included.

Measures will be put in place to ensure that local traffic flows as freely as possible, especially during cable installation works for UGC options and crossing road conductor stringing. In addition, open trench lengths will be kept to a minimum to minimise traffic disruption. Two-way traffic will be maintained wherever possible on wider roads. Where this is not possible, single-file traffic will be considered. The period during which traffic is subjected to one-way flow will be kept to a minimum. Where roads are too narrow for safe working, temporary road closure options for the works will be discussed with the Garda Siochána and the relevant Local Authority. Where temporary road closure is required, a temporary diversion route will be agreed with the relevant authorities, although provision for access by local residents and local deliveries will be maintained as far as possible throughout the work in each locality.

Roads used by construction traffic will be inspected and cleaned where necessary and aggregate materials will be removed from road surfaces as required.

Work in the public road along the route will be governed by Health and Safety Authority requirements, Department of Transport Guidelines (Guidance for Control and Management of Traffic at Road Works, 2007) and the local authorities. Road signage during the works will be in accordance with the requirements of the Traffic Signs Manual: Chapter 8 — Temporary Traffic Measures and Signs for Roadworks, published (and as amended) by the Department of Transport.

4.5.9.2 *Noise*

Noise issue is directly related to the traffic requirements for construction activity and therefore considerations and mitigation measures described for the traffic management issue apply.

The other source of noise to be considered is from construction activities.

Construction noise and vibration impacts are by their nature temporary. This is particularly so for linear infrastructure schemes such as this, where intensive works in close proximity to sensitive receptors will be short-term as construction progresses along the route. However, resulting short-term noise levels can be high, depending on the activities being carried out and the plant employed.

Vibration impacts are unlikely to be significant for most construction activities for UGC and OHL options. However, specific activities such as piling (as ground conditions dictate) and ground compaction in proximity to sensitive receptors can result in disturbance to residents. Cosmetic damage to properties is unlikely (except in unusual circumstances), but residents have concerns about this aspect and require reassurance.

Sensitive receptors include residential, community, religious and educational premises within the route corridor for all options. A route corridor width of 100 metres either side of the scheme should be sufficient to establish the potential noise impact on the community for the route option.

For the UGC options it should also be considered the noise issue related to power failure incidents on UGC during its operational life. It can take some time to locate and repair due to the difficulties in finding the fault and the need to expose cabling. Repair works will be localised but may be of a similar intensity to initial construction impacts.

In general, for both technology options, noise generating activities are likely to occur predominantly during the trenching works and the construction of the mast foundations. During this time noise will be produced from earth moving equipment, rotary piling rigs and concrete mixer trucks.

The potential for vibration at sensitive locations during construction is typically limited to excavation works and piling. Vibration from construction and operational activities will be limited to the values which will not give rise to nuisance or damage to property.

A Noise and Vibration Management Plan will be developed and will outline measures to reduce the potential impacts from noise and vibration associated with the construction phase. This includes:

- The erection of barriers as necessary around noisy processes and items such as generators, heavy mechanical plant or high duty compressors;

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- Appointing a site representative responsible for matters relating to noise and vibration;
- Monitoring typical levels of noise and vibration during critical periods and at sensitive locations;
- Selection of plant with low inherent potential for generation of noise and or vibration;
- All site access roads will be kept even so as to mitigate the potential for vibration from lorries; and
- Placing of noise/vibration causing plant as far away from sensitive properties as permitted by site constraints and the use of vibration isolated structures where necessary.

Best practice dictates that the potential noise impact of the development is assessed against appropriate international standards. All sound measurements shall be carried out in accordance with ISO Recommendations R 1996, “Assessment of Noise with Respect to Community Response” as amended by ISO Recommendations R 1996/1, 2 and 3, “Description and Measurement of Environmental Noise”, as appropriate.

Noise and vibration from construction activities will be limited to values outlined in the Noise and Vibration Plan.

4.5.9.3 Summary

Table 48 Traffic and Noise during Construction Assessment

Category	OHL-MT	UGC-MT	OHL-MS	UGC-MS
Traffic and Noise during Construction				

Taking all these factors on traffic and noise during construction into account: The Moy – Tonroe 110 kV OHL and Moy – Srananagh 110 kV OHL perform best with low-moderate impact (**Green**). The Moy – Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a moderate-high negative impact (**Blue**).

4.6 Overall Assessment of Options

The sub-criteria have been aggregated to give an overall score for each of the main criteria for each option. A comparison of the three options under the five main criteria and the overall assessment is shown in the table below.

ID		OHL-MT	UGC-MT	OHL-MS	UGC-MS
Type		OHL	UGC	OHL	UGC
Scheme		Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Srananagh 110 kV	Moy – Srananagh 110 kV
Multi-Criteria Assessment	Technical				
	Economic				
	Environmental				
	Socioeconomic				
	Deliverability				
	Overall				

Table 49: Overall Multi-Criteria Assessment

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

Dark Blue	Blue	Dark Green	Green	Cream

In terms of technical performance, the Moy – Tonroe 110 kV OHL options performance in nearly all sub-criteria better or equal to the other options but the security standard compliance. Here, the Moy – Tonroe 110 kV is surpassed by its UGC counterpart and performs with a moderate impact. Overall, this option performs best on the technical impact assessment.

This economic assessment illustrates that the various options have different potential implication in regards with the various economic sub criteria. Overall, the options are balanced out over most of the sub-criteria but implementation costs. Here, the OHL options perform better than the UGC options due to lower implementation costs for the new circuit. The Moy – Tonroe 110 kV OHL options performs best in this regard, despite the additional implementation cost for a new 110 kV substation in Tonroe near Ballaghadreen, due to the shorter length of new circuit, shorter associated uprate. Overall, Moy – Tonroe 110 kV OHL performs best on the economic impact assessment.

This high level assessment illustrates that the various options have different potential impacts on the various environmental sub criteria. Both OHL options score similarly with Moy - Srananagh scoring worst for landscape and visual. Both UGC options score similarly, with potential impacts on soils and water in these sensitive catchments a significant issue for consideration. Overall, on balance, a 'moderate' environmental impact is predicted for the various options.

In terms of the socioeconomic impact assessment, both the Moy-Tonroe 110kV UGC and the Moy-Srananagh 110kV UGC option perform equally and are the best performing options. Comparatively, the UGCs present less risk and has a less impact than the OHL options in the context of all sub-criteria, lessening the socio-economic impacts generally. The Moy-Tonroe 110kV OHL option performs moderately and is the next best performing option. The option which presents the most risk and may have a significant impact is the Moy-Srananagh 110kV OHL option. The risk and significance of the impact on the Moy-Srananagh 110kV OHL option is evident in its performance under: settlements & communities; recreation & tourism landscape & visual criteria.

The deliverability assessment shows the different performance of the options from Step 4 to completion of construction and energisation. Here, the OHL options perform better or equal to the UGC options in nearly all sub criteria but the permits and wayleaves criteria. For OHL options, acceptance from landowners may be more difficult to achieve given the visual issues associated with the infrastructure and the land take required which may displace existing or future activities/development the landowner had intended on carrying out. Furthermore, the OHL options perform better in the terms of project plan flexibility and the impact on water, air quality, traffic and noise during the construction.

Taking all the criteria of the multi-criteria analysis into account: Overall, The Moy – Tonroe 110 kV OHL performs best with low-moderate impact (**Green**). The Moy –

Tonroe 110 kV UGC and Moy – Srananagh 110 kV UGC perform equally with a moderate impact (**Dark Green**). Moy – Srananagh 110 kV UGC has been shown to perform with a moderate-high impact (**Blue**).

5 Stakeholder Engagement

5.1 Communication activities

This section summarises the activities undertaken by EirGrid to advertise the engagement process.

5.1.1 Email Correspondence

Prior to the start of the consultation, EirGrid emailed TDs, Senators, MEPs and Local Councillors (see Appendix A) to inform them of the proposals and provide them with details on the upcoming engagement activities.

5.1.2 Print Media

In order to advertise the public information days, EirGrid took out newspaper ads in five local newspapers in the four weeks leading up to the public events. Initially, these were full page ads with images, but they were reduced to smaller text-only information ads closer to the event.

The newspapers were:

- The Sligo Champion
- The Roscommon Herald
- The Western People (*)
- The Connacht Telegraph (*);
- The Mayo News (*)

Additionally, EirGrid sent press releases to three of the newspapers (*) to inform them about the events and the wider North Connacht 110 kV project, and as a result they published articles which added to the publicity of the project.

5.1.3 Radio

A representative from EirGrid's External Affairs appeared on several local radio stations to present the North Connacht 110 kV project and inform people about the forthcoming public information days:

- MidWest Radio on June 11th 2018
- Shannonside on June 11th 2018
- Castlebar Community Radio on July 6th 2018

5.1.4 Social Media

EirGrid's External Affairs team used Twitter, Facebook and LinkedIn to share the location of the Mobile Information Unit (MIU), alongside images of the team on the ground. There were primarily positive responses shared across Twitter and Facebook, with only two negative responses being shared on Facebook.

5.2 Engagement Activities

This section summarises the engagement activities undertaken by EirGrid as part of the engagement process.

5.2.1 Meetings

EirGrid hosted meetings with stakeholders who were designated as high interest and high influence to inform them of the proposals and gather their feedback.

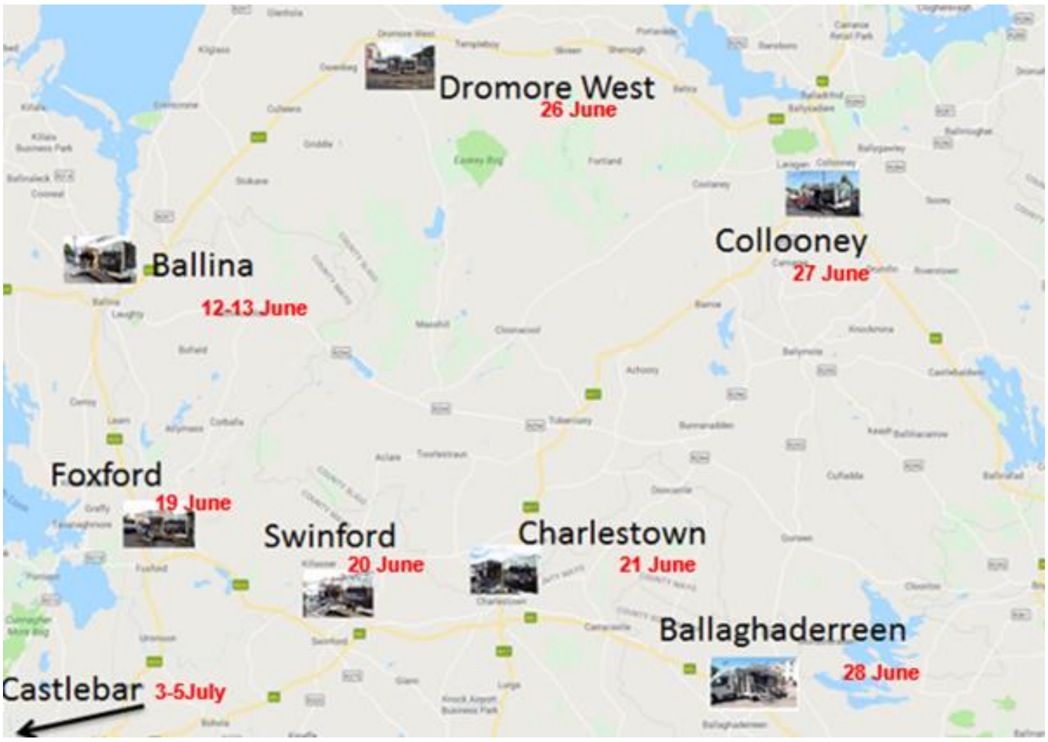
Meetings were held with the following stakeholders:

- Roscommon County Council
- Mayo County Council
- Sligo County Council
- Northern Western Regional Assembly
- Western Development Commission
- IFA Reps in North Connacht
- Investment and Development Agency (IDA)
- Chairman and Committee of Bonniconlon Show
- Local Group of Landowners in Foxford

5.2.2 Public Information Days

During the summer of 2018, EirGrid hosted a number of public information days in Foxford, Swinford, Charlestown, Dromore West, Collooney, Ballaghadreen, using its Mobile Information Unit (MIU). In the MIU, visitors could review a plethora of information materials and at least three EirGrid staff members were on hand to answer questions. Around 100 people visited the MIUs over the course of their public outreach. They represented a range of stakeholder groups including members of the public, local business owners, councillors, developers of green energy projects.

EirGrid also hosted three Open Information Days in its Castlebar office from 3rd to 5th July 2018.



5.3 Feedback received

Based on EirGrid's staff perceptions and written received feedback, most of those who engaged with the proposals agreed with the need for the project and were overall supportive of the proposals. Mayo County Council, Northern Western Regional Assembly and Investment and Development Agency (IDA) all stressed the importance of having the infrastructure in place to support other strategic plans in the area. In contrast, the Western Development Commission felt that the North Connacht 110 kV project would not meet future demands for renewable energy in the region and from that perspective the proposals were not ‘future-proofed’.

The UGC option was preferred to the OHL option, but some members of the public acknowledged that the currently proposed OHLs were more aesthetically pleasing than the previously considered 220 kV or 400 kV pylons associated with the Grid West Project. In contrast, Mayo County Council expressed a preference for an OHL using twin pole sets.

In terms of routing, both Bord na Mona and Mayo County Council expressed preference for the Moy - Tonroe option. However, whereas Mayo County Council supported an OHL option, Bord na Mona felt that an UGC would perform better in terms of current carrying capability. Bord na Mona also asked for the Bellacorick 110kV station to be the starting point of the project or alternatively, for the planned circuit uprate from Bellacorick to Moy - be of sufficient capacity.

The written feedback identified a range of different concerns that participants felt EirGrid should consider.

- **Ecology:** the National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht highlighted the Appropriate Assessment requirements of the Habitats Directive and other environmental legislation that must be considered in the development of the project to ensure that adverse effects on habitats and species of conservation importance are avoided. Another stakeholder stressed that OHL would have an adverse impact on the local wildlife.

- **Noise concerns:** concerns were raised about the noise emitted from high-voltage power lines in wet weather both in terms of general disturbance and for health reasons.

- **Property value:** there were concerns that the presence of OHLs might have an adverse impact on property value.

- **Landscape and Visual:** there were concerns that the natural beauty of the countryside would be ruined if OHLs were installed.

- **Health concerns**: there were concerns that there could be a negative impact on residents' health with reference to electromagnetic radiation.

In terms of engagement, one individual claimed that EirGrid were not engaging with the public appropriately, but instead were following a path of 'Decide, Announce, Defend'. Stakeholders, however, were appreciative of the meetings organised by EirGrid.

5.4 Accounting for Feedback in the Multi-Criteria Assessment

The multi-criteria assessment includes all the related concerns, grouped into five criteria: Technical, Economic, Environmental, Socio-Economic and Deliverability. These criteria must be considered by Eirgrid.

Given the topics raised the stakeholder feedback has been considered in:

- Ecology concerns as part of the Biodiversity/flora and fauna in 4.3.1
- Noise concerns, including climatic impacts, as part of both Traffic and noise in 4.5.9 during construction and the enduring impact of the project in Traffic and Noise in 4.3.6. Further information in regards with noise can be found in an evidence based environmental Study[35].
- Landscape and Visual are both part of the assessment. The section 4.3.4 describes the impact of an UGC or OHL on the environment. The socioeconomic impact is elaborated in the section 4.4.3.
- In terms of health concerns Eigrid has developed the booklet "Power Lines and Your Health". This publication gives an overview of the electricity transmission system in Ireland and the Electric and Magnetic Fields (EMF) associated with it. This publication is available on EirGrid's website[36].
- The valuation of property is not explicitly part of the multi criteria assessment. While a best performing OHL route will be cross-country, EirGrid expects that the interaction with settlements and communities will be minimal.

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[35] http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Evidence-Based-Environmental-Study-8-Noise.pdf
[36] http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_Power_Lines_and_your_Health.pdf

6 Assessment of Project Complexity

The analysis to date has shown that each technology options of the North Connacht 110 kV Project requires a new circuit. The new build could be implemented as an OHL, UGC or a hybrid of both OHL and UGC. Any option involves the acquisition of land and its transformation into a transmission corridor which eventually facilitate the new circuit.

The implementation of North Connacht 110 kV Project affects many customers and stakeholders and may affect the natural, human and built environment along its potential corridor. Therefore, the project has been classified as Tier 3 having regard to EirGrid's Framework for Grid Development.

7 Conclusions

In the Step 1 for the North Connacht Project, the need for this project was identified.

In order to meet this need, the *Longlist of Technology Options* was created in the Step 2 – Options Report which could potentially meet the identified need. The *Longlist of Technology Options* included 23 technology options which comprised 110 kV line uprates only and 110 kV new build of circuits. For the new build both underground cable (UGC) and overhead line (OHL) were analysed. This evaluation was based on "straight-line" point-to-point options (with some provision made for anticipated divergence from a straight line) and standard capital costs (with some contingency). The *Longlist of Technology Options* was subject to initial high-level technical and economic appraisal, facilitating the creation of the *Refined List of Technology Options* of four OHL and two UGC technology options which do meet the identified need for the project. A more detailed, but still high level, assessment against technical, economic, environmental, socio-economic and deliverability criteria was carried out on the *Refined List of Technology Options* of six Technology Options. The result of this multi criteria assessment is the *Shortlist of Technology Options* of four options which will be taken into the Step 3 of The Framework for Grid Development.

In this Step 3 – Preferred Options Report, the developed *Shortlist of Technology Options* has been assessed in greater detail. The technology options are as follows:

1. Moy – Tonroe new 110 kV – OHL plus 32 km uprates;
2. Moy – Srananagh new 110 kV – OHL plus 58 km uprates;
3. Moy – Tonroe new 110 kV – UGC plus 32 km uprates; and
4. Moy – Srananagh new 110 kV – UGC plus 0 km uprates;

All the technology options have Moy 110 kV substation (Ballina) as the starting point and either Tonroe (Ballaghaderreen) or Srananagh as the terminating 110 kV substation. The two point to point connections could be built as OHL or UGC[37]. The four technology options are as follows:

In accordance with The Framework, the complexity of the project was defined as Tier 3.

Taking all five criteria of the assessment into account, the best performing option is Moy-Tonroe 110kV OHL.

	ID	OHL-MT	UGC-MT	OHL-MS	UGC-MS
	Type	OHL	UGC	OHL	UGC
	Scheme	Moy – Tonroe 110 kV	Moy – Tonroe 110 kV	Moy – Srananagh 110 kV	Moy – Srananagh 110 kV
Multi-Criteria Assessment	Technical	Green	Dark Green	Dark Green	Blue
	Economic	Green	Dark Green	Dark Green	Dark Green
	Environmental	Dark Green	Dark Green	Dark Green	Dark Green
	Socioeconomic	Dark Green	Green	Blue	Green
	Deliverability	Dark Green	Blue	Dark Green	Blue
	Overall	Green	Dark Green	Dark Green	Blue

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

Dark Blue	Blue	Dark Green	Green	Cream

A more detailed breakdown on the assessment is given below.

[37] The hybrid of overhead line and underground cable as technology option was not analysed yet and could represent a viable technology option.

Technical: the Moy – Tonroe 110 kV OHL option performance in nearly all of the seven sub-criteria is better or equal to the other options. Therefore, this option performs best on the technical impact assessment.

Economic: the variations in the six sub-criteria for the economic assessment effectively are balanced out with the exception of implementation costs. Here, the OHL options perform better than the UGC options due to lower implementation costs for the new circuit. The Moy – Tonroe 110 kV OHL option performs best in this regard, despite the additional cost for the redevelopment of the existing Tonroe 110 kV station near Ballaghadreen.

Environmental: the findings of the six environmental sub-criteria illustrated that the various options have different potential impacts on the various environmental sub criteria. Both OHL options score similarly with Moy - Srananagh scoring worst for landscape and visual and biodiversity/flora and fauna. Both UGC options score similarly, with potential impacts on soils and water in these sensitive catchments a significant issue for consideration. Overall, the impact of these sub-criteria created a balance, with a 'moderate' environmental impact predicted for the various options.

Socio-Economic: both UGC options perform equally and are the best performing options. Comparatively, at this stage the UGCs present less risk and have less impact than the OHL options in the context of all five sub-criteria, lessening the socio-economic impacts generally.

Deliverability: the OHL options perform better or equally to the UGC options in nearly all sub criteria with the exception of the permits and wayleaves sub criteria. Relatively poor ground and road conditions can be expected in the study area. This could result in significant changes in scope of work and would be associated with delays in construction and installation timelines of the UGC options. Therefore, the 110 kV OHL options perform better for the deliverability assessment.

Overall, the best performing option is **Moy – Tonroe 110 kV OHL** with low-moderate impact (**Green**). **The Moy – Tonroe 110 kV UGC** is the best UGC option with a moderate impact (**Dark Green**). In line with the Framework, these two options will be brought forward into Step 4.

The project enters Step 4 of The Framework. Here EirGrid will develop various corridors for the best performing options. EirGrid will engage actively on different corridor options for each of the best performing option. Following based on the landowners' and stakeholders' feedback, the best performing corridor is specified. Within the corridors we will develop a route which will specify the location of any new equipment or infrastructure.

Appendix A. List of Figures

Appendix B. List of Tables