The Grid West Project

Report for the Independent Expert Panel

Volume 1
Main Report

REPORT FOR THE INDEPENDENT EXPERT PANEL

PROJECT: **Grid West Project**

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1. INTRODUCTION

1.1 EIRGRID'S ROLE

EirGrid is the national electricity Transmission System Operator (TSO) for Ireland. Its role and responsibilities are set out in Statutory Instrument No. 445 of 2000 (as amended); in particular, Article 8(1) (a) gives EirGrid, 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, EirGrid is statutorily obliged to offer terms and enter into agreements, where appropriate and in accordance with regulatory direction, with all those using and seeking to use the transmission system. Upon acceptance of connection offers by prospective network generators and demand users, EirGrid must develop the electricity transmission network to ensure it is suitable for those connections.

1.2 ENERGY POLICY

The Irish Government has a target that 40% of electricity consumed be from renewable sources by 2020[1]. This is on foot of a binding European Union (EU) target, which recognises the need for Europe to increasingly decarbonise its energy system. In order for renewable electricity production to reach the market, the transmission grid must be strengthened to transmit the variable output from renewable energy sources. As a responsible TSO, whose role is to support Government in achieving national policy objectives, EirGrid must ensure the transmission network necessary to facilitate this is in place.

Grid25, published in October 2008, is EirGrid's "Strategy for the Development of Ireland's Electricity Grid for a Sustainable and Competitive Future". Grid25 identifies the need for "Major infrastructural development from Mayo to the main bulk transmission system in the eastern part of the region", to connect renewable generation in the area and facilitate anticipated growth in regional electricity demand.

1.3 THE GRID WEST PROJECT

The Grid West project is the largest Grid25 project in the north west region, in terms of both scale and capital investment. Its primary objective is to connect a significant quantity of wind generation in north Mayo to the electricity transmission network.

[1] Government White Paper, 12th March 2007, *Delivering a Sustainable Energy Future for Ireland.* The original target set in this paper was 33%. This was increased to 40% in the Carbon Budget of October 2008 and confirmed in the National Renewable Energy Action Plan, July 2010.

By connecting the electricity generated from the region's renewable energy resources to the national electricity transmission system, the Grid West project will assist Ireland in meeting its national renewable energy policy goals.

In the short and medium term, the majority of this renewable generation will come from onshore wind; in the longer-term, renewable energy resources in the region may include offshore wind, wave and tidal energy.

The reinforcement of the electricity transmission network in the region will also help facilitate regional economic development.

1.4 THE INDEPENDENT EXPERT PANEL

In January 2014, the then Minister for Communications, Energy and Natural Resources, Mr. Pat Rabbitte TD, announced the establishment of an Independent Expert Panel (IEP).

Under the Terms of Reference[2], as prescribed by the IEP, overhead and underground route options are to be published side-by-side, in objective and comparable terms. The performance of each option, in respect of set environmental, technical and economic criteria, is to be assessed.

1.5 SCOPE OF THIS REPORT

This report provides comprehensive, route specific studies and reports on fully underground and overhead options for the project. It includes an assessment of potential environmental impacts, technical efficacy and costs.

It presents information for each of the options in a consistent fashion, in line with the IEP Terms of Reference. Each option is analysed from a technical, environmental and economic perspective.

EirGrid presents each option in separate chapters. Such an approach, while facilitating comparability, does lend itself to repetition and while every attempt is made to minimise this, it is unavoidable to a certain degree.

The environmental analysis of each option explores the potential impact on environmental factors, addresses mitigation and the likely effect on the receiving environment. This analysis is not equivalent to an Environmental Impact Statement (EIS). As per the provisions of EirGrid's Project Development and Consultation Roadmap[3] (the Roadmap), an EIS will be prepared for the selected project solution in advance of submitting a planning application to An Bord Pleanála.

[2] Appendix 4 – IEP Terms of Reference
[3] Appendix 1 - EirGrid's Project Development and Consultation Roadmap

1.6 PROJECT DEVELOPMENT TO DATE

The Roadmap is a structured framework that provides consistency in the development of EirGrid's major projects, from inception through to construction. It sets out the five stages of project development and identifies key points for public, landowner and stakeholder engagement.

The Grid West project is developed in accordance with the Roadmap and four different options were considered at Stage 1, namely:

- High Voltage Alternating Current (HVAC) overhead lines;
- HVAC underground cables;
- High Voltage Direct Current (HVDC) overhead lines; and
- HVDC underground cables.

The Stage 1 Report[4] concluded that the preferred option was a HVAC OHL at 400,000 volts (400kV). In October 2013, the Route Corridor and Substation Evaluation Report[5] was published, identifying the 'Emerging Preferred Route Corridor' (EPRC) for a 400kV overhead line for the Grid West project as running from north Mayo to Flagford, Co. Roscommon.

In January 2014 EirGrid announced a number of initiatives[6] to address concerns raised by the public and stakeholders during consultation on its major projects, including a commitment to undertake a comprehensive underground analysis for the Grid West project. On foot of this announcement, in June 2014 EirGrid published the Underground Route Options Preliminary Evaluation Report[7] which identified a preferred underground route option for the Grid West project running from north Mayo to Flagford.

Extensive landowner engagement was undertaken on an indicative line route within the EPRC and the preferred underground route option. This has provided the basis for the studies which have informed this report.

In addition, in December 2014, EirGrid published a review of its consultation process designed to enhance future public engagement. This review outlined a number of commitments[8] including a focus on further improving and updating the Roadmap to ensure more effective community, landowner and stakeholder participation.

1.7 TECHNOLOGY OPTIONS

This report analyses a number of potential solutions to meet the project needs. These are:

- A High Voltage Direct Current (HVDC) underground cable (UGC) option which facilitates a fully underground solution;

[4] Appendix 2 - EirGrid Grid West Stage 1 Report – Section 3.2 Technical Foundation Report, March 2013
[5] Appendix 3 - EirGrid Grid West Route Corridor and Substation Evaluation Report, October 2013
[6] http://www.eirgrid.com/media/Grid25Initiatives.pdf
[7] Appendix 8 - Underground Route Options Preliminary Evaluation Report, July 2014
[8] http://www.eirgrid.com/media/ReviewingAndImprovingOurPublicConsultationProcess.pdf

- A 400kV High Voltage Alternating Current (HVAC) overhead line (OHL) option; and
- A 220kV HVAC OHL option incorporating an investigation of the maximum amount of partial undergrounding cable (PUG) possible.

Each potential solution is analysed in a consistent manner in accordance with the criteria set out in the IEP Terms of Reference.

1.8 CONCLUSION

EirGrid believes that this report meets the Terms of Reference set out by the IEP. Comprehensive, route specific studies of fully undergrounded and fully overhead options for Grid West were undertaken. These included assessments of potential environmental impacts/effects, technical efficacy and cost factors in accordance with the Terms of Reference.

2. SUMMARY

Figure 2-1 below shows the report structure and the following summary provides an accessible overview of the report that follows herewith.

The report is presented in three parts: the background and consideration of the need and technology options are outlined in chapters 1-4; chapters 5, 6 & 7 are each standalone assessments of the underground and overhead options, respectively; and a summary of options and next steps is outlined in chapters 8 & 9.

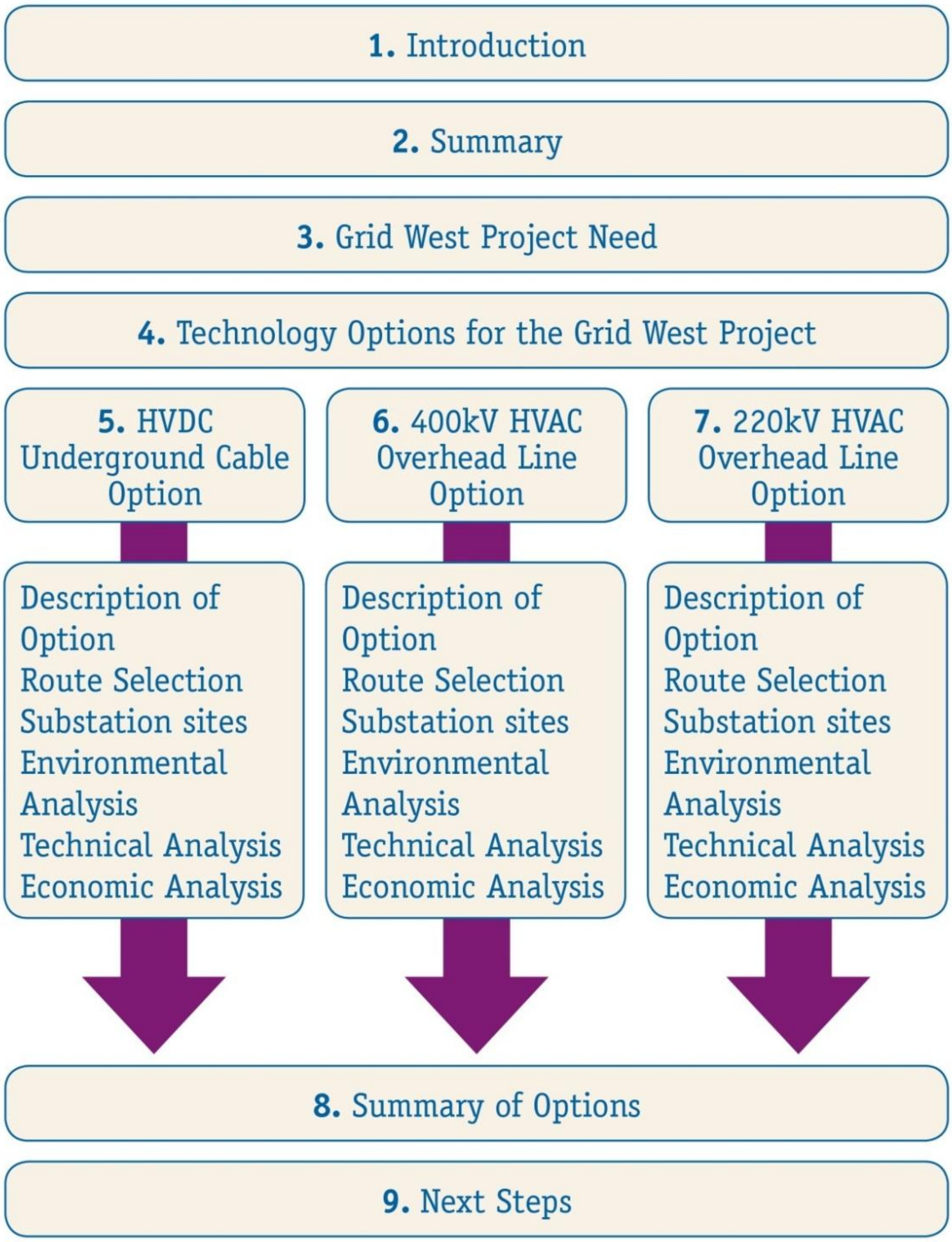

Figure 2-1 Overview of Report Structure

2.1 PROJECT NEED

As Transmission System Operator (TSO), EirGrid is statutorily obliged to plan and develop the national electricity transmission network. In addition, it must connect customers and generators that meet its requirements to the network.

The Commission for Energy Regulation (CER) directs that applications from electricity generators to connect to the transmission and distribution systems are processed in groups called ‘gates’.

The most recent group of applications, called ‘Gate 3’, was processed in 2013 and includes a significant amount of wind generation. This includes 647MW of renewable generation projects located in north Mayo. The majority of this generation is associated with two projects; Oweninny, developed jointly by ESB and Bord na Móna, and Cluddaun, a Coillte development. EirGrid, in accordance with its statutory obligations, provided these projects with connection offers.

As a responsible TSO, whose role it is to support Government in achieving national policy objectives, EirGrid must ensure the transmission network necessary to facilitate the connection of approved generation is in place. In addition, EirGrid is required to plan appropriately for future requirements. A detailed assessment of the network capability in the north Mayo region showed that that the existing 110kV network, even if upgraded, cannot transmit the contracted additional Gate 3 generation. Further development of the transmission network is therefore necessary.

Notwithstanding this, EirGrid continually reviews the need for its strategic infrastructure projects. It closely monitors the status of the proposed renewable energy projects in north Mayo, to ensure that the need for the Grid West project remains. If the amount of renewables seeking to connect to the grid altered significantly, this would require a review of the need.

2.2 TECHNOLOGY OPTIONS

Electrical networks, and their associated technologies, vary around the world depending on (inter alia) electrical demand, population density, economic prosperity, topography and land use. Further considerations include the location of natural sources (e.g. water, coal, gas and increasingly wind, wave, tidal and solar) for the generation of electrical power.

The strategic importance of the national electrical grid to any country means that the TSOs have to utilise technology that is capable of ensuring that the required levels of security and reliability are met at all times.

No single technology, or mix of technologies, is appropriate for all transmission infrastructure projects. The most appropriate technology for a project is determined on its own merits, having regard to the nature, extent and location of a given project.

In considering a new transmission circuit, the technology considerations are as follows:

- The appropriate use of Alternating Current (AC) or Direct Current (DC) technology;
- The transmission voltage for the circuit, that considers the amount of capacity to be added, and the characteristics of the transmission network to which it is connecting; and
- The appropriate use of overhead line (OHL) or underground cable (UGC) technology.

EirGrid's statutory responsibility as TSO is to develop a safe, secure, reliable, economical transmission network in Ireland, with due regard for the environment[9]. This responsibility is reflected in the national policies and standards that direct the design and development of transmission infrastructure, which are consistent with European and international practice.

All transmission projects, regardless of the technology being employed, are designed to meet prescribed levels of performance and security. These are set out in the following documents:

- The Transmission Planning Criteria (TPC)[10];
- The Operational Security Standards (OSS)[11]; and
- The Grid Code[12].

Any network development is designed to comply with national safety regulations, and corresponding international and European regulations. EirGrid, in common with other national TSOs, develops the transmission system to ensure that the security and reliability of the network meets the prescribed levels of performance, safeguarding the continuity of electricity supply to all of its customers.

Historically and currently, HVAC technology is the most widely used technology for electrical transmission networks. This is due to the relative ease and low economic cost of connecting HVAC equipment to form complex meshed transmission networks[13].

HVDC technology is mostly used where long distances are involved and where there is a need to bulk transfer power from one point to another. This type of technology can also be accommodated into a meshed HVAC transmission network.

2.3 ROUTE SELECTION

A study of constraints within the Grid West Study Area formed an important part of the work in identifying indicative overhead line and cable routes. The process by which constraints were identified and mapped is set out the Grid West Constraints Report (2012) which is presented in Appendix 16 of this IEP Report.

[9] SI 445 of 2000 (as amended); Article 8(1) (a)

[10] EirGrid, Transmission Planning Criteria, 1998 (http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf)

[11] EirGrid, Operational Security Standards, 2011 (http://www.eirgrid.com/media/Operational%20Security%20Standards.pdf)

[12] EirGrid, Grid Code, 2013 (http:// www.eirgrid.com/media/GridCodeVersion5.pdf)

[13] Meshed networks are networks which have multiple connections to ensure reliability.

Constraints are defined as factors which present potential obstacles to identifying substation or converter station locations, route corridors and cable and line routes. They are best avoided where possible but, where they cannot be avoided, the nature of the constraint, and the development of mitigation measures against unwanted impacts upon it, are critical factors considered when designing the project. Constraints include settlements, ecology, landscape, geology, water, cultural heritage, technical considerations, utilities and other infrastructure.

On the Grid West project the primary basis of identifying constraints and suitable routes for the technology options considered is founded upon the expertise and experience of the specialists in the project team. In the Grid West study area, as detailed in the Constraints Report, there are more than 80 identified constraints layers, of different importance across the study area, and many of which overlap. The constraints were mapped and overlaid upon one another to produce a ‘heat map’, which identified the relative degree or density of constraints across the study area. This heat map was used in identifying suitable routes for the underground cable and overhead line options, which impact on the least number of constraints possible, taking all of the constraints into consideration.

2.3.1 Identifying a Preferred Underground Cable Option

EirGrid undertook detailed technical studies and hosted a number of workshops with local authorities in Mayo, Galway and Roscommon, as well as the National Roads Authority (NRA). Thirty-one possible underground cable routes from north Mayo to both Flagford in Co. Roscommon and Cashla in Co. Galway were identified. These routes run mainly along local roads. Four partial submarine routes were also considered.

The preferred UGC route was selected based on a range of criteria including length of route, existing infrastructure, diversions during construction, social impact and cultural heritage, as well as impact on Natura 2000 sites.

For a HVDC solution, converter stations are required at each end of the UGC. A number of potential converter station locations were identified in north Mayo and Flagford. Possible converter station locations are identified by 1km circular areas. Based on a range of criteria and taking account of feedback received from public consultation, the Grid West project team identified least constrained sites in north Mayo and at Flagford.

The preferred route runs from north Mayo to Flagford along 113km of local roads, see Figure 2-2. EirGrid proposes a 320kV HVDC UGC as the preferred technology. The capital cost at inception for this installed 500MVA capacity option is €426.0 million, inclusive of the converter stations. Accounting for life-cycle costs and the phasing of the capital costs between 2015 and 2019 and discounting at the annual values by the prescribed rate, the present value for this option is €476.8 million. The cost per MVA of capacity is €0.954M/MVA.

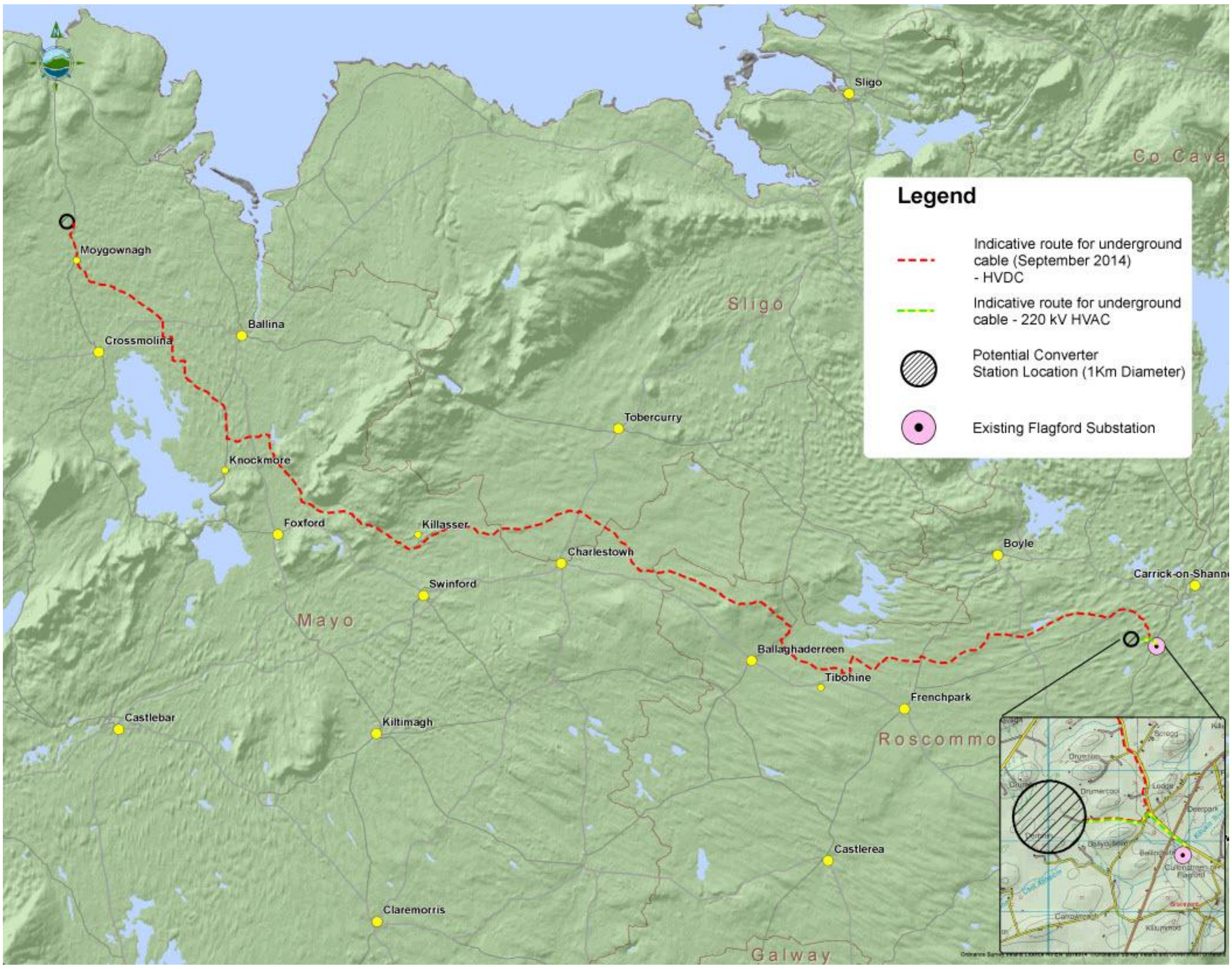

Figure 2-2 **Overview Map of the HVDC UGC option**

2.3.2 Identifying a 400kV HVAC OHL Option

The project team identified an indicative 400kV OHL running from north Mayo to Flagford, based on environmental appraisal, technical studies and stakeholder and public consultation.

The proposed route as shown in Figure 2-3 commences at a new substation 2.5km north west of Moygownagh in north Mayo and runs through the counties of Mayo and Roscommon, to the existing substation in Flagford. The approach to the Flagford substation is considerably congested with existing 110kV and 220kV overhead lines, leaving limited scope for the addition of a 400kV OHL.

An underground solution on the approach to Flagford was considered. In order to comprehensively investigate the feasibility of HVAC UGC, EirGrid commissioned engineering consulting firm, London Power Associates (LPA), to review the use of HVAC UGC and assess the extent to which it meets the project need. It can be concluded from the LPA report[14] that this is more feasible at lower voltages.

[14] Appendix 11 – LPA Report, Cable Studies for Grid West – Partial AC Underground Solution, January 2015

Hence, on the outskirts of Flagford an existing 220kV line will be undergrounded (at 220kV) for a distance of approximately 8km, largely along local roads, from its intersection with the Grid West line to the Flagford substation.

This compensatory undergrounding measure i.e. undergrounding on a different lower voltage circuit, will ensure that no new overhead lines are introduced to the Flagford area. The existing 220kV line will be upgraded to 400kV.

A standard 400kV tower has formed the basis for work on line design to date.

Analysis of the constraints identified across the Study Area formed an important part of the work in identifying an indicative line route. Initially, a 1km wide Emerging Preferred Route Corridor (EPRC) running from north Mayo to Flagford, was identified. The project team sought to identify within this 1km wide corridor an indicative OHL route, using constraints and areas of sensitivities mapped within the corridor. A key design consideration was settlements. EirGrid's policy is, where possible to locate a line at least 50m from houses. On the Grid West project, there are no houses within 50m of the current indicative line.

The project team, in consultation with landowners, worked to refine and develop the indicative line for the project, including the positioning of towers along this line. The OHL design presented in this report is the indicative OHL for the project as of September 2014, see Figure 2-3.

At the western end of the proposed project, a new substation will be developed at a site approximately 2.5km north west of Moygownagh. At the eastern end, the proposed line connects into the existing substation at Flagford. The OHL and substation locations were evaluated under environmental, technical and economic criteria.

The capital cost at inception for this installed 1,580MVA capacity option is €235.1 million. Accounting for life-cycle costs and the phasing of the capital costs between 2015 and 2019 and discounting at the annual values by the prescribed rate, the present value for this option is €222.1 million. The cost per MVA of capacity is €0.141M/MVA.

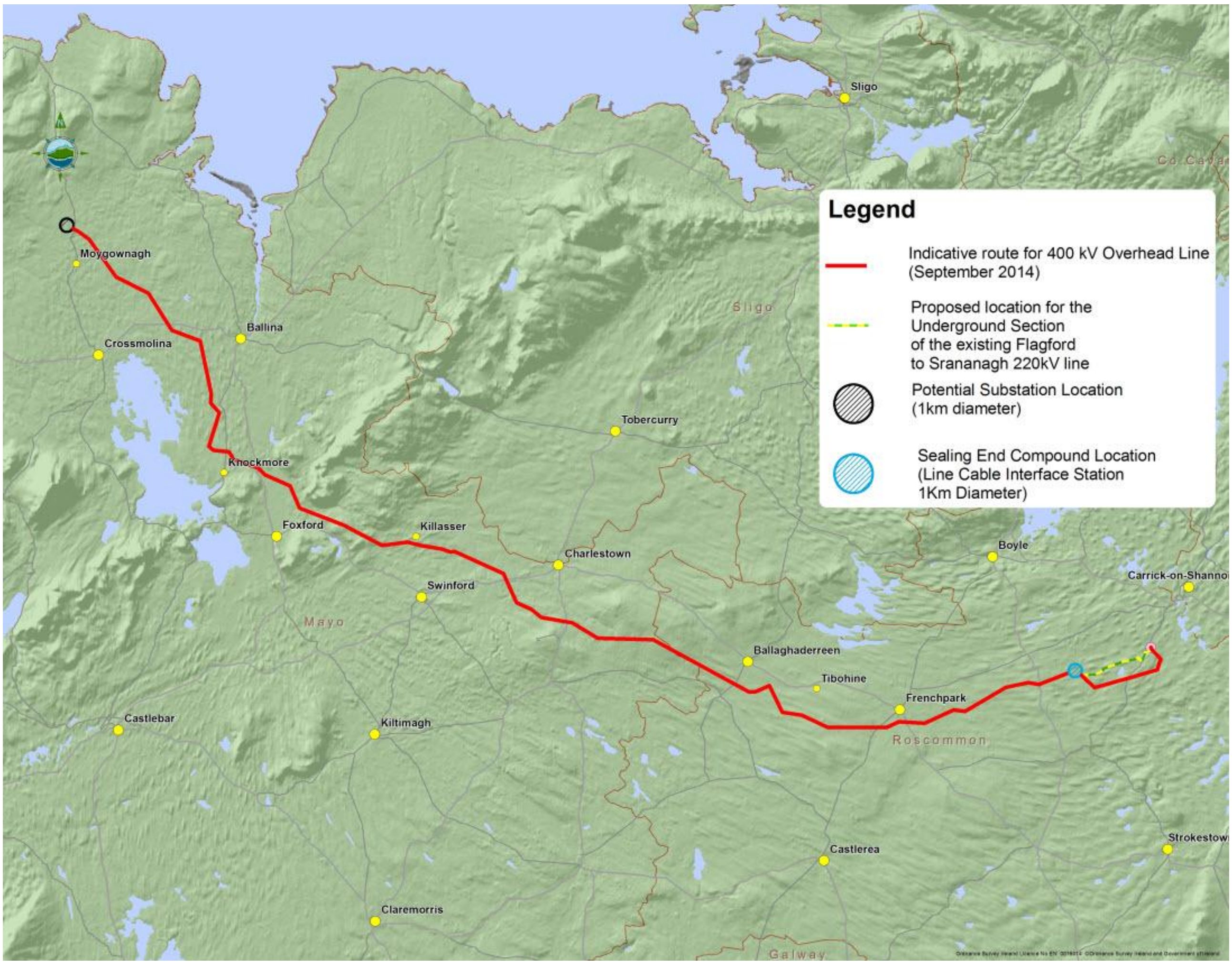

Figure 2-3 Overview Map of the 400kV HVAC OHL Option

2.3.3 Identifying a 220kV HVAC OHL and Partial Underground (PUG) Option

In order to investigate comprehensively the feasibility of HVAC UGC, EirGrid commissioned engineering consulting firm, London Power Associates (LPA), to complete a review of the maximum amount of HVAC UGC that could be utilised and assess the extent to which it meets the project need.

The LPA report examined a HVAC UGC solution at either 400kV or 220kV. It can be concluded from the report that:

- An 8km to 10km circuit of 400kV HVAC UGC in the region is not feasible;
- A partial underground option using 220kV was possible within certain technical limitations;
- 30km is the maximum total length (with mitigation) of 220kV UGC that could be used in the north west region of Ireland; and
- From a technical perspective, to install the total available UGC on a single project would significantly reduce the possibility of using UGC on future transmission projects in the region.

On the basis of these findings, EirGrid considered a 220kV HVAC OHL option and a 220kV HVAC PUG option that uses the maximum amount of HVAC UGC possible.

The project team identified an indicative 220kV OHL route. The proposed route as shown in Figure 2-4 follows the same route as the 400kV OHL option, commencing at a new substation 2.5km north west of Moygownagh in north Mayo and running through the counties of Mayo and Roscommon, to the existing substation in Flagford. To facilitate the comparative analysis as per the Terms of Reference, on the outskirts of Flagford an existing 220kV line (Flagford - Srananagh) will be undergrounded for a distance of approximately 8km, largely along local roads, from its intersection with the Grid West line to the Flagford substation.

This compensatory undergrounding measure, i.e. undergrounding on a different circuit, will ensure that no new overhead lines are introduced to the Flagford area and that the 220kV HVAC OHL and 400kV HVAC OHL options are as similar as practically possible to facilitate comparison.

A standard 220kV tower has formed the basis for work on line design to date.

Having regard to the findings of the LPA report which identified a maximum of 30km of UGC possible in the region, EirGrid evaluated a further option as follows:

- A 2km section of 220kV UGC at the approach to the north Mayo substation;
- An independent 'section' of approximately 20km in length, which may be applied mid-route or to extend either of the underground sections into the Flagford Substation or the proposed north Mayo substation. A sealing end compound would be required at each point on the circuit where the OHL transitions to the UGC and vice versa; and
- The remainder of the circuit (approx. 85km) developed as a 220kV OHL using standard single circuit 220kV transmission towers.

The environmental, technical and economic effect of the end-to-end solution will vary depending on the amount of UGC installed.

The route was divided into six sections[15] based on approximate 20km sections of the indicative OHL route option, which could potentially be undergrounded along local roads. These sections were appraised under a number of environmental and technical criteria.

[15] Appendix 15 – Environmental Appraisal of the 220kV Partial Underground Section Option

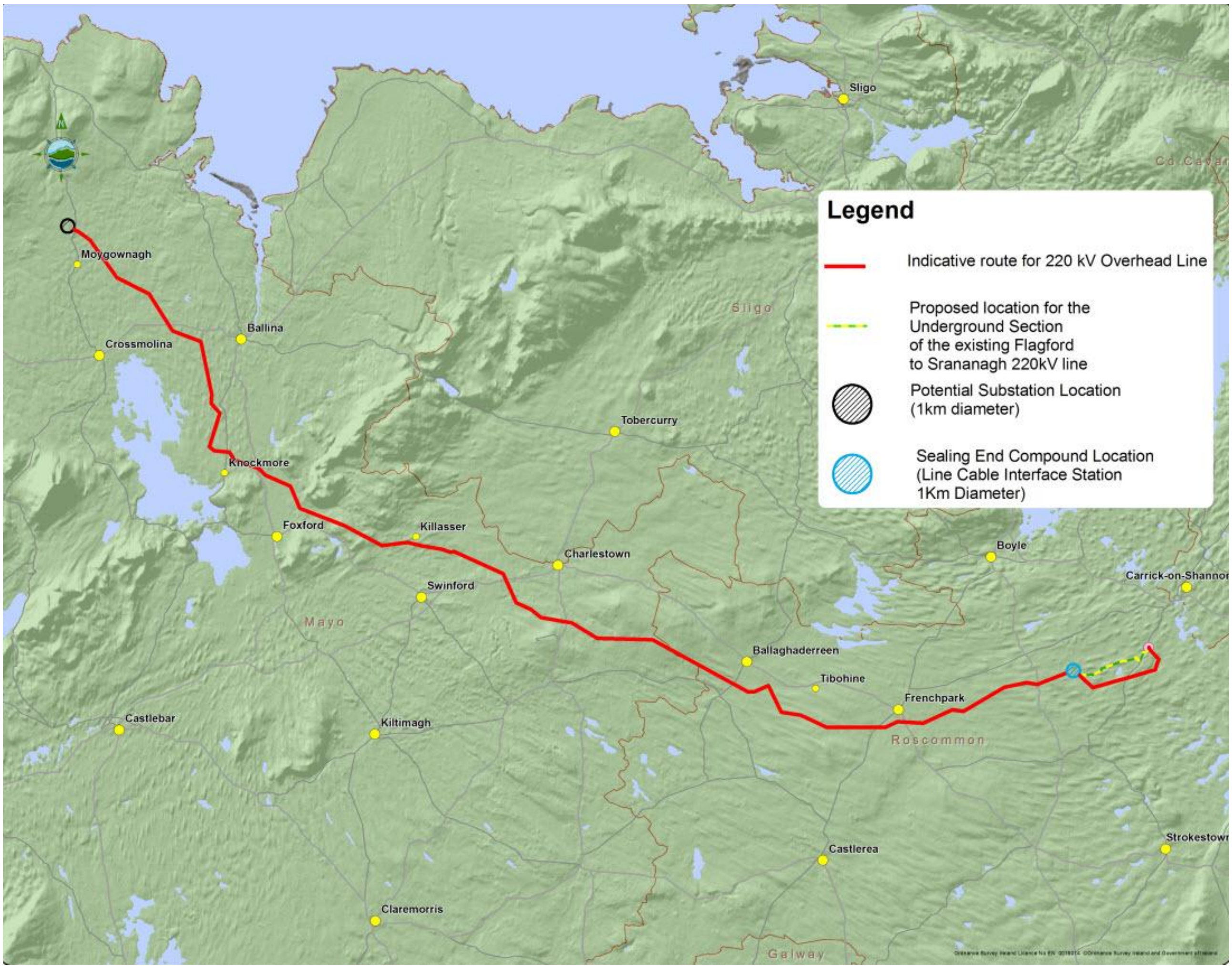

Figure 2-4 Overview Map of the 220kV HVAC OHL Option

The capital cost at inception for the 220kV HVAC OHL option is €205.0 million. Accounting for life-cycle costs and the phasing of the capital costs between 2015 and 2019 and discounting at the annual values by the prescribed rate, the present value for this option is €207.4 million.

The capital cost at inception for the 220kV HVAC PUG option is €244.5 million. Accounting for life-cycle costs and the phasing of the capital costs between 2015 and 2019 and discounting at the annual values by the prescribed rate, the present value for this option is €249.0 million.

The installed capacity of both the 220kV HVAC OHL and PUG option is 600MVA. The cost per MVA of capacity for these options is €0.346M/MVA and €0.415M/MVA respectively.

2.4 SUMMARY OF OPTIONS

At present, there is approximately 2,000MW of generation awaiting processing in Co. Mayo. The development of even part of this could drive the requirement for a second circuit from the north Mayo area back to the EHV network (most likely Cashla 220kV substation). If this was to occur, the full capacity of any of the options above could then be realised, as the second circuit would ensure no loss of generation in the case that there was a temporary loss of one of the circuits.

	HVDC UGC Option Capacity (MVA)	400kV OHL Option Capacity (MVA)	220kV OHL Option Capacity (MVA)	220kV PUG Option Capacity (MVA)
Capacity (Upgraded 110kV Network)	190	190	190	190
Capacity (Grid West Project)	500	1,580	600	600
Total Available Secure Capacity (with 2nd Circuit)	**690**	**1,770**	**790**	**790**
Bellacorick Subgroup	**-600**	**-600**	**-600**	**-600**
Surplus Secure Capacity	90	1,170	190	190
% of Future Generation (2,000MW) Accommodated by Surplus	**5%**	**59%**	**10%**	**10%**

Table 2-1 Summary of the Option Capacity (MVA) Assuming Further Infrastructure is Built.

The transfer capability of each option has to be viewed in terms of the current need, its available rating and surplus capacity available to accommodate future needs.

All the environmental, technical and economic assessments for each of the options, as per the Terms of Reference, are presented in a series of summary tables (pages 234 and 235) to facilitate an overview of all the findings in an accessible format.

2.5 NEXT STEPS

The IEP has indicated it will review the report to assess that all options were considered in a fair, objective and comparable way, in line with their Terms of Reference. Subject to the panel's approval, EirGrid will publish it for public consultation.

Feedback from this round of public consultation, in addition to on-going analysis and evaluation, will lead to the identification of a preferred solution. This option will be progressed as part of a planning application to An Bord Pleanála.

3. GRID WEST PROJECT NEED

3.1 THE NEED FOR GRID DEVELOPMENT

As the national TSO, EirGrid is statutorily obliged[16] to offer terms and enter into agreements, where appropriate and in accordance with regulatory direction, to all those using and seeking to use the electricity transmission system. EirGrid must ensure that the grid can accommodate any new generation seeking to connect. Hence, when offers by prospective energy generators and demand users are accepted, EirGrid must develop the transmission grid to ensure it is suitable for those connections.

Historically, EirGrid, in common with the majority of other European TSOs, developed its transmission network based on traditional demand and generation patterns, ensuring the infrastructure needed to move electricity from where it is generated to high demand points, is in place. It also manages system operations to ensure supply and demand is balanced at all times.

Government policy[17] means the nature of electricity generation is changing. Increased energy from renewable sources means that EirGrid, in common with other European TSOs, must develop the network in order to bring renewable energy sources onto the system. On-going innovation by EirGrid via its DS3 programme[18] places it at the forefront of managing these new forms of generation and their impact on the transmission system. Over the past number of years EirGrid has optimised existing grid assets to operate them closer to their limits without materially adversely impacting system security.

Notwithstanding this, increased transmission infrastructure is necessary if renewable generation is to be incorporated into Ireland's fuel mix and demand growth met.

For electricity generators, the Commission for Energy Regulation (CER) has determined that applications to connect to the transmission and distribution systems are processed in groups called 'gates' in accordance with the Group Processing Approach[19].

The most recent group, Gate 3[20], comprises a significant amount of wind generation that contribute to meeting the Irish Government's renewable energy targets. Under Gate 3, 647MW of renewable generation projects located in the area around the existing Bellacorick 110kV substation in north Mayo, applied to connect to the grid. The existing transmission grid in Co. Mayo is shown in Figure 3-1. These Gate 3 projects are promoted by generators collectively known as the Bellacorick Subgroup. EirGrid, in accordance with its statutory obligations, has provided the generators with connection offers.

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16 Statutory Instrument No.445 of 2000 (as amended).

17 Government White Paper, 12th March 2007

18 http://www.eirgrid.com/operations/ds3/

19 Commission for Energy Regulation, September 2004, Group Processing Approach for Renewable Generator Connection Applications, CER/04/317.

20 Commission for Energy Regulation, 16 December 2008, Criteria for Gate 3 Renewable Generator Offers & Related Matters, Direction to the System Operators, CER/08/260.

To date, of the 647MW of generation offers made to wind generators in the Bellacorick Subgroup, 400MW has been accepted and 200MW are still awaiting acceptance[21]. The remaining connection offers of 47MW have lapsed. The majority of the generation is associated with two projects; Oweninny, developed jointly by ESB and Bord na Móna, and Cluddaun, a Coillte development. The existing 110kV network, after further development to maximise its capacity, is capable of accommodating up to 190MVA of the generation seeking to connect. The remaining generation (410MVA) will be connected to the transmission system at a new substation in north Mayo. The exact split of generation may be subject to optimisation closer to the connection dates of the windfarms.

To accommodate the quantity of generation seeking to connect at the existing Bellacorick 110kV substation, EirGrid has a statutory requirement to develop the network in order to increase its capacity.

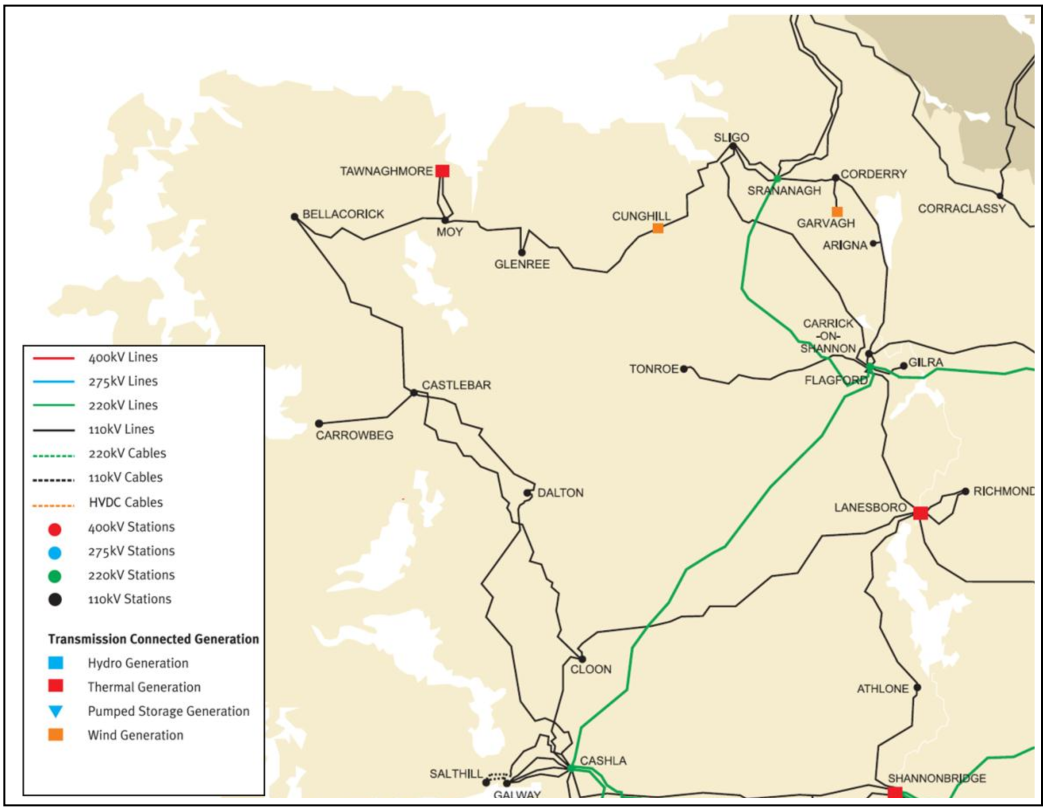

Figure 3-1 **Extract[22] from EirGrid/SONI Transmission System Map, January 2014 Showing Existing Grid Infrastructure in County Mayo (the black lines are existing 110 kV circuits)**

21 It is expected that these connection offers will be required to be accepted in 2015.

22 The entire map is available at www.eirgrid.com.

3.2 FUTURE NEEDS

In addition to meeting current needs, as a responsible TSO, EirGrid must develop the network in such a way that it facilitates future needs. Polices that EirGrid are particularly cognisant of when developing the Grid West project include:

- National & European energy policies – the Irish Government has a target that 40% of electricity consumed be from renewable sources by 2020[23].
- The Mayo County Council Renewable Energy Strategy[24] – which seeks to develop additional renewable energy projects, focussing on technologies such as biomass, ocean energy, pumped storage and further wind generation; and
- The Marine Renewables Industry Association (MRIA)[25] Report – which identified the north Mayo coastline as a priority zone for the future development of wave generation technologies.

EirGrid strategically assesses development options and considers longer term connection requirement scenarios in conjunction with the immediate need to connect contracted renewable generation in the north Mayo area to the transmission network.

In this context, in addition to the existing generation in Co. Mayo and that expected as a result of Gate 3, EirGrid has received generation connection applications from facilities in Co. Mayo beyond Gate 3 totalling approximately 2,000MW. These applications include a variety of technologies; biomass, pumped storage, conventional and further wind generation.

EirGrid is also required to strategically assess the longer term need of both existing and new demand customers. The level of demand in the north Mayo area over past number of years has risen and is expected to continue to do so as per EirGrid's latest analysis[26]. Also, given the size of the present demand, the available long-term capacity in the area is limited. The latest analysis (based on median demand growth levels) shows that the existing network is expected to facilitate demand growth in the Mayo area up until 2021.

3.3 MEETING THE NEED

As above, of the 647MW of generation offers made to wind generators in the Bellacorick Subgroup, 400MW has been accepted and 200MW are still awaiting acceptance[27]. The remaining connection offers of 47MW have lapsed. Therefore there is a need to facilitate the connection and transmission of 600MW of the Subgroup. In accordance with EirGrid's statutory obligations and directions from the CER, EirGrid is obliged to offer a connection and therefore the "do nothing" option is not feasible.

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[23] Government White Paper, 12th March 2007, *Delivering a Sustainable Energy Future for Ireland.* The original target set in this paper was 33%. This was increased to 40% in the Carbon Budget of October 2008 and confirmed in the National Renewable Energy Action Plan, July 2010.

[24] Mayo County Council, 9 May 2011, Renewable Energy Strategy for County Mayo, 2011-2020 (http://www.mayococo.ie/en/Planning/MayoCountyDevelopmentPlan2014-2020/Document3,24887,en.pdf)

[25] Marine Renewables Industry Association, 1 August 2010, Initial Development Zones to Focus on Realizing Ireland's Ocean Energy Potential - White Paper.

[26] EirGrid, All-Island Ten Year Transmission Forecast Statement, 2013 and All-Island Generation Capacity Statement 2015-2024.

[27] It is expected that these connection offers will be required to be accepted in 2015.

This generation is seeking to connect at the existing Bellacorick 110kV substation (already connected to the existing transmission network by two 110kV lines, one to the Castlebar 110kV substation and the other to the Moy 110kV substation, near Ballina (see Figure 3-1)). In addition to the Grid West project itself, the reinforcement of grid infrastructure in the north Mayo area also includes other local system reinforcements which are currently ongoing or in the planning process. Both existing circuits can currently accommodate a maximum of 105MVA each. The lines will be uprated to 190MVA to ensure that these existing corridors are optimised, thus minimising the amount of new infrastructure required.

In order to meet the levels of performance and security of supply required of the electricity transmission network, the network must be capable of operating securely with any single electrical circuit out of service. (This is applicable to the 'meshed' transmission network, and not generation 'tails'[28]). Therefore, the existing meshed 110kV network, when reinforced, has a capability of transmitting up to 190MW of electricity produced by the generators in the Bellacorick area.

To accommodate the 400MW of generation that has accepted, and given the limited capacity of the network at Bellacorick, even when reinforced to enable the secure export of up to 190MW of generation, additional transmission infrastructure is required.

Acceptances of outstanding connection offers, 200MW, by the remaining generators will further compound the need for additional transmission infrastructure. At least one high capacity circuit, in addition to the upgrading of the local 110 kV network, is therefore required to accommodate the Bellacorick Subgroup.

In order to connect the expected generation and provide the capacity to accommodate future developments, the development of a single Extra High Voltage (EHV)[29] circuit is considered the most appropriate strategic solution for this area. Such infrastructure will minimise the likely adverse environmental impact that could inevitably be expected to arise from the development of a multiplicity of lower-capacity circuits in the area, in addition to their associated cost.

A further consideration is the limit imposed on the amount of generation that can be lost following the failure of any item of plant and equipment, referred to as the Largest Single Infeed (LSI)[30]. The limit, currently 500MVA, ensures continued safe operation of the power system without interrupting customers.

The new single EHV circuit will therefore provide a connection for up to 500MW of generation in the area.

[28] Generation tails or radial feeds refers to single point to point connection which is susceptible to a single point of failure.

[29] For the purposes of this report a HVAC circuit at or in excess of 220kV, and for a HVDC at or in excess of 200kV, is classed as EHV.

[30] For an explanation of Largest Single Infeed, see http://www.eirgrid.com/media/Largest%20Single%20Infeed%20-%201pg%20Summary.pdf

As the generation will be ‘tailed’ to the end of the Grid West circuit, and is less than the existing LSI limit of 500MVA, one single circuit is sufficient for the level of Gate 3 generation proposed.

3.4 SUMMARY OF NEED

In accordance with the prevailing regulatory process for the connection of new generation, known as Gate 3, 600MW of renewable generation have current connection offers, 400MW of which have accepted and are awaiting connection to the transmission system in north Mayo.

The existing 110kV network, after further development to maximise its capacity, is capable of accommodating up to 190MW of the generation seeking to connect. The remaining generation (410MW) will be connected to the transmission system at a new substation in north Mayo. The exact split of generation may be subject to optimisation closer to the connection dates of the windfarms.

As outlined above, it is prudent that the connection capacity of the solution progressed is capable of supporting growth in electricity demand in the area, such as a new large industrial customer.

4. TECHNOLOGY OPTIONS FOR THE GRID WEST PROJECT

4.1 FACTORS AFFECTING APPROPRIATE TECHNOLOGY SELECTION

Electrical networks and decisions regarding the appropriate technologies to employ vary around the world and are dependent on a number of factors. The most notable factor is geography, i.e. the size of the country, and natural features such as mountains, swamps and bogs, deserts, snow and ice and water bodies. Further considerations include the dispersion of population, population density and the location of natural resources, such as water resources for hydropower, coal and gas fields for thermal generation, and increasingly wind, wave, tidal and solar resources for renewables generation.

The strategic importance of the electricity transmission system to any country is such that the TSOs have to utilise technology that is capable of ensuring the required levels of security and reliability are met.

No single technology, or mix of technologies, is appropriate for all transmission infrastructure projects. The most appropriate technology for a project is determined on its own merits, having regard to the nature, extent and location of a given project.

In considering a new transmission circuit, the technology considerations are as follows:

- The appropriate use of Alternating Current (AC) or Direct Current (DC) technology;
- The transmission voltage for the circuit, which considers the amount of capacity that is required to be added and the characteristics of the transmission network to which it is connected; and
- The appropriate use of OHL or UGC technology.

4.2 NATIONAL, EUROPEAN AND INTERNATIONAL PRACTICE

4.2.1 Transmission Network Development

EirGrid's statutory responsibility as TSO is to develop a safe, secure, reliable and economical transmission network in Ireland, with due regard for the environment. This responsibility is reflected in the national policies and standards that direct the design and development of transmission infrastructure, which are consistent with European and international practice. They set out how the network and any development need is assessed and include:

- The Transmission Planning Criteria (TPC);
- The Operational Security Standards (OSS); and
- The Grid Code.

The TPC sets out the range and criteria that the network should be assessed and tested to. Forecasted future changes to the demand or generation are tested against the TPC which regularly initiates a needs assessment for reinforcements to the network. The TPC also assists in determining what type of reinforcements is appropriate.

The OSS sets out a range of standards that the network must comply with to be operational and would also determine whether a reinforcement option was appropriate.

Finally, the Grid Code sets out the requirements that users of the transmission system must comply with for continued connection and operation of the transmission network. These include design criteria for the network and its users that must be respected when developing reinforcements.

All three documents are interrelated and therefore aligned for consistency.

The principles in both the TPC and Grid Code are consistent with the network codes developed by the European Network of Transmission System Operators for Electricity (ENTSO-E). Network codes[31] are a set of rules drafted by ENTSO-E, with guidance from the Agency for the Cooperation of Energy Regulators (ACER), to facilitate the harmonisation, integration and efficiency of the European electricity market. Each network code is an integral part of the drive towards completion of the internal energy market and achieving the European Union's energy objectives[32]. These objectives are intended to satisfy the interests of electricity consumers in terms of the cost of electricity and the reliability of supply.

In addition, the ENTSO-E Ten Year Network Development Plan[33] has recommended the standardisation of transmission planning standards.

4.2.2 Technologies in Use

Although different in size the network covered by ENTSO-E (including Great Britain and continental Europe) is the most relevant for comparison purposes, considering the topography, geography and mix of electricity transmission technologies in use.

	Length of HVAC Circuits (km)	Of Which HVAC Cable	Sum of HVDC Cable
220 – 285 kV	141,359	3,230	---
330 kV	9,141	14	---
380 / 400 kV	151,272	1,512	---
750 kV	471	0	---
Sum	**302,243**	**4,756**	**5,260**

[Source: ENTSO-E, Statistical Factsheet 2013, Provisional Values as of 25 April 2014]

Table 4-1 Summary of European Circuit Length by Technology and Circuit Type

31 https://www.entsoe.eu/major-projects/network-code-development/Pages/default.aspx
32 http://ec.europa.eu/clima/policies/package/index_en.htm
33 https://www.entsoe.eu/major-projects/ten-year-network-development-plan/Pages/default.aspx - TYNDP, 2012

The above table summarises the lengths of electricity transmission circuits by technology (i.e. HVAC and HVDC) and circuit type (i.e. OHL and UGC). The figures are taken from the most recent statistics provided by ENTSO-E.

From the above, it can be seen that:

- The total length of transmission circuit, regardless of technology, amounts to approximately 312,000km;
- Approximately 98% of circuits (by circuit length) utilise HVAC OHL technology; and
- Approximately 2% of circuits (by circuit length) are UGC, with approximately an even use of HVAC and HVDC.

Regarding the use of HVAC UGC in Europe, which amounts to a total of 3,230km at 220-285kV and a total of 1,512km at 380-400kV, the longest length of any single land cable circuit is 20km[34] (for 380-400kV) and 64km[35] (for 220-285kV).

4.2.3 Electric and Magnetic Fields (EMF)

The transmission system is designed and operated in accordance with the international guidelines on EMF provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP[36]). EirGrid's position on EMF and health is based on the authoritative conclusions and recommendations of established health and scientific agencies which have reviewed the body of scientific research. These agencies have consistently concluded that the research does not indicate that EMF causes adverse health effects at the levels encountered in our everyday environment and that compliance with the existing ICNIRP standards provides sufficient public health protection. The guidelines are reviewed by the World Health Organisation and endorsed by the EU and the Irish Government.

4.3 GRID WEST TECHNOLOGY OPTIONS

4.3.1 Technology Studies Undertaken for the Grid West Project

In January 2014 EirGrid announced a number of initiatives to address concerns raised by the public and stakeholders during consultation on its major projects, including a comprehensive underground analysis for the Grid West project.

Power System Consultants (PSC) and London Power Associated (LPA), two internationally recognised specialist engineering consultancy companies, were engaged to conduct detailed investigations specific to the use of HVDC and HVAC UGC technology:

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[34] A 20km, 400 kV, 3 phase underground power cable to link Elstree substation in north London with new indoor high voltage substation in St John's Wood, close to central London. Refer to the joint paper 'Feasibility and Technical Aspects of Partial Undergrounding of Extra High Voltage Power Transmission Lines (December 2010) that was submitted to the European Commission in December 2010 by Europacable and ENTSO-E.

[35] A 64km, 225kV, 3 phase underground power cable link between Boutre and Trans in the south of France.

[36] Further information regarding the ICNIRP and EMF is available at: http://www.icnirp.org/

1. The PSC report[37] assessed the viability of a fully undergrounded solution utilising HVDC and the key issues and characteristics associated with the technology; and
2. LPA investigated the use of HVAC UGC and the techniques for mitigating issues arising from their installation on the Irish Transmission System. The LPA report[38], confirmed that the use of 220kV HVAC UGC in excess of 30km or the use of any 400kV HVAC UGC is unlikely to be feasible.

4.3.2 Technology Selection for the Grid West Project

To address the need for the network reinforcement described in chapter 3 of this report, and to avoid the need for multiple lower voltage circuits, a single high capacity circuit is considered by EirGrid as the most appropriate and sustainable solution for the Grid West project.

The technical studies confirmed that a fully underground solution is not feasible using HVAC, but is feasible using HVDC. Consequently, HVDC is the proposed underground technology.

For the OHL solution, both the 400kV and 220kV HVAC OHL solutions are feasible and meet the immediate need of the project with different properties and varying levels of flexibility. The 220kV OHL option is proposed to allow the use of partial undergrounding along the route, within the technical limitations that this entails.

The installed capacity of each of the options is:

- The HVDC UGC option is rated for 500MVA[39];
- The 400kV HVAC OHL option is rated for 1,580MVA; and
- The 220kV HVAC OHL option is rated for 600MVA.

As described in Section 3.3 above the Largest Single Infeed (LSI) currently in Ireland is 500MVA. That means the largest single loss of load or generation that the Irish grid can withstand without placing security of supply at risk is currently 500MVA. The transfer capability of each option therefore, given the specific configuration of the Grid West project, is currently no more than 500MVA. As the Irish system grows and develops, the LSI may increase, thus enabling flows exceeding 500MVA on the Grid West circuit.

As described in Section 3.2 above there is 2,000MW of generation awaiting processing in Co. Mayo. The development of even part of this could drive the requirement for a second circuit from the north Mayo area back to the EHV network (most likely at the existing Cashla 220kV substation in Co. Galway). If this was to occur then the full capacity of any of the options above could then be realised as the second circuit would ensure no loss of generation in the case that there was a temporary loss of one of the circuits. Whilst all options meet the immediate need of the project, for the HVDC UGC option,

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37 Appendix 5 - PSC, Grid West Project HVDC Technology Review, Reference JA4846, 17 December 2014

38‘ Appendix 9 - LPA, Investigation into Mitigation Techniques for 400/220kV Cable Issues, 17 December 2014

39 The rating of HVDC circuits is generally quoted in MW, however for ease of comparison we have assumed unity power factor and displayed the rating in MVA, to enable a better comparison with the HVAC options.

due to the inflexibility in modification of HVDC equipment, to deliver a higher capacity solution such as equivalent to the 400kV HVAC OHL option would add very significantly to the works and cost.

4.3.3 UGC Technology Option for Grid West

The optimum underground technology for the Grid West project is a Voltage Source Converter (VSC) HVDC symmetrical monopole operated at 320kV. The installed capacity of the converter stations is 500MVA.

As this option requires the conversion of HVAC to HVDC, and vice versa, the appropriate substation designs to integrate into the proposed and existing meshed HVAC network at either end will vary also. The UGC technology and construction methods are described in detail in Appendix 7 of this report.

To increase the capacity of the HVDC system it would be necessary to supplement the identified solution with either another symmetrical monopole or bipole arrangement.

While integrating HVDC into a meshed HVAC system is not the typical application for the technology, having regard to its nature, extent and location, a fully undergrounded HVDC solution of 113km is a viable option for the Grid West project.

The UGC Report[40] identified and assessed thirty one potential UGC routes for the Grid West project based on a range of set criteria. It concluded that an UGC should be constructed along the public road network where possible rather than cross country.

4.3.3.1 Indicative UGC Station Design

The HVDC option will use Generation 4 multi-level VSC technology. This technology will require converter stations much the same size as that of an existing one at Woodland, Co. Meath, see Figure 4-1. The area of the compound for each of the Grid West converter stations (at either end of the UGC route) will be approximately 2.16 hectares (180m x 120m), or 5.34 acres.

The converter station buildings will house the power electronics for the HVDC to HVAC conversion; associated equipment will also be required. These converter stations will include a single 500MVA transformer.

[40] Appendix 8 - Underground Route Options Preliminary Evaluation Report, July 2014

Figure 4-1 Existing VSC Converter Station for the East West Interconnector at Woodland, County Meath

4.3.3.1.1 <u>North Mayo Substation</u>

In addition to the converter station, a new 110kV indoor station using gas insulated switchgear (GIS) will be required. These will be co-located within a single compound in north Mayo.

This substation will contain a 110kV busbar and associated equipment to provide connections for the local windfarms. Having regard to the ultimate extent of grid infrastructure development in the north Mayo area, consideration is given in the design of this 110kV building to accommodating potential future growth.

Figure 4-2 Typical GIS Substation

To address the concerns of local residents regarding the number of possible 110kV circuits associated with windfarm connections approaching the substation in north Mayo, EirGrid will underground all approaching 110kV circuits within a radius of 2km of the new substation. This will result in no 110kV OHL approaching the new substation.

It should be noted that the 110kV switchgear is largely identical and therefore an appropriately sized substation will be required for all Grid West options.

4.3.3.1.2 Flagford Substation

The preliminary finding is to locate the required converter station at Flagford approximately 2km from the existing substation. The converter station will be connected to the existing substation via 220kV HVAC UGC installed in local roads.

In the existing Flagford station, a new 220kV line bay onto the existing 220kV busbar, with the associated switchgear, gantry and terminating equipment, will be required.

4.3.4 OHL Technology Options for Grid West

Two OHL options are proposed:

- A single 400kV OHL solution, with a minimum rating of 1,580MVA[41] (i.e. summer rating for when the ambient temperature is the highest); and
- A single 220kV OHL solution, with a minimum rating of 600MVA[42] (i.e. summer rating for when the ambient temperature is the highest).

The proposed HVAC OHL options have a maximum transfer capability of 500MVA. For this reason the design of the Grid West project provides for 500MVA transformer capacity at each end. This should not be viewed as a limiting factor since it is relatively straightforward to add further transformer capacity at relatively low cost.

4.3.4.1 Indicative Line Design

Potential tower types for Grid West are still under consideration[43]; but for the purposes of this report, standard 220kV (Figure 4-3) and 4000kV (Figure 4-4) towers are used. The OHL technology and construction methods are described in Appendix 6. There will be further consultation with the public on the preferred tower type when the project design is confirmed, should the project proceed as an OHL solution.

[41] Maximum continuous ratings.
[42] Maximum continuous ratings.
[43] For tower design information visit EirGrid's website: www.eirgridprojects.com/projects/gridwest/towerdesign

Figure 4-3 Photomontage of 220kV Single-Circuit Lattice Steel Tower Structures

Figure 4-4 Photomontage of 400kV Single-Circuit Lattice Steel Tower Structures

4.3.4.2 Indicative Substation Design

4.3.4.2.1 North Mayo Substation

The proposed new north Mayo substation will contain a 110kV busbar and associated equipment required to support the local network and provide the connections for the local windfarms. This will be a GIS substation identical to that required for the HVDC options as described in Section 4.3.3.1.1 above.

Transformation from the EHV circuit voltage (i.e. either 400kV or 220kV) to 110kV is required, with the equipment specification dependant on the technology. The 400kV OHL option will require a single transformer, whilst the 220kV OHL option will require two transformers. In each instance the development of the EHV high voltage switchgear would be limited to providing a circuit breaker bay for the associated transformers.

The proposal to underground 2km of the 220kV OHL option into the north Mayo substation will require additional outdoor AIS (Air Insulated Switchgear) equipment in the form of filters and reactors in the substation compound to accommodate the cable.

4.3.4.2.2 Existing Flagford Substation

This option requires new equipment in the existing substation. The scale of the extension depends on the option selected.

The 400kV OHL option will involve the installation of new 400kV and 220kV AIS switchgear. This will consist of a 400kV AIS switch bay; a single 500MVA 400kV/220kV transformer; and a 80MVAr 400kV reactor. The 220kV side of the transformer will connect via short lengths of 220kV UGC into a new 220kV line bay on the existing 220kV busbar.

The 220kV OHL option will involve the installation of a new 220kV line bay onto the existing 220kV busbar with the associated switchgear, gantry and terminating equipment. The proposal to underground approximately 8km of the 220kV OHL option into Flagford will require additional outdoor AIS equipment i.e. filters and reactors in the substation compound to accommodate the cable.

4.3.4.2.3 Cable Sealing End Station

A sealing end compound is required where a mid-section partial UGC is employed. These will be placed at each point on the circuit where an OHL transitions to an UGC and vice versa. Therefore, two such sealing end compounds are needed for each extent of partial UGC along an OHL. Currently there is no mid-section 220kV cable in Ireland and therefore, as part of this option, the appropriate standardisation of such a compound will be developed.

The sealing end compounds will need to include the following 220kV equipment:

- Protection-related equipment (i.e. current and voltage transformers);
- Surge arrestors on the OHL side;
- Cable sealing ends on UGC side;
- Lattice steel landing gantry; and

- A control room to incorporate protection and control equipment, communications equipment and auxiliary power supplies.

The above requirements were developed into an indicative layout as illustrated in Figure 4-5. In effect, the compound has the form of a small substation, with associated external equipment and apparatus. A compound site area is approximately 20m x 25m.

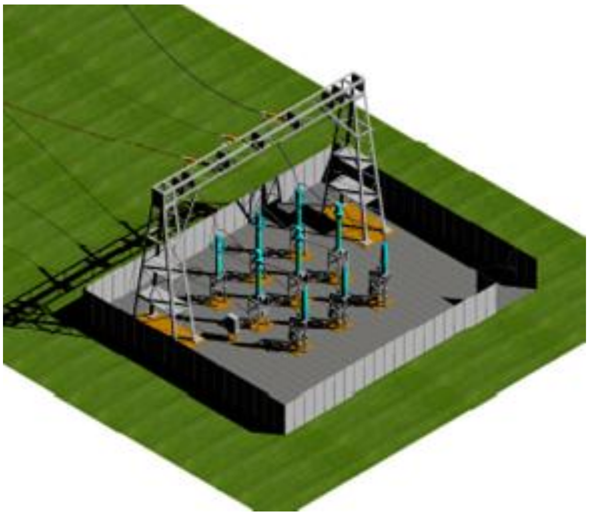

Figure 4-5 Indicative Cable Sealing End Compound

4.4 CONCLUSION

As evidenced by the chapter above, no single technology, or mix of technologies, is appropriate for all transmission infrastructure projects. In the case of Grid West, the project team has considered the following technology considerations:

- The appropriate use of Alternating Current (AC) or Direct Current (DC) technology;
- The transmission voltage for the circuit, which considers the amount of capacity that is required to be added and the characteristics of the transmission network to which it is connected; and
- The appropriate use of OHL or UGC technology.

In addition, the chapter examined some of the specific technologies that could be applied to each of the route options.

The chapters that follow assess each of these technologies against detailed environmental, technical and economic criteria.

5. HVDC UNDERGROUND CABLE OPTION

5.1 DESCRIPTION OF OPTION

To achieve a fully underground solution from north Mayo to Flagford over a distance of approximately 113km, HVDC technology is required. As stated in the preceding chapter, the optimum solution is to utilise VSC HVDC technology configured as a symmetrical monopole, operated at 320kV and rated to a capacity of 500MVA.

The HVDC UGC option for the Grid West project comprises a number of components which can be summarised as:

- **A new 110kV GIS substation**: in the Moygownagh area in north Mayo, including a 500MVA HVDC/110kV transformer and 110kV switchgear to connect the wind generation in the area, and switchgear to connect to the existing 110kV network;
- **A 500MVA HVDC symmetrical monopole converter station in north Mayo:** using VSC technology and including associated equipment to connect to the new 110kV substation;
- **c.113km of 320kV XLPE HVDC UGC:** between the two new converter stations in north Mayo and Roscommon;
- **A 500MVA HVDC symmetrical monopole converter station in Roscommon:** using VSC technology with associated equipment including the HVDC 500MVA 220kV transformer to connect to the existing Flagford 220/110kV substation;
- **c.2km of 220kV XLPE HVAC cable:** between the new converter station and the existing Flagford 220kV substation; and
- **Modification to the 220kV Flagford substation:** a new 220kV bay to connect the cable to the new converter station c.2km away.

An illustration of the emerging preferred technical solution for this project is shown in Figure 5-1.

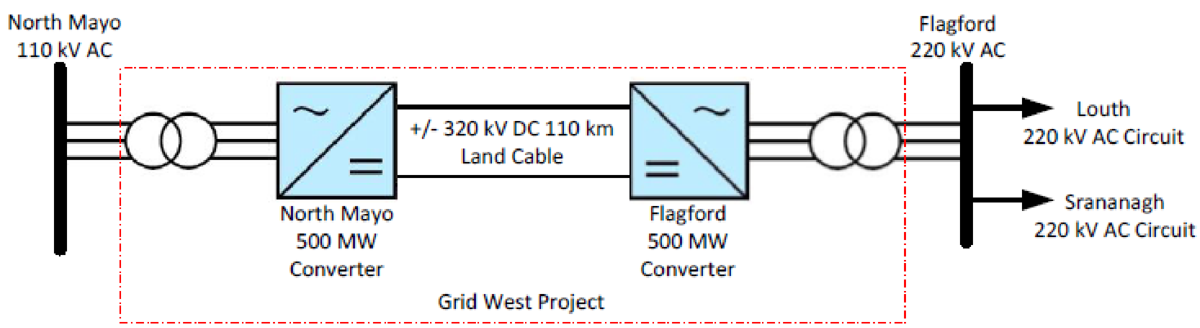

Figure 5-1 Emerging Preferred Technical Solution

5.2 HVDC UGC – INDICATIVE ROUTE

The UGC Report[44] identified and assessed thirty-one potential UGC routes for the Grid West project based on a range of criteria.

The routes are as shown in Figure 5-2 below:

- Ten routes from north Mayo to Flagford;
- Seventeen routes from north Mayo to Cashla; and
- Four partially submarine routes, two from north Mayo to Flagford and two to Cashla.

The emerging preferred UGC route, identified in the report, runs from north Mayo to Flagford and is shown in red in Figure 5-2.

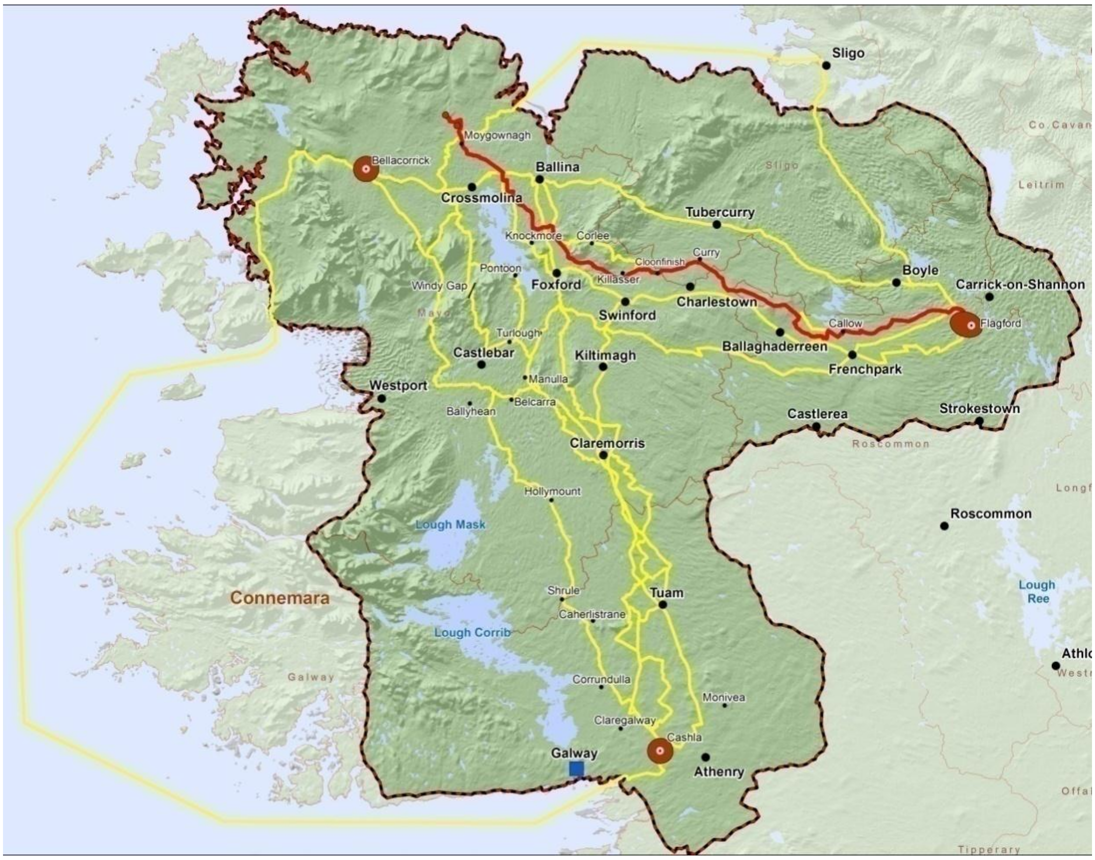

Figure 5-2 **Routes for HVDC Cable considered for Grid West Project.**

5.3 ASSESSMENTS UNDERTAKEN TO DATE

Prior to identifying a preferred UGC route for the HVDC option, a series of meetings and workshops were held with the relevant local authorities and the National Roads Authority (NRA). These are the

[44] Appendix 8 - Underground Route Options Preliminary Evaluation Report, July 2014

statutory bodies responsible for the national, regional and local road networks and for matters of planning and sustainable development. During these workshops the assessment criteria for the routes were considered and possible cable routes/options were considered. The criteria are as follows:

- Length of route (km);
- Existing infrastructure (number of crossings of bridges, railways, existing services etc.);
- Roads upgrade programme;
- Traffic diversions during construction;
- Social impact;
- Cultural heritage sites; and
- Natura 2000 sites (SPA/SAC).

5.4 IDENTIFICATION OF PREFERRED UGC ROUTE OPTION

Assessed against the criteria listed above, the preferred UGC route is shown in Figure 5-3, along with potential locations for converter stations in north Mayo and Roscommon.

Figure 5-3 Preferred Grid West UGC Route – July 2014

The route was presented to the public at a series of open days in July 2014. Minor adjustments to the route were considered based on feedback received. Detailed maps of the emerging preferred UGC route option are shown on Drawing Nos. 6424-1600 to 6424-1631[45].

In the event that the UGC option is selected for the Grid West project, EirGrid will continue to seek feedback on the preferred route, including its specific siting and design, and will make changes where feasible and appropriate.

[45] Volume 3 of this IEP report

5.5 HVDC CONVERTER STATION LOCATIONS

The UGC Report[46] identified and assessed potential converter station locations for the Grid West project. Additional site selection studies identified two sites in north west Mayo shown as DCB1 and DCB2 on Figure 5-4. For the purposes of this report and to facilitate the assessment of the option, DCB2 has been selected as the preferred north Mayo converter station location.

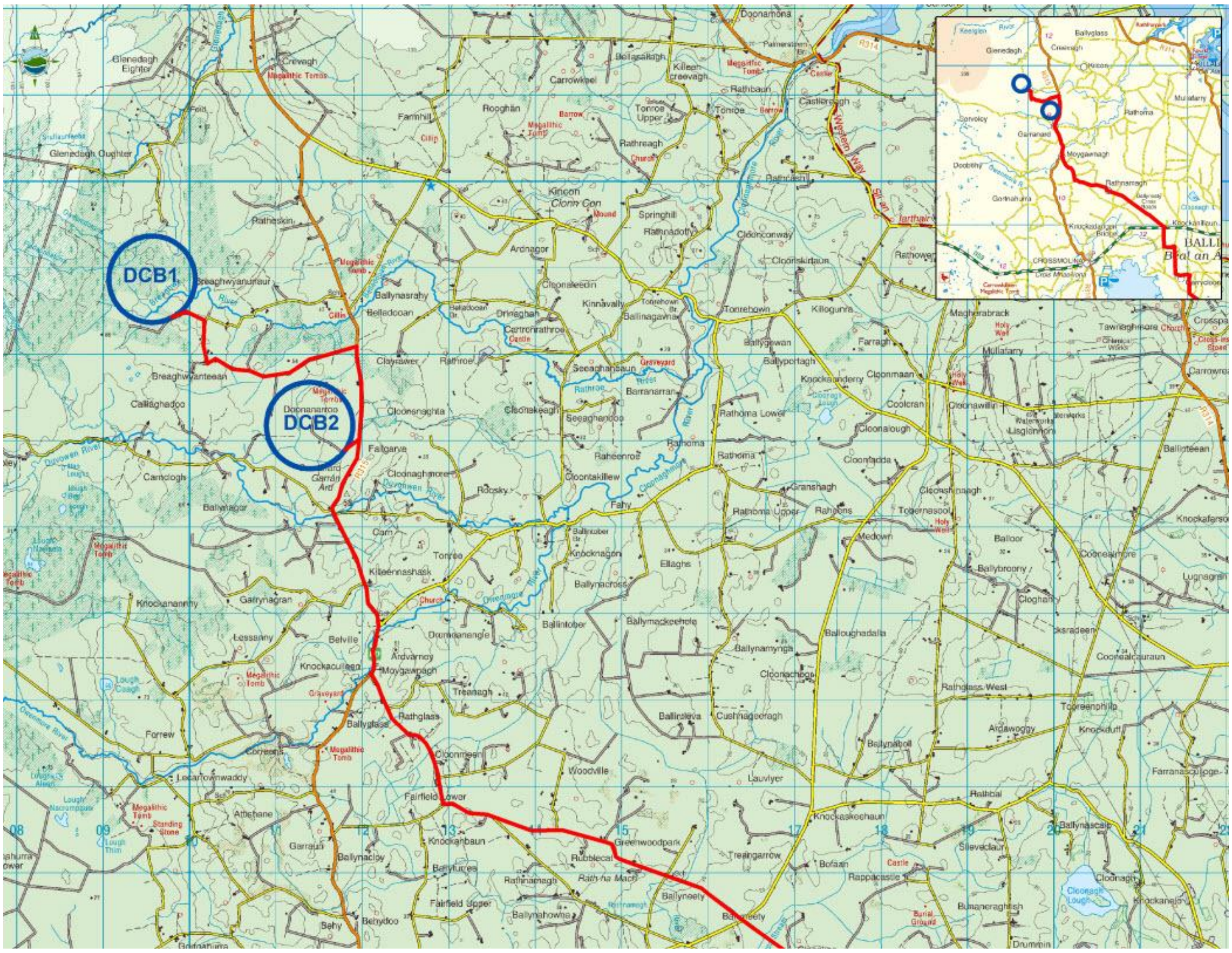

Figure 5-4 North West Mayo HVDC Converter Station Locations

A total of eight converter station locations in the Flagford area, designated DCF1 to DCF8 in Figure 5-5, were considered and to facilitate the assessment of the option, DCF7[47] is selected as the preferred location.

46 Appendix 8 – Underground Route Options Preliminary Evaluation Report, July 2014

47 Appendix 12 - Environmental Appraisal of the Converter Site Selection at Flagford

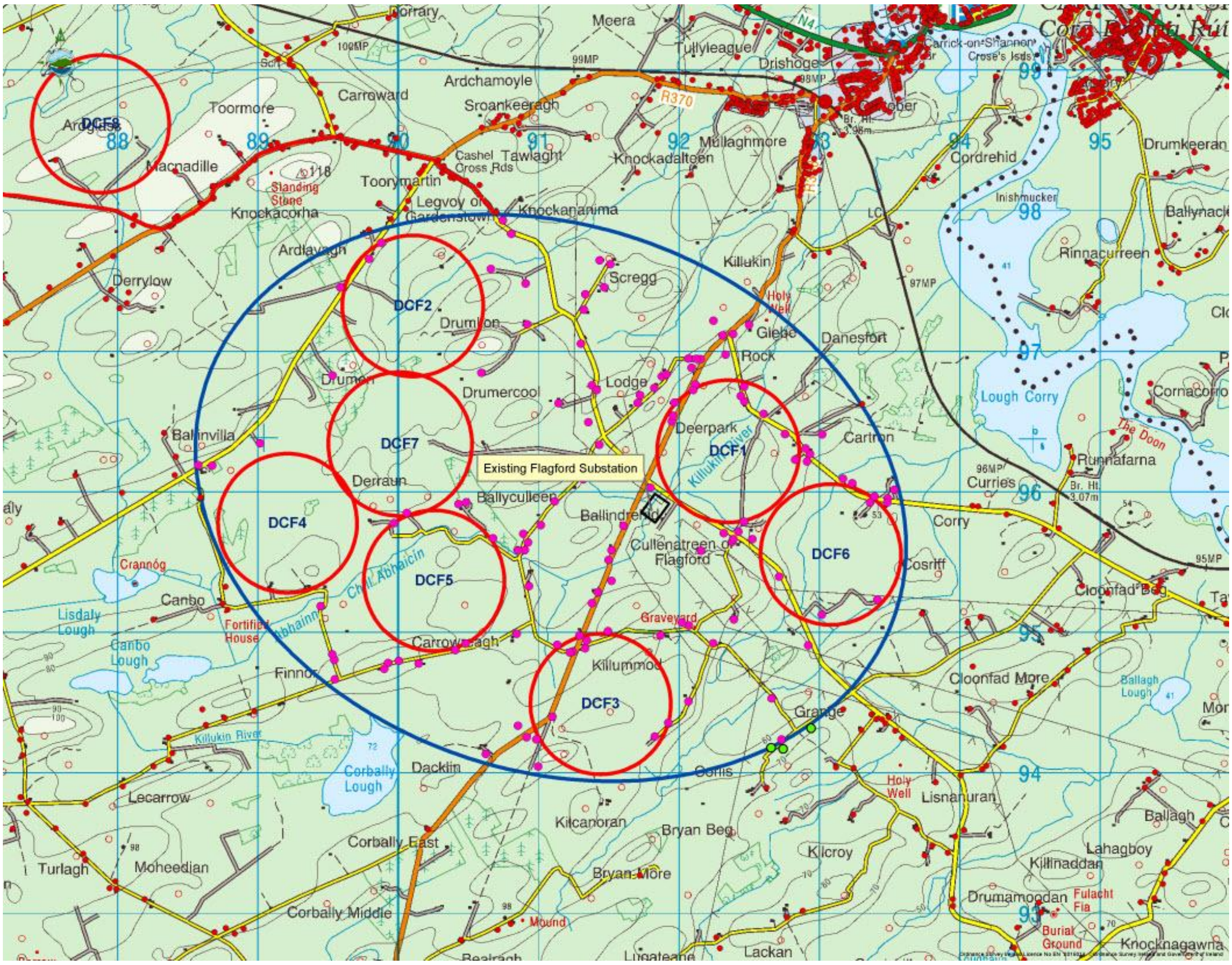

Figure 5-5 **Revised Roscommon HVDC Converter Station Locations – Post July 2014 Consultation**

Should the UGC option be selected for the Grid West project, EirGrid will continue to consult with the public and other stakeholders regarding the best route and converter station locations, and their specific siting and design. Where necessary, further adjustments may be made. However, for the purposes of this report, the cable route that is assessed is the one running from converter station location DCB2 in north Mayo to DCF7 in Roscommon. A 220kV UGC will link DCF7 to the existing Flagford substation. An overview map of this route is shown in Figure 5-6.

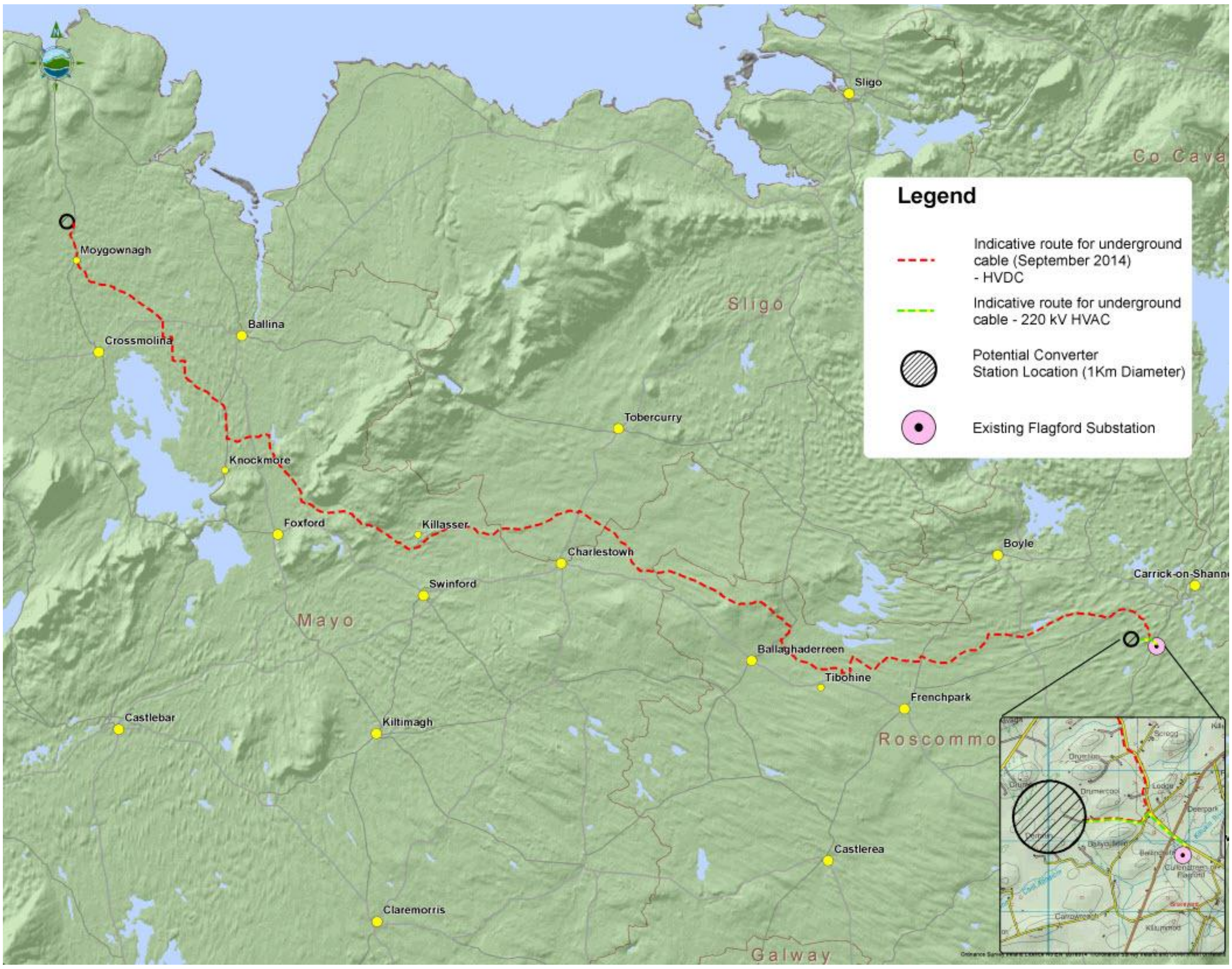

Figure 5-6 **Overview Map of the HVDC UGC Option**

5.6 ENVIRONMENTAL ANALYSIS

5.6.1 Introduction

Following a review of environmental studies to date, an environmental appraisal of the HVDC UGC option was carried out based on the IEP Terms of Reference. The Terms of Reference include a range of environmental criteria to be addressed with respect to potential impacts from the proposed UGC option. Where possible and relevant at this stage in the project, potential effects have also been identified including the duration and type of effect (positive/negative, direct/indirect, temporary/permanent etc.).

In Section 5.6.15, a summary of the findings of the environmental appraisal has been completed for each criteria/parameter as follows:

- Biodiversity, Flora and Fauna;
- Water;
- Soils and Geology;
- Landscape/Visual;
- Cultural Heritage;
- Settlement/Communities;
- Air Quality;
- Climatic Factors;
- Material Assets;
- Recreation and Tourism; and
- Traffic and Noise.

The process of selecting the identified UGC route is set out in the UGC Report[48]. This route selection is based on minimising the overall impact, taking a balanced view of all constraints.

The UGC option will include a converter station in north Mayo and a converter station near Flagford, Co. Roscommon. The environmental assessment of the UGC route and the converter station sites/zones was completed as part of the UGC Report and a further appraisal[49] based on public feedback and consultation as well as additional specialist studies.

The impact and effect of each parameter is classified in terms of significance and ranges from “more significant” to “less significant” depending on the level of significance of each parameter along the route of the UGC. Ease of mitigation of the identified impacts and effects for each parameter is classified as a range from “difficult to mitigate” to “possible to mitigate”. The possibility for residual effect, following implementation of the mitigation measures, is presented as a range from “more likely” to “less likely”. The range of impact and effect significance, ease of mitigation and the likelihood of residual effect (following mitigation) is presented as follows:

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[48] Appendix 8 Underground Route Options Preliminary Evaluation Report
[49] Appendix 12 Environmental Appraisal of the Converter Site Selection at Flagford

More significant
Difficult to Mitigate/
More Likely

Less significant/
Possible to Mitigate/
Less Likely

As the project progresses and a preferred option is selected, the specific design and routing/location of this option will form the basis for preparation of an Environmental Impact Statement (EIS) for submission to An Bord Pleanála as part of an overall planning application. As part of this process, additional detailed studies will be undertaken, including those needed to inform an Environmental Impact Assessment (EIA) and an Appropriate Assessment (AA) as required under the Habitats Directive.

In this context, it is reiterated that the environmental appraisal undertaken for the purpose of this IEP report should not be considered as equivalent to the significantly more detailed environmental assessment that will be undertaken for the purposes of preparing a project-specific EIS.

At this stage it is only possible to provide a high level assessment of possible mitigation measures for the UGC, based on desktop studies and fieldwork completed to date. Potential mitigation measures are set out below for each of the impacts considered.

The mitigation measures that can be identified at this stage of the project are generally related to standard best practice for infrastructure projects and are not unusual. As such, the costs associated with the mitigation measures described are included in the construction costs estimates for the UGC option. Once a circuit is in operation, fault repair activities may be required, which will necessitate access to the circuits. For underground cable options, in the event of a fault, sections of cable may need to be repaired, which may require isolated road closures or traffic management schemes for a period of weeks. It is not expected that the costs of mitigating the environmental impacts of such repairs will have a significant bearing on the overall cost of this option.

Regardless of which option emerges as the preferred solution for Grid West, a Construction Management Plan (CMP) will be prepared. The CMP will be a live document that will be continuously reviewed, improved and updated throughout construction as a result of project monitoring. Revisions will also include any changes and improvements made during the works from an environmental perspective.

The principal controls for environmental management will be identified and controlled primarily through the CMP and method statements for the construction phase of the project.

The aims of the CMP are to:

- Provide a mechanism for ensuring that measures to mitigate potentially adverse environmental impacts identified in the environmental assessments are implemented;
- Ensure that good construction practices are adopted throughout the construction of the proposed development;
- Provide a framework for mitigating unexpected impacts during construction;
- Provide assurance to third parties that their requirements with respect to environmental performance will be met;
- Provide a mechanism for ensuring compliance with environmental legislation and statutory consents; and
- Provide a framework for compliance auditing and inspection to enable EirGrid and its contractors to meet all environmental performance objectives.

The appointed contractor will develop project-specific environmental management procedures and method statements, detailing how they will prevent or mitigate the environmental impacts identified, taking into account aftercare requirements and information from subsequent investigations and surveys.

The contractor will agree the CMP in consultation with EirGrid's project management team and relevant local authorities and statutory bodies.

The CMP will include the following:

- A clear management structure with allocated responsibilities for environmental performance;
- Identification, assessment and management of significant environmental impacts;
- Compliance with legal and other requirements applicable to activities impacting on the environment;
- Environmental policies, objectives and targets to meet legal requirements;
- Environmental improvement programmes to implement policy objectives and targets;
- Operational controls to prevent and minimise significant environmental impacts;
- Details on emergency planning and accident prevention; (an emergency response plan will also be included);
- Details on monitoring and measuring performance; and
- Details on reviewing and reporting environmental performance.

All reports will be available to EirGrid to assist in monitoring and evaluating the environmental performance of the project.

5.6.2 Biodiversity, Flora and Fauna

5.6.2.1 Methodology

In conducting the analysis of impacts on the biodiversity, flora and fauna, standard guidelines for environmental assessment have directed the environmental appraisal to date. The standard guidelines and methodologies for survey and assessment used include:

- Smith et al (2011) *Best Practice for Habitat Survey and Mapping*. The Heritage Council.

- NRA (2009) *Ecological Surveying Techniques for Protected Flora and Fauna during the Planning of National Road Schemes*.
- Gilbert G., Gibbons D.W., & Evans J, (1998). *Bird Monitoring Methods: A Manual of Techniques for Key UK Species*. RSPB, Sandy.
- Commission for Environmental Assessment (2006). *Biodiversity in EIS and SEA*, Background Document to CBD Decision VIII/28: Voluntary Guidelines on Biodiversity-Inclusive Impact Assessment.
- NRA (2009) *Guidelines for Assessment of Ecological Impacts of National Road Schemes*. Rev.B.
- IEEM (2006) *Guidelines for Ecological Impact Assessment.* Institute of Ecology and Environmental Management.
- EirGrid (2012). *Ecology Guidelines for Transmission Projects: A Standard Approach to Ecological Impact Assessment of High Voltage Transmission Projects*.

This high-level assessment of the UGC route option is informed by extensive desktop and field studies. An ecological desktop study included:

- The identification of sites designated for nature conservation;
- Collation of information on rare and protected habitats and species;
- Examination of OSI maps and aerial photography; and
- Review of datasets and reports held by the National Parks and Wildlife Service (NPWS), National Biodiversity Data Centre (NBDC) and Birdwatch Ireland, amongst others.

Field surveys to date include:

- The 2013 and 2014 land access surveys (habitats, flora, mammals, invertebrates etc.);
- Breeding birds (Summer 2013 and 2014);
- Wintering birds (Winter 2012/2013 and 2013/2014);
- Bats (Summer 2014); and
- Marsh fritillary butterfly (September 2013 and 2014).

5.6.2.2 Review of UGC Route and Converter Stations

For the most part, the preferred UGC route runs under public roads, with cable joint pits to occur every 800-1200m, and converter stations at each end. Impacts to ecological receptors from the UGC option will arise mainly from construction associated with river crossings and converter stations.

A summary description and high-level assessment of impacts to identified key ecological receptors in the vicinity of the proposed UGC route is summarised below. Key ecological receptors identified are detailed under the following headings:

- Designated Sites;
- Aquatic Ecology;
- Habitats;
- Birds; and
- Other Fauna.

The potential impacts and effects on these receptors are based on an understanding of the anticipated likely impacts, in particular from the proposed river crossings at the key locations highlighted, and with consideration of the site specific ecological sensitivities.

These ecological receptors will require careful consideration during the final route selection, detailed design and construction stages. The potential impacts assume a best practice approach to mitigation procedures, monitoring and construction management.

Best practice will be followed in the design and construction stages, as recommended by relevant guidelines, including but not limited to:

- *CIRIA (2006) Control of water pollution from linear construction projects. C649.*
- *NRA (2006) Guidelines for the Treatment of Badgers prior to the Construction of National Road Schemes;*
- *NRA (2006) Guidelines for the Treatment of Otters prior to the Construction of National Roads Schemes;*
- *Eastern Regional Fisheries Board (2006). Requirements for the Protection of Fisheries and Habitats during Construction and Development Works at River Sites. Eastern Region Fisheries Board, Blackrock, Co. Dublin (http://www.fisheriesireland.ie/Salmon-management/salmon-management.html); and*
- *National Roads Authority (2005a). Guidelines for the Crossing of Watercourses During the Construction of National Road Schemes. National Roads Authority, Dublin.*

The guidelines from the Eastern Regional Fisheries Board and the NRA will also be followed to mitigate potential impacts and effects as identified in the Soils and Geology and Water Sections of this report.

5.6.2.2.1 Designated Sites

The current proposed route design has been carefully considered and several iterations culminating in the current design and location. The avoidance of potential significant impacts on European Designated Sites (Special Areas of Conservation (SAC) and Special Protection Areas (SPA)) are key considerations informing the current route.

River Moy SAC:

The proposed route of the UGC is located predominantly within the catchment area of the River Moy Special Area of Conservation (SAC-site code 2298). This SAC is designated for the following qualifying interests (the species and habitats for which the site is designated):

- White-clawed crayfish (*Austropotamobius pallipes*) [1092];
- Sea lamprey (*Petromyzon marinus*) [1095];
- Brook lamprey (*Lampetra planeri*) [1096];
- Salmon (*Salmo salar*) [1106];
- Otter (*Lutra lutra*) [1355];
- Active raised bogs [7110];

- Degraded raised bogs still capable of natural regeneration [7120];
- Depressions on peat substrates of the *Rhynchosporion* [7150];
- Old sessile oak woods with *Ilex* and *Blechnum* [91A0]; and
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) [91E0].

It should be noted that, although not a qualifying interest, the freshwater pearl mussel is an important feature of the River Moy catchment, and is considered under the aquatic ecology section.

In total, 48 identifiable surface water features (rivers and streams) are crossed by the UGC, the majority of which are in the catchment of the River Moy SAC. The UGC crosses 4 river channels within the SAC designation including:

- The River Moy main channel north of Foxford (Tonybaun/Carrowkeribly);
- The Yellow River (main tributary of the River Moy);
- River Moy main channel at Ballanacurra; and
- Mullaghanoe River and tributaries.

Specific locations within the SAC are detailed further in the table below where direct and indirect impacts to habitats and species may arise.

Location	Ecological Receptor Description
River Moy at Tonybaun/ Carrowkeribly ca. 7km S of Ballina	The UGC exits the road and crosses the River Moy valley. Approximately 620m of varied habitat (described below) is crossed off-road. Approximately 275m is within the boundary of River Moy SAC. Habitats in the SAC are dominated by non-qualifying habitats including wet grassland, hedgerows, scrub. Annex I listed habitats which may potentially occur at this location include; • Semi-natural woodland (Old sessile oak woods with *Ilex* and *Blechnum*) • Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* – priority habitat. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.
Yellow River (between Ballina and Swinford)	The Yellow River crossing will be off road. This is a salmonid river with high water quality (Q4-Q5). It is an important spawning river for Salmon in the Moy SAC. Semi-natural qualifying riparian woodland habitat (Old sessile oak woods with *Ilex* and *Blechnum*) grows along the bank of this river. Other qualifying Annex II species potentially occurring include crayfish, lamprey and otter.
Tributaries between Yellow River and Loobnamuck townland (N of Swinford)	A minimum of 4 no. rivers are crossed which are linked to the Moy SAC. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.
River Moy at Bellanacurra (N of Swinford)	The River Moy crossing will be off-road. This SAC is a salmonid river with high water quality (Q4-Q5). Semi natural riparian woodland habitat (Annex I -Old sessile oak woods with *Ilex* and *Blechnum*) is present along the bank of this river. Other qualifying Annex II species potentially occurring include crayfish, lamprey and otter.
Mullaghanoe River and tributaries (NE of Swinford)	The UGC route crosses approximately 140m of the River Moy SAC (off-road). This is a salmonid river with high water quality (Q4-Q5). It is an important spawning river for Salmon in the River Moy SAC. Semi-natural woodland habitat and unimproved wet grassland occurs along the bank of this river within the potential impact zone. Other qualifying Annex II species potentially occurring include crayfish, lamprey and otter.

Table 5-1 River Moy SAC Crossings

The potential impacts and effects of the final design on European designated sites will be considered in detail in the Appropriate Assessment process as required under Article 6(3) of the E.U. Habitats Directive.

Potential impacts and likely significant effects could include the following:

- Direct impacts to relevant Annex I habitats identified above, which typically occur as narrow strips (<20m) along the river channel. It is anticipated that impacts can be avoided in most cases with sensitive routing. Where impacts are unavoidable, they are likely to be permanent to allow maintenance of a clearway to facilitate maintenance and fault repair.
- Temporary significant pollution risk (negative impact) to protected aquatic species. This risk is related to the potential for increased suspended solids arising from construction works and storage/removal/reinstatement of disturbed soil or peat and/or the release of construction

related pollutants. There is also a low risk of bentonite escaping during the process of directional drilling at river crossings. Any impact could result in adverse effects to qualifying Annex II species such as salmon, lamprey and crayfish and to fresh water pearl mussel. These impacts are further considered below under the aquatic ecology section.
- Disturbance risk to Otter including the potential loss of resting or breeding sites (if present).
- Ongoing risk of pollution and disturbance during operation if faults arise and further excavation works are required.

Such effects may have implications for the conservation status of qualifying habitats/species and the overall integrity of the River Moy SAC.

Other Designated Sites:
For the crossing associated with the River Lung Valley, the route runs along the edge of **Tullaghanrock Bog SAC** (Site Code 002354) and **NHA** (Site Code 2013) for 260m. This designated site consists of bog woodland (Annex I listed) and wet grassland fringing relatively undamaged raised bog (Annex I priority habitat). The location of the UGC route would present direct risks to fringing bog habitats within the SAC. Marsh fritillary (listed on Annex II of EU Habitats Directive) would require consideration in fringing wet grassland habitat. The effects on hydrological flows within the bog would need to be assessed in detail.

The UGC route runs (on road) alongside **Cornaveagh Bog NHA** and **Tullaghan Bog NHA**, approximately 4km and 5km north-east of Frenchpark respectively. Both these sites are remnant raised bogs and works in the vicinity will need to be assessed for potential risks to sensitive habitats and species. It also runs (on road) alongside the northern boundary of the **Moy Valley pNHA** a former Corncrake (bird) breeding site (listed Annex I – Birds Directive).

5.6.2.2.2 Aquatic Ecology

The western sections of the UGC route and the north western substation are located in the Cloonaghmore river catchment (predominantly Good or High water quality/ Water Framework Directive (WFD) status[50]). The majority of the route and most sensitive section (based largely on importance for salmonids) is the River Moy catchment (predominantly Good or High water quality/ WFD status).

The UGC route also crosses through the Moy-Deel *Margaritifera* Sensitive Area between Moygownagh and Ballina. While not a qualifying interest of the River Moy SAC, freshwater pearl mussel are an Annex II species protected under the Habitats Directive and the population in the River Deel is of international importance.

Much of the River Moy catchment is sensitive to temporary soil erosion and disturbance (following construction/site clearance in particular where forestry has been planted), as much of the catchment is located on sloping ground with peat soils. The river crossings, particularly within the River Moy SAC,

[50] http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True

will present a short-term, significant pollution risk to aquatic based species including Atlantic salmon, trout, lamprey species, white clawed crayfish and freshwater pearl mussel. There is also an ongoing risk of pollution and disturbance during operation if faults arise and further excavation works are required.

Toward the eastern part of the corridor the route enters the River Shannon catchment (predominantly Poor/ Moderate water quality/WFD status) in the vicinity of Ballaghaderreen, including crossing the Lung and Breedoge Rivers. The eastern catchment and sub-basins are generally in low lying areas with less risk of soil/water runoff and therefore present lower potential risks to sensitive aquatic species.

Potential impacts and effects to key aquatic ecology receptors are considered in the table below.

Receptor	Potential Impact	Potential Effect
Freshwater Pearl Mussel	Increased sediment load causing a decline in water quality. Minimum water quality level of Q4-5 required	Smothering of mussel beds, loss of individuals and spawning beds. Resulting decline in population, recruitment, abundance, extent and/or distribution.
Salmon and Trout	Increased sediment load causing a decline in water quality. Minimum Q4 required.	Smothering of spawning beds. Resulting decline in population, recruitment, abundance, extent and/or distribution.
Brook and Sea Lamprey	Increased sediment load causing a decline in water quality.	Smothering of spawning beds (lamprey require gravel spawning beds). Resulting decline in population, recruitment, abundance, extent and/or distribution.
Crayfish	Increased sediment load causing a decline in water quality and loss of habitat heterogeneity. Minimum Q3-4 required.	Loss of suitable habitat. Resulting decline in population, recruitment, abundance, extent and/or distribution.

Table 5-2 Key Aquatic Ecology Receptors and Potential Impacts and Effects

Pollution control will be required at all stream, river and drainage ditch crossings, in particular where linked to the River Moy SAC. Detailed and potentially species-specific surveys will be required for aquatic fauna in order to inform specific mitigation measures (if required).

5.6.2.2.3 <u>Habitats</u>

The UGC is located primarily within the existing road network. Roadside fringe habitats including hedgerows and grassland verges may be impacted at some locations. However, the scale of this cannot be confirmed at this stage. Direct permanent habitat removal may occur at or close to riparian habitats where the cable is routed through private lands off the public road, in order to cross streams and rivers. The indirect effects to wetlands (bogs in particular) from drainage effects will also require consideration. Where the UGC route is located off-road, (in particular at river crossings), the sensitivity of ecological habitats in conjunction with other technical and environmental constraints will inform the locations of temporary works areas.

Key areas which will require off-road crossings are identified below:

- **River Moy, Foxford to Ballina Valley**: The UGC route crosses approximately 620m of the River Moy valley off-road. Habitats at this location consist of hedgerows and managed farmland/ less managed wet grassland. This area includes lands within the River Moy SAC. Direct impacts would arise to grassland habitat and hedgerows/treelines. These impacts are likely to be permanent, to allow maintenance of a clearway to facilitate cable maintenance and fault repair.
- **River Lung Valley**: The UGC route crosses approximately 1,300m of the River Lung valley off-road. Habitats at this location consist of degraded bog, raised bog, scrub, bog woodland, wet grassland, plantation forestry and managed farmland. This area includes lands adjacent to the southern boundary of Tullaghanrock Bog SAC. Direct impacts to local/county important habitats in the river valley would arise. Raised bog may potentially conform to Annex I listed priority habitat (although this would require confirmation surveys) and therefore be of international importance. These impacts are likely to be permanent to allow maintenance of a clearway to facilitate maintenance and fault repair.
- There are numerous other river crossings/streams required along the route of the proposed UGC route. Typical habitats within the corridor include; scrub, semi-natural woodlands, managed farmland, less managed farmland and degraded bog. Permanent habitat loss may occur at locally important habitat types at a multitude of stream crossings, and careful UGC route design will be required to minimise this.

The numerous stream and drainage ditch crossings will require pollution controls and detailed consideration of proposed work methods e.g. trenching, directional drilling, delineation of works areas etc., to minimise impacts to semi-natural habitats.

5.6.2.2.4 Birds

Breeding Birds:

The UGC route generally avoids areas identified as locally important for breeding birds. However, breeding birds still require consideration at specific locations (rivers and wetlands) regarding potential disturbance effects associated with vegetation clearance, construction works, storage of spoil etc. Breeding Kingfisher (listed on Annex I Birds Directive) and Dipper will require consideration at river crossings in particular.

Wintering Birds:

A number of locations have been determined based on results of winter bird surveys (2012 – 2014 inclusive) where potential temporary disturbance effects may arise to wintering Whooper Swans and other sensitive bird species (e.g. wintering Hen Harrier). Whooper Swan and Hen Harrier are species listed on Annex I of the Birds Directive. Disturbance and displacement of wintering birds requires consideration at the river crossings locations and any road works adjacent to bog areas. The UGC route passes through one regular wintering Whooper Swan site. Sensitive sites for wintering birds requiring consideration include the River Moy valley, River Lung south of Ballaghaderreen, and the boglands around Frenchpark.

5.6.2.2.5 Other Fauna

Protected species requiring particular consideration in relation to the UGC include:

- Otter - listed on Annex II of the E.U. Habitats Directive, and a qualifying interest of the River Moy SAC; and
- Bat species – Listed on Annex IV of the E.U. Habitats Directive.

Disturbance impacts potentially affecting otter during construction include direct impacts to breeding/resting sites (if present) and indirect impacts due to visual and noise disturbance. This could result in the loss of resting, foraging or breeding sites, and potentially a temporary decline in extent of the range of this species. Bat roosts (within bridges/mature trees) have the potential to be impacted during river crossing construction works.

Otter and bat breeding sites will require consideration in the vicinity of river crossings to minimise potential disturbance effects, in particular during construction.

Mammals including Pine Marten, Red Squirrel and Badger are dispersed throughout the study area and may require mitigation consideration for potential disturbance effects

5.6.2.3 Summary of UGC Option – Biodiversity, Flora and Fauna

A summary of the key considerations with respect to the biodiversity, flora and fauna of the UGC study area is provided in the table below. These comments are based on the results of initial desktop and field studies and are an indication only of potential impacts and effects.

Ecological Receptor	UGC – Summary of Impacts/Effects
European Sites (SAC/SPA)	1.39km of SAC crossed. No SPAs crossed. Potential direct adverse impacts identified to non-qualifying habitats at 4 River Moy SAC crossings and numerous non designated watercourses within the overall catchment (linked to SAC). Identification, confirmation and evaluation of all Annex I Habitats (EU Habitats Directive) will be required. Based on this desk review, the risk of direct impacts on qualifying habitats (Annex I) habitats is low as the river crossings are predominantly on agricultural land. Potential hydrological/other ecological impacts to Tullaghanrock Bog SAC. Potential impacts to qualifying interests of European Sites will be considered in detail in the Appropriate Assessment Process required under Article 6(3) of the Habitats Directive.
NHA/ pNHA	Four pNHA/NHAs at edge of proposed route. Potential for direct drainage effects to these wetlands.
Aquatic Ecology	The entire UGC route requires detailed consideration of route design, works areas (locations), construction methods and pollution controls, in particular throughout the River Moy catchment. All streams, drainage ditches, forestry, soils and upland areas in particular will require identification so as to inform potential pollution risk downstream and appropriate mitigation to reduce pollution risk.
Habitats	The vast majority of the route is proposed along the existing road network meaning significant impacts are focused at river crossings and possibly wetlands in the vicinity of works areas (drainage effects). Direct impacts to Annex I listed (non-designated) habitats are unlikely except possibly at one location in the River Lung valley. Direct adverse effects may arise to riparian and river habitat due to horizontal directional drilling and other ancillary site works. Horizontal directional drilling approach will avoid direct impacts to riparian/ river habitats although risks of pollutant runoff exist.
Birds	Sensitive bird sites are predominantly avoided. The UGC route passes through one identified wintering Whooper Swan site although any impacts are likely to be of low significance. Kingfisher and other breeding bird sites require consideration at all river crossings.
Other Fauna	The key concern is the potential for disturbance impacts to Otter and bat species (breeding sites) at and in the vicinity of river crossings.

Table 5-3 Summary of Biodiversity Considerations for the Proposed UGC

5.6.2.4 Mitigation Measures for Biodiversity Flora and Fauna – UGC option

Preconstruction surveys and the implementation of seasonal working restrictions, as well as the supervision of works by an experienced ecologist will allow for appropriate biodiversity protection. Detailed mitigation measures will be developed and set out in specific procedures for the protection of flora and fauna in a Construction Management Plan for the project. Any unavoidable residual disturbance identified in relation to sensitive bird and mammal populations shall be carried out only under licence from the National Parks and Wildlife Service (NPWS). For example, if any works need to be carried out during a sensitive ecological season, pre- or during the construction phase, the required consultation and licences will be obtained from NPWS.

The prevention of pollution to watercourses and subsequent impacts on the River Moy, River Lung and other rivers and streams is very important, in particular, for species of conservation importance such as salmon, crayfish, lamprey, otter and kingfisher.

Construction work in sensitive environmental areas will be supervised by an ecologist. The ecologist will carry out preconstruction surveys and advise, as necessary, on ecological issues. The ecologist will also liaise with the NPWS on relevant issues and report on the progress and success of the relevant mitigation measures.

The contractor will be instructed to minimise hedgerow loss and in particular to avoid mature trees. The removal of hedgerow will always be the minimum width required and any tall trees present will preferably be left in situ. However, it will be necessary to remove trees at certain locations. The ecologist will monitor the removal of any trees that have the potential to contain bats.

Disturbance to the roots of various trees will be avoided following the standard procedure to limit excavation of any works beyond the area of the drip-point of the canopy.

Where the cable is to cross or be laid in close proximity to streams, to protect stream-side hedgerows and trees from damage prior to construction, a leave strip will be marked delimiting areas where construction activity is to be avoided.

5.6.3 Water

5.6.3.1 Methodology

Surface Water

The relevant key criteria identified in the Grid West Constraints study are deemed the most appropriate with which to assess the impacts on surface water along the UGC route. The criteria include:

- Potential impact on river crossings; and
- Potential impact on lakes.

Groundwater

The relevant key criteria identified in the Grid West constraints study are deemed the most appropriate with which to identify the impacts on groundwater along the UGC route. The criteria include:

- Aquifer potential & characteristics;
- Karst features;
- Groundwater vulnerability (See note 1 below); and
- EPA/GSI source protection zones (See note 2 below).

Note 1:

Groundwater vulnerability represents the intrinsic geological and hydrogeological characteristics that determine how easily groundwater may be contaminated by human activities. Vulnerability depends on the quantity of contaminants that can reach the groundwater, the time taken by water to infiltrate to the watertable and the attenuating capacity of the geological deposits through which the water travels. These factors are controlled by the types of subsoils that overlie the *groundwater, the way in which the contaminants enter the geological deposits (whether point or diffuse) and the unsaturated thickness of geological deposits from the point of contaminant discharge).*

Note 2:

There are two main elements to source protection land surface zoning:

- *Areas surrounding individual groundwater sources; these are termed source protection zones(SPZs); and*
- *Division of the SPZs on the basis of the vulnerability of the underlying groundwater to contamination.*

These elements are integrated to give the source protection zones.
Two source protection areas are recommended for delineation:

- *Inner Protection Area (SI):*
  This area is designed to protect against the effects of human activities that might have an immediate effect on the source and, in particular, against microbial pollution. The area is defined by a 100-day time of travel (TOT) from any point below the water table to the source. In karst areas, it will not usually be feasible to delineate 100-day TOT boundaries, as there are large variations in permeability, high flow velocities and a low level of predictability. In these areas, the total catchment area of the source will frequently be classed as SI.;
- *Outer Protection Area (SO):*
  Encompasses the remainder of the groundwater source catchment area or ZOC. It is defined as the area needed to support an abstraction from long-term groundwater recharge i.e. the proportion of effective rainfall that infiltrates to the water table.

As reported by the EPA and GSI, groundwater sources, particularly public, group scheme and industrial supplies, are of critical importance in many regions. Consequently, the objective of source protection zones is to provide protection by placing tighter controls on activities within all or part of the zone of contribution (ZOC) of the source.

5.6.3.2 Review of UGC Route and Converter Stations

Surface Water:

River Crossings

In total, the UGC route crosses 48 identifiable surface water features (i.e. rivers and streams).

The most westerly sections of the UGC route and the north Mayo converter station locations are in the Cloonaghmore river catchment (predominantly Good or High water quality WFD status[51]).

The majority of UGC route then passes though the wider River Moy catchment. The River Moy catchment has predominantly Good or High water quality WFD status.

Toward its eastern end, the cable route enters the River Shannon catchment (predominantly Poor/ Moderate water quality WFD status). In the vicinity of Ballaghaderreen, the route crosses the Lung and Breedoge Rivers within the River Shannon catchment.

[51] http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True

In summary, the UGC route passes through the following primary river catchments from west to east:

- Cloonaghmore River catchment (predominantly Good or High water quality WFD status[52]);
- River Moy catchment (predominantly Good or High water quality WFD status); and
- River Shannon catchment (predominantly Poor/Moderate water quality WFD status).

It is proposed to construct the UGC along the public road network rather than cross-country. The only sections where the UGC route leaves the road network are where horizontal directional drilling is needed under surface water features, such as rivers, streams and drains, and to avoid any major existing services or structures, such as bridges or railway tracks, along the route. The converter stations will constructed off-road.

Following the local road network means that this option 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 may result in elevated suspended solids entering receiving water courses. The effect of this impact will be the deterioration of water quality downstream of the construction works and an indirect effect on downstream ecological habitats and species, as described in Section 5.6.2.

In order to minimise the risks of any potential adverse impacts on the surface water quality, construction methodologies in the vicinity of surface water features (including horizontal directional drilling under rivers, streams and drainage ditches) will be carried out according to best practice.

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

Lakes:

The western section of the UGC route (i.e. as far east as Callow) is dominated by Lough Conn, Lough Cullin and a number of other smaller lakes. At its closest, the route is approximately 1km from Lough Conn. A small lake, Lough Alick, is located between Lough Conn and the route, which runs approximately 100m from this lake. Ballycong (Carrowkeribly) Lough is located within 45m of the UGC route (north of Foxford). At Callow, the UGC route runs north of the Callow Loughs, at a distance of over 1.7km at its closest to the Loughs.

The eastern section of the UGC route (i.e. east of Callow, as far as Flagford) is dominated by Lough Gara and other smaller lakes. The UGC route is within 750m (at its closest) from Lough Gara. Towards Flagford, at Cloonshaghan, the route runs within 50m distance of Cavestown Lough and further north-east, at Clogher, it runs to within 400m distance of Clogher Lough.

52 http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True

Potential impact on lakes from construction works, particularly in the area of peat, will be similar to the impacts detailed earlier in relation to rivers. Construction methodologies in the vicinity of all lakes will be carried out according to best practice, in order to minimise the risks of any potential adverse impacts on the surface water quality of the lakes.

Groundwater:

Aquifer Potential & Characteristics

The Bedrock Geology/Bedrock Aquifer along the UGC route (from west to east) is presented in the table below.

Over half of the UGC route (approximately 56.6km) is located 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 option will impact on aquifer recharge. However, if groundwater is impacted by construction works or from repair works during the operational phase of the development, for example 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.

Bedrock Type	Aquifer Type	Approx. Length of UGC Route (km)
Sandstones, Shales, Limestones	Pl	2.6
Impure Limestones	Ll	3.9
Pure Bedded Limestones (Karstified)	Rk	21.6
Granites & Other Igneous Intrusive Rocks	Pl	11.2
Sandstones	Lm	1.6
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	6
Shales & Limestones	Ll	14.5
Sandstones	Lm	0.5
Volcanics	Pl	1.6
Mixed Sandstones, Shales & Limestones	Ll	4.8
Volcanics	Pl	4.5
Mixed Sandstones, Shales & Limestones	Ll	0.5
Volcanics	Pl	1.5
Mixed Sandstones, Shales & Limestones	Ll	3.3
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	29

Where:
Pl *Poor Aquifer - Bedrock which is generally unproductive, except for local zones;*
Ll *Locally Important Aquifer - Bedrock which is moderately productive, only in local zones;*
Lm *Locally Important Aquifer - Bedrock that is generally moderately productive;*
Rk *Regionally Important Aquifer - Karstified;*
Rkc *Regionally Important Aquifer - Karstified, with conduits.*

Table 5-4 Groundwater Vulnerability along the UGC Route

Karst Features

The UGC route does not pass within 5km of any recorded karst features for the western section of the line, as far as Ballaghaderreen. The UGC route east of Ballaghaderreen to Flagford passes 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.

Groundwater Vulnerability

The Groundwater Vulnerability along the UGC route is recorded as follows:

Groundwater Vulnerability	Approx. % Along UGC Route
Low	26.8%
Medium	25.7%
High	36%
Extreme	10.6%
X* (Rock at or near surface OR Karst)	0.9%

* The Extreme category includes a subcategory 'X', representing rock outcrop and subsoil less than1 m thick.

Table 5-5 Groundwater Vulnerability along the UGC Route

The High, Extreme and X Vulnerabilities recorded mainly relate to the karstified pure bedded limestone bedrock, which is a regionally important aquifer (vulnerable to population).

EPA/GSI Source Protection Zones

According to the EPA/GSI Source Protection Zone Map (www.gsi.ie), the UGC route does not intercept any Source Protection Zones (SPZ).

The closest SPZ to the UGC route is the Rockingham SPZ, which is located (at its closest) 2.4km north of the UGC route. This SPZ is in place to protect Rockingham Springs (located east of Boyle town), which is the source for the Boyle/Ardcarne Regional Water Supply Scheme (serves Boyle town). The UGC route is at a great enough distance from the SPZ to ensure that construction works on the route would have no impact or effect on the SPZ.

Converter Station Sites Location Appraisal:

The water assessment of the converter station sites/zones was completed as part of the UGC Report[53] and further assessment[54] based on public feedback and consultation as well as additional specialist studies.

5.6.3.3 Mitigation Measures for Water – UGC Option

Mitigation measures will be put in place to prevent or minimise pollution of watercourses and loss of habitat, in particular at the River Moy and River Lung, as agreed with relevant local authorities. Best operational practices will ensure the development is not likely to give rise to pollution of soil or groundwater. Spill containment will be carried out according to best practice guidelines and codes of practice and will be inspected and maintained regularly.

[53] Appendix 8 Underground Route Options Preliminary Evaluation Report, July 2014

[54] Appendix 12 Environmental Appraisal of the Converter Site Selection at Flagford

Storage areas, machinery depots, site offices, temporary access roads and the disposal of spoil will be located as far as is practicable from watercourses. Storage areas for potentially polluting substances will be bunded. Fuels, lubricants and hydraulic fluids for equipment used on the construction site, as well as any solvents, oils, and paints will be carefully stored in containment areas and fuelling and lubrication of equipment will not be carried out close to watercourses. Fuelling of vehicles and transfer of other potentially polluting liquids shall be undertaken on a suitably sized concreted area.

Where dewatering is necessary, management of dewatering discharge will be essential to mitigate potential impacts to receiving streams. Where necessary, discharge licences will be obtained by application to the relevant authority.

A Pollution Incident Response Plan (or Pollution Control Plan/Emergency Response Plan) will be in operation with appropriately trained personnel and spill containment equipment maintained at the site throughout the construction phase.

It is anticipated at this stage that the majority of river and stream crossings will be carried out using horizontal directional drilling or other trenchless techniques. A method statement on Watercourse Crossings will be included in the CMP.

Routine upstream and downstream surface water quality analysis will monitor any potential impact on the quality of the local surface waters during the construction phase of the development.

Minor river and stream crossings not directly discharging to an SAC may be carried out by trenching across the channel bed, employing temporary diversion and other mitigation methods.

Disturbance of bankside soils and in-stream sediments will be kept to the minimum required for the cable laying process. Banks and stream beds will be reinstated in a manner that will minimise the potential for erosion and return the river/stream to as close to its original condition as possible.

5.6.4 Soils and Geology

5.6.4.1 Methodology

The key criteria identified for the assessment of the UGC route include:

- Soil/Subsoil Geology (as classified in GSI and EPA databases and the National Soil Survey data);
- Bedrock Geology (as classified in GSI and EPA databases);
- Irish Geological Heritage Sites (generally designated as a result of a specific geological interest (e.g. rare fossils or bedrock exposures):
    - Proposed Geological Natural Heritage Areas (NHA's)
      Geological Survey of Ireland (GSI) has compiled a list of sites proposed for designation as Natural Heritage Areas (pNHAs);
    - County Geological Sites (CGS)

GSI has also determined a secondary list of County Geological Sites (CGS) which may be considered for protection at local authority level (possibly within future County Development Plans);

- Unidentified Geological Sites (U)
  These are also included in the GSI database; and
- Roscommon/Leitrim and Sligo IGH Sites[55].

- Karst Features (GSI database). Limestone which has been eroded by dissolution, producing ridges, towers, fissures, sinkholes and other characteristic landforms (including turloughs, potential turloughs, boreholes, caves, dry valleys, estavelles, enclosed depressions, springs, superficial solution features and swallow holes).

Assessment of soils and geology is carried out with reference to the Institute of Geologists of Ireland (IGI) "Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements" (2013).

5.6.4.2 Review of UGC and Converter Stations

5.6.4.2.1 Soil/Subsoil Geology

As construction of the UGC will occur along the public road network rather than cross-country, it is highly likely that, during construction works, only made ground and possibly the upper layer of subsoils (if the road is a shallow structure) would be disturbed. It is expected that significant areas of peat will be encountered and will need to be removed and managed[56] along the route during the construction phase.

The soil/subsoils geological environment along the western section of the UGC route is dominated by low to medium quality agricultural land, including some cutover peat, as far south as Knockmore, Co. Mayo. Bedrock outcrop is prominent in the Foxford area (from Knockmore to Callow). From Callow eastwards, the UGC route follows the local roads across predominantly poorly drained agricultural landscape, with extensive patches of cutover bog. The UGC route runs to the north of Charlestown and, as such, avoids an area of blanket bog to the south of Charlestown.

Potential impacts from these works may include uncontrolled sediment release to nearby surface waters. In particular, construction works in areas of peat may result in elevated suspended solids entering receiving waters. The effect of this impact is the deterioration of water quality downstream of the construction works and an indirect effect on downstream ecological habitats, as described in Section 5.6.2.

As part of the eventual EIS and Appropriate Assessment for a preferred option for the Grid West Project, additional assessments, including landslide and slope stability risk assessment and the

[55] As provided by the GSI.
[56] All excavated material will be transferred to a licenced landfill.

potential for bog bursts and landslide hazards will be considered, particularly if the final route option is proposed in areas of elevated and sloping ground.

5.6.4.2.2 Bedrock Geology

The bedrock geology along the UGC route (from west to east) is presented in the table below.

Over half of the UGC route, approximately 56.6km, is located on karstified Pure Bedded Limestone, which is a Regionally Important Aquifer that is classified by the GSI as highly vulnerable (as discussed in the Water Section of this report).

If karstified bedrock is directly or indirectly impacted by construction works or from repair works during the operational phase of the development, for example 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 affects downstream water supplies.

Bedrock Type	Approx. Length of UGC Route (km)
Sandstones, Shales, Limestones	2.6
Impure Limestones	3.9
Pure Bedded Limestones (Karstified)	21.6
Granites & Other Igneous Intrusive Rocks	11.2
Sandstones	1.6
Pure Bedded Limestones (Karstified, with Conduits)	6
Shales & Limestones	14.5
Sandstones	0.5
Volcanics	1.6
Mixed Sandstones, Shales & Limestones	4.8
Volcanics	4.5
Mixed Sandstones, Shales & Limestones	0.5
Volcanics	1.5
Mixed Sandstones, Shales & Limestones	3.3
Pure Bedded Limestones (Karstified, with Conduits)	29

Table 5-6 Bedrock Classification along the UGC Route

It is noted that there are a number of quarries located along the UGC route option, particularly in the areas of Bunnafinglas, Corradrishy and Boherhallagh in County Mayo. These quarries have the potential to be valuable resources for aggregate, both locally and regionally, and have been considered in the route corridor assessment and indicative route design to date. All relevant sites identified as having potential aggregate or mineral potential will be considered further at EIS stage when a preferred option is selected. However, as the UGC option will follow the local road network, it is unlikely that any extractive industries will be impacted directly by an UGC option.

5.6.4.2.3 Irish Geological Heritage Sites

The UGC route does not pass over any proposed geological Natural Heritage Areas (NHAs) although, north of Foxford, it does pass within 1km of the *'River Moy - Fluvial and Lacustrine Geomorphology'* NHA.

The UGC route does not pass over or close to any County Geological Sites (CGS), nor does it pass over or close to any Unidentified Geological Sites (U).

The UGC route is located within approximately 400m of one Roscommon/Leitrim IGH Site, south east of Boyle ('*Cavetown House, Clogher Lough'*). There are no County Sligo IGH sites within 10km of the UGC route.

5.6.4.2.4 Karst Features

The UGC route does not pass within 5km of any recorded karst features for the western section of the line, as far as Ballaghaderreen. The route east of Ballaghaderreen, towards Flagford, passes through an area with a number of recorded karst features, (including one potential turlough), as well as 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.

5.6.4.3 Mitigation Measures for Soils and Geology – UGC Option

It is anticipated that the majority of the cable route construction will be carried out in peat or soft ground that will need to be removed and disposed of appropriately. There may also be areas where rock breaking will be required. The CMP will set out details and method statements for the excavation and safe disposal of the material. Following final route design and prior to commencement of construction, comprehensive site surveys will establish ground conditions along the UGC route.

5.6.5 Landscape/Visual

5.6.5.1 Methodology and Information Sources

The landscape criteria that form the basis of appraisal in this section are based on the classification of landscape constraints in work to date on Grid West. This section is based on a desktop study of all the available landscape inventories and cartographic sources and a two day windscreen survey of the study area carried out in 2012. As the project progressed (public feedback, changes to relevant County Development Plans, additional site surveys etc.) these studies were updated using "live desktop constraints mapping" to reflect the most up-to-date information available.

A number of sources were used to gather information on the existing landscape within the study area. Following the desktop exercise, a windscreen survey was carried out to check the accuracy of the key desktop findings and to ascertain the broad baseline characteristics of the wider landscape. The County Development Plans and County Landscape Character Assessments (LCA) were the main sources of information for the desktop study. Key features identified in these documents were checked and verified on the ground for accuracy and relevance. The windscreen survey, for example, identified the extent and nature of key protected views and designated areas. These designated areas were compared to undesignated areas to ascertain relative significance.

The landscape criteria that form the basis of assessments in this section include the classification of landscape considerations in work to date on Grid West, as follows:

- International and National Landscape Designations;
- County Landscape Designations;
- Significant Recreational Areas;
- Significant Designed Landscape Features;
- Landscape Character; and
- Amount of route/structures, including converter stations on elevated land in relation to houses.

A project specific methodology was developed to identify the landscape constraints within the Grid West study area. The current UGC route option was selected following the identification, consideration and avoidance, where possible, of these constraints.

This methodology takes account of the fact that local authority development plans differ in how they recognise their landscapes and landscape features of value. It also takes into account ways in which people enter or view the landscape, (walks, trails etc.), as well as the landscape qualities such as wilderness, scale and rarity.

All relevant sensitive features within the Grid West study area and in the vicinity of the UGC route option are detailed in the Constraints Report[57].

The landscape assessment of the converter station sites/zones was completed as part of the UGC Report[58] and further appraised[59] based on public feedback and consultation as well as additional specialist studies.

[57] Appendix 16 The Grid West Constraints Report, August 2012
[58] Appendix 8 - Underground Route Options Preliminary Evaluation Report, July 2014
[59] Appendix 12 Environmental Appraisal of the Converter Site Selection at Flagford

5.6.5.2 Existing environment

5.6.5.2.1 National and International Landscape Designations

There is one national landscape designation within the study area – Ballycroy National Park in Co. Mayo. There are no Landscape Conservation Areas within the study area and no Special Amenity Area Orders have been made within the study area.

Two sites within the study area were nominated by the State in 2010 to a Tentative List for UNESCO World Heritage Site status; *Céide Fields and North West Mayo Boglands* and *Rathcroghan Complex*. Candidate sites remain on this list for at least one year during which consultation must take place with relevant stakeholders before possible inscription on the World Heritage List. The identified sites are still on the list, as of January 2015.

County	UNESCO World Heritage Sites – Tentative list	National Parks	Landscape Conservation Areas	Special Amenity Area Orders
Mayo	Tentative list 2010 – Céide Fields and North West Mayo boglands	Ballycroy National Park	none	none
Roscommon	Tentative list 2010 – Rathcroghan Complex	none	none	none

Table 5-7 National and International Landscape Designations within the Study Area

5.6.5.2.2 County Landscape Designations

The landscape constraints contained in the County Development Plans and County LCAs considered relevant to this study are summarised in the table below using each Council's terminology. All relevant features within the Grid West Study Area are detailed in the Stage 1 Report[60]. A detailed description of the relevant landscape character areas identified along the underground cable route (sourced from the Landscape Character Assessments of the relevant county development plans) is included in Appendix 13. This information supports the Landscape Character Assessment data included in Appendix 8.1 of the Constraints Report (2012). As the Sligo County Development Plan has not changed since 2012, the information in the Constraints Report is the most up-to-date landscape information available.

[60] Appendix 2 - EirGrid Grid West Stage 1 Report – Chapter 5: Constraints, March 2013

County Development Plan/LCA	Views	Routes	Landscape Value	Year of Survey Work
Mayo (2008-2014)	Highly Scenic Vistas	Scenic Routes	Vulnerable Features (coastline, lakeshores, rivers, headlands estuaries, skylines, ridges, promontories)	2002
Roscommon (2008-2014)	Scenic Views	Scenic Routes Driving Routes Walking Routes Cycling Routes	Areas of Exceptional Value Places of Interest and Visitor Attractions	2007
Leitrim (2009-2015)	Outstanding (protected) Views and Prospects	Long Distance Routes	Areas of High Visual Amenity	2002
Sligo (2011-2017)	Scenic Views to be Preserved	Scenic Routes	Sensitive Rural Landscapes Visually Vulnerable Areas (coastline, lakeshores, rivers, headlands estuaries, skylines, ridges, promontories)	1998

Table 5-8 Landscape Designations as Contained in County Development Plans

County Development Plans - Designated Views

All scenic views as identified in the County Development Plans or County LCAs have been included in the landscape constraints mapping. While all designated scenic viewpoints are listed as constraints for information gathering purposes, key viewpoints were assessed for relative sensitivity during the windscreen survey carried out in April 2012. The characteristics and significance of these views vary greatly within the study area; therefore it was not assumed that all designated views are of equal significance.

County Development Plans - Landscape Value

Some County LCAs have ascribed sensitivity or value ratings to Landscape Character Areas, and where areas within a county have been assigned a very high sensitivity or value (for example Lough Key) this has been included in the constraints mapping. Parts of these designated areas may be more sensitive than others, but generally these areas were considered sensitive to the proposed development.

County Development Plans - Designated Routes

All scenic routes, driving routes, walking routes and cycling routes, as identified in the County Development Plans or County LCAs, have been included in the constraints mapping. These are included as they contribute to the amenity of particular areas. It should be noted that the characteristics of these routes vary greatly within the study area; some travel through landscape of great drama and rarity, while some travel through relatively ubiquitous agricultural and inhabited landscape.

County Development Plan Landscape Policies, Objectives and Development Management Standards/Guidelines

A listing of relevant landscape policies of the relevant County Development Plans is contained in the Grid West Constraints Report[61] and are directly concerned with the relationship between the landscape and significant infrastructure projects.

5.6.5.2.3 <u>Significant Recreational and Heritage Landscape Features</u>

Aside from the designations in the County Development Plans, there are a number of landscape features of recreational value such as marked walking and cycling routes and designed landscapes with significant heritage value, as listed in the table below.

County	Main Walking Routes	Main Cycling Routes	Designed Landscapes with Significant Heritage Value	Other
Mayo	Western Way Bangor Trail Foxford Way Pilgrim's Walk Croagh Patrick Heritage Trail National Looped Walks	Great Western Greenway Westport Cycle Hub	Historic Gardens and Designed Landscapes – with main landscape features substantially present as defined in NIAH Inventory	Candidate Wilderness Area (Coillte)
Roscommon	Suck Valley Way Miner' s Way & Historical Trail National Looped Walks	The Kingfisher Cycle Trail The Táin Cycling Route The Lough Ree and Shannon Cycling Tour	Historic Gardens and Designed Landscapes – with main landscape features substantially present as defined in NIAH Inventory	
Leitrim	North West Trail (Walking & Cycling) Leitrim Way Miner's Way & Historical Trail National Looped Walks		Historic Gardens and Designed Landscapes – with main landscape features substantially present as defined in NIAH Inventory	
Sligo	Miner' s Way & Historical Trail Sligo Way National Looped Walks		Historic Gardens and Designed Landscapes – with main landscape features substantially present as defined in NIAH Inventory	

Table 5-9 Features of Significant Recreation and Heritage Value

[61] Appendix 16 The Grid West Constraints Report, Appendix 8.2 Landscape Policies, August 2012

5.6.5.2.4 General Landscape Constraints

Apart from the constraints listed above, more general landscape factors have been considered such as topography, landscape scale, landscape complexity, rarity, open or horizontal landscapes, and areas of wilderness. Lakes, the coastline, major rivers and ridgelines were considered landscape constraints due to their sensitive qualities, although it may not be possible to avoid impact on such landscape features completely.

The relationship between plains and mountains was taken into consideration, for example the extent of visual influence of the Nephin Mountains. The extent of views across lakes was also a consideration, for example views westwards across Lough Conn.

Many areas, particularly to the west and in elevated areas, exhibit characteristics of wilderness with very little evidence of human impact. These areas would be sensitive to the inclusion of new elements in the landscape. Other parts of the study area display patterns of human habitation and agriculture that may also be sensitive to the inclusion of electricity infrastructure.

A draft National Landscape Strategy, launched in July 2014, will change the Landscape Character Assessment (LCA) process in Ireland and studies to date for the Grid West project have made every effort to "future proof" the constraints assessment by including constraints not only listed in public sources, but also recorded as part of from fieldwork.

5.6.5.3 Review of UGC Route and Converter Stations

The identified UGC route runs along public roads for the most of its length, with cable joint pits (and attendant vegetation removal and manhole covers) to occur every 800-1200m, and converter stations at each end. This type of development is less common in the rural landscape than the more usual overhead transmission line. Permanent physical landscape effects are minimised by constructing the cable within the road. It is not anticipated that there will be any large scale, permanent removal of roadside vegetation.

The main permanent, visible structures associated with the proposed UGC route option for the Grid West project will be the new converter stations north west of Moygownagh in Co. Mayo and in the vicinity of the existing Flagford substation. The site footprint for each converter station will be in the order of approximately 180m by 120m, the buildings approximately 24m at their highest point.

The converter stations, by nature of their scale, will be visible locally. The preferred location at Flagford (DCF7) is, however, remote from local roads and currently has one house within the identified location zone (1km radius). The local topography lends itself to screening over distances and, if the HVDC option is developed and a site is selected, further screening and mitigation measures can be incorporated into the design. A final decision on a location for the converter station in north Mayo has not yet been taken but, as stated elsewhere, for the purposes of this report the DCB2 location is taken as the preferred location.

Proposals to mitigate the visual effects at the converter station locations would include site selection, earthworks, screening and planting.

With regard to the cables themselves, there will be a requirement for horizontal directional drilling to cross major water features, such as the River Moy, and the cables will be diverted off-road where the route encounters existing infrastructure such as railway lines and bridges.

Along the UGC route (following the construction stage), manhole covers, fences and maintenance activity will be visible. Depending on the exact location, there may be a small amount of permanent vegetation removal or change where the route travels cross country or requires horizontal directional drilling under rivers or other obstructions with resulting visual effects.

5.6.5.4 Landscape Effects of the UGC Option and Converter Stations

The key landscape effects will be:

Construction Stage:

- Short-term adverse effects at construction stage when more activity (people, machinery, materials, vehicles) will occur in landscapes known for their characteristics of wilderness or remoteness. There may also be more activity during occasions of maintenance during the operational stage.
- Short-term changes in traffic circulation, and resulting changes to landscape character arising from road closures and traffic diversions at construction stage;
- Physical landscape effects arising from vegetation removal where the route crosses over open countryside and at areas where horizontal directional drilling is required; and
- Physical landscape effects arising from earthworks and reinstatement.

Operational Stage:

- The main permanent landscape change will occur in the vicinity of the converter stations. These compounds will be significantly larger than any other structures in the existing landscape;
- Physical landscape effects arising from changes to the surfaces of roads;
- Potential permanent removal of taller vegetation over the short cross-country cable sections;
- Introduction of new elements such as converter stations, manholes, fences, gates, warning signage, into the landscape; and
- Physical landscape effects arising from vegetation/soil changes where the route crosses over open countryside and at areas where horizontal directional drilling is required.

5.6.5.5 Visual Effects of the UGC Option and Converter Stations

While landscape effects are concerned with the changes to the fabric and character of the landscape, visual effects result from changes to views.

Visual effects are anticipated to arise from plant and equipment along the UGC route and at the location of the converter stations during the construction phase. However, the most significant visual effects associated with the UGC route will be temporary and short-term, with the exception of the converter stations which will be permanent structures. Screening and screen planting at the converter station sites will mitigate the long-term visual effects.

There will be some visual effects resulting from any permanent removal of vegetation along the cross-country parts of the route but this is likely to be localised. There may also be localised visual effects associated with the above ground structure of manholes, fences, gates and warning signage.

5.6.5.6 Mitigation Measures for Landscape and Visual – UGC Option

Potential landscape and visual impacts from construction facilities, particularly at the converter stations, will be mitigated by a range of design measures (building dimensions, materials, colour and finishing) and landscaping measures (local planting). These measures will be agreed with the relevant local authority.

Lighting control features will be established on site during the construction of the converter stations and any compounds along the route. Lighting will be used only when required for security and safety during night-time operations and will be kept to the minimum level necessary.

External lighting will be designed to avoid unnecessary stray illumination beyond the site boundary or skywards which might otherwise give rise to light pollution (sky glow, glare and light trespass) and which could cause visual intrusion. The level of illumination will be appropriate to the operations in an area and in accordance with recognised international standards. Overlighting will be avoided and glare will be kept to a minimum by placing down-lighting on tall posts.

Specifically designed lighting equipment will be installed where required, to minimise the spread of light above the horizontal.

An emergency lighting system consisting of individual self-contained emergency lights will be provided where required including at the converter stations. These will provide illumination for essential operations and for access.

5.6.6 Cultural Heritage

5.6.6.1 Introduction

The recorded cultural heritage resource along the identified UGC route is set out below along with a preliminary analysis of the potential impacts and effects.

5.6.6.1.1 <u>Methodology</u>

This study summarises the cultural heritage resource based on a desktop study of published and unpublished documentary and cartographic sources, with limited field survey undertaken where access was permitted. All relevant documentation, including the relevant county, town and local development plans, as well as heritage plans, were reviewed.

5.6.6.1.1.1 Appraisal Methodology

All known cultural heritage sites were mapped in GIS along with high resolution aerial photography and Ordnance Survey Ireland (OSI) First Edition Mapping (Circa 1830).

- Candidate World Heritage Sites;
- National Monuments, be they in the ownership or guardianship of the State, in the ownership of a local authority or monuments under preservation orders;
- Record of Monuments & Places (RMP) and Sites and Monuments Record (SMR) from www.archaeology.ie;
- Records of Protected Structures from Sligo, Mayo and Roscommon County Councils;
- National Inventory of Architectural Heritage (NIAH) for Counties Sligo, Mayo and Roscommon;
- Demesnes Landscapes and Historic Gardens indicated on the OSI First Edition Mapping; and
- Cartographic and aerial anomalies and new unrecorded sites identified from field inspection.

Relevant County Development Plans were reviewed in the preparation of this report (Mayo CDP 2014-2020, Roscommon CDP 2014-2020, Sligo CDP 2011-2017). The development plans contain lists of cultural heritage sites including national monuments, recorded monuments, architectural conservation areas, protected structures and protected views as well as base case assessments of the landscape character of the county. The plans also outline the counties' heritage policies and objectives that aim to protect and promote the archaeological, architectural and cultural heritage of the region. This evaluation was carried out with due regard to these policies and other relevant information contained within the plans.

5.6.6.1.1.2 Windscreen Survey

Following a detailed desk study, a windscreen survey and site inspections (where access was permitted) of the proposed UGC route were undertaken to assess further the potential impacts and effects that the underground option would have on the receiving cultural heritage environment.

5.6.6.2 Inventory of Archaeological Sites along UGC Route

5.6.6.2.1 World Heritage Sites

There are no UNESCO World Heritage sites within 100km of the proposed UGC route. There are two candidate World Heritage Sites in close proximity, namely, the Céide Fields and north Mayo Boglands, and the Rathcroghan Complex.

The Céide Fields are located approximately 12km north of the proposed location for the converter station in north Mayo and the UGC route runs approximately 9.6km to the north of the Rathcroghan Complex.

5.6.6.2.2 National Monuments in the ownership or guardianship of the State

There are seven National Monuments in the ownership or guardianship of the State within 5km of the proposed UGC[62]. The nearest sites are Cashelmore (SLO46-011), an impressive stone fort near the top

[62] Appendix 13 Environmental Data for the HVDC Underground Cable Option

of a ridge overlooking Lough Gara, 2.5km to the north of the route, and Kildermot church, a possible Norbertine Abbey on the shores of Ballydermott Lough. The sites are located 2.5km and 2.6km to the north and north east of the UGC route respectively. The remaining sites are all in excess of 3km from the route.

5.6.6.2.3 National Monuments in the ownership of a Local Authority/Religious Sites

There are two religious sites (church/graveyards) in the Archaeological Survey Database located within 100m of the proposed route. These include a burial ground in Templemoyle/Coollagagh. This site lies adjacent to the proposed UGC route and is defined by a stone wall enclosing a mound with grave slabs, grave stones and modern memorials. Similarly the site in Cullin is found adjacent to the proposed UGC route near an old ford (Cullin is just west of Coolcashla – the church site is at a T-Junction just beside the UGC route). The site is overgrown and was the location of a 'pound' in the mid nineteenth century.

5.6.6.2.4 Sites and Monuments Record (SMR)

There are thirty-two recorded monuments within 100m of the proposed UGC route. Relative to other areas, Prehistoric sites are underrepresented in this inventory. There are two megaliths listed, one in Ballyglass, Moygownagh, set back from the road and a court tomb located in a field in Coollagagh, and in a poor state of preservation. A standing stone in Knockacorha is also well set back from the proposed UGC route.

Six enclosures and nine ringforts are found along the length of the proposed UGC route. These sites typically represent early medieval farmsteads (500-1100 AD) and over 45,000 have been found throughout the country. Ringforts are usually circular with a diameter of between 20 and 60 metres. They are defined by an earthen bank formed by material thrown up from a fosse or ditch immediately outside the bank.

Christian sites are represented by a single church at Cullin and a graveyard at Templemoyle/Coolagagh. There are no religious houses along the UGC route.

In many instances, along the UGC route, there are sites for which, in the absence of archaeological excavation, the precise date cannot be determined; many of these sites could date to either the prehistoric or early medieval period. These sites include an earthwork in Tullaghanrock and a mound in Breaghwyanteean. Later early modern sites associated with the 'Big house' and our industrial heritage include the designed landscape at Creggan, Roscommon and the water mill at Carrowmoremoy, Mayo.

5.6.6.2.5 Additional unrecorded sites

Seven new sites were discovered along the proposed UGC route during the field survey and a review of available aerial photographs and historic mapping. The majority of these sites were post medieval or relatively modern. These sites are as listed below.

Description	Townland	County
Possible enclosure	Gran	Mayo
Lime Kiln	Coolagagh	Mayo
Arch Feature	Cloonmore	Mayo
Lime Kiln	Barroe	Mayo
Tree Ring	Cavetown	Roscommon
Old bridge	Cloonacarrow	Roscommon
Church (2nd edition map)	Ballyderg	Roscommon

Table 5-10 Additional Unrecorded Sites Located Within 100m of the Proposed Route

5.6.6.3 Inventory of Architectural Sites

5.6.6.3.1 Architectural Conservation Areas

There are no Architectural Conservation Areas (ACA) in proximity to the UGC route.

5.6.6.3.2 Records of Protected Structures and the National Inventory of Architectural Heritage

Both the NIAH surveys and the Record of Protected Structures for Counties Sligo, Mayo and Roscommon were referenced as part of this report. It is notable that, relative to other counties, rural structures seem to be underrepresented or absent in the surveys, in particular bridges, of which there are a number of stone examples along the route e.g. Garranard, Moygownagh, Templemore and Breedoge. Three recorded sites, including a lime kiln at Edmondstown, a church at Boyle and a church at Creggan, are found within 100m of the UGC route.

5.6.6.3.3 Demesne Landscapes and Historic Gardens

Demesne landscapes and historic gardens appear as shaded areas on the OSI first edition mapping. In the preparation of this assessment OSI first edition mapping was used in conjunction with the NIAH Garden Survey to map all demesne landscapes and historic gardens within 100m of the proposed development. Twelve demesne landscapes are found in close proximity to the UGC route, only two of which have their main features substantially present. These demesnes include the Bishop's Palace at Edmondstown and the Glebe house at Cavetown[63]. The remaining sites are described as having unrecognisable main features.

5.6.6.4 Potential Impacts and Effects

The following list comprises an inventory of all the sites and monuments where the prescribed 'zone of notification' as defined in the Archaeological Survey of Ireland (ASI), extends into existing carriageways and may be impacted upon by construction works. The sites are listed geographically from west to east in the table below.

[63] Appendix 13 Environmental Data for the HVDC Underground Cable Option

SMR	Classification	Townland	County
MA021-045	Enclosure	Garranard	Mayo
MA039-008	Ringfort - rath	Ardagh (tirawley by.)	Mayo
MA039-073	Ringfort - rath	Corroy	Mayo
MA049-078001	Burial ground	Coollagagh	Mayo
MA049-080	Ringfort - cashel	Coollagagh	Mayo
MA049-083	Megalithic tomb - court tomb	Coollagagh	Mayo
MA049-093	Church	Cullin	Mayo
MA061-059001	Ringfort – rath	Graffy	Mayo
MA061-059002-	Souterrain	Graffy	Mayo
MA061-059003	Redundant record	Graffy	Mayo
MA061-074	Water mill - horizontal-wheeled	Carrowmoremoy	Mayo
RO008-025	Ringfort - unclassified	Tullaghanrock	Roscommon
RO008-051	Ringfort – rath	Ratra	Roscommon

Table 5-11 Sites with 'Zones of Notification' Extending into the Proposed Route

The majority of potential construction effects will be direct, physical impacts on known and previously unrecorded archaeological, architectural or cultural heritage sites, structures, monuments or features. Care has been taken during the early design stages to avoid such impacts as far as is practicably possible, taking into account all the other constraints.

UGC and associated works are unlikely to impact upon the setting of cultural heritage sites. The installation of cables within open trenches along existing carriageways will follow a route that has been previously disturbed. In the event of encountering cultural heritage remains, avoidance may be possible by re-routing the cables within a permitted planning corridor. If avoidance is not possible, the impact on the cultural heritage sites would represent a permanent, major adverse effect. It is important to note that it is difficult to ascertain the exact impact level prior to a programme of archaeological testing at these locations. The development of these roads, including their widening, re-grading and re-surfacing may have directly impacted on archaeological features and may have removed any sub-surface remains.

From a review of historic mapping it is clear that many of the local access roads pre-date the first edition ordnance survey (1829-1842) and developed from lanes connecting clachans and towns. Most of these roads would have generally respected the integrity of local landmarks and monuments; a notable exception to this being the ringfort at Tullaghanrock. Furthermore many of the roads traverse marginal land and were constructed on embankments. Elsewhere, particularly to the east of the scheme, many of the local roads post-date the first edition ordnance survey. Again these roads are through boggy ground of low agricultural value. This is significant as these areas generally have a low incidence of cultural heritage sites and few vernacular architectural features or street furniture.

5.6.6.5 Mitigation Measures for Cultural Heritage – UGC Option

Continuing consultation with the DAHG and other relevant stakeholders is necessary throughout the project timeline. Typical mitigation measures include the following:

- Avoidance – movement of cable route to avoid cultural heritage remains;
- Archaeological testing – in areas of high archaeological potential, pre-construction archaeological testing is recommended;
- Archaeological monitoring – monitoring of construction works by a qualified archaeologist in areas of moderate archaeological potential, or areas of high archaeological potential where preconstruction archaeological testing was undertaken. There is potential that archaeological deposits could be discovered during the construction phase;
- Demarcation to prevent any inadvertent damage – where there is the potential that an archaeological site or potential archaeological site will be impacted upon in gaining access to construct the proposed development;
- Archaeological excavation in the event of archaeological deposits being discovered where avoidance is not possible;
- The proposed development will not have a direct, physical impact on any designated architectural sites, including sites contained in the RPS, NIAH and Garden Surveys. There is the potential that some previously unrecorded architectural sites will experience direct, physical impacts in gaining access for construction. These sites will be highlighted for the contractor during the construction phase to ensure that they are not inadvertently impacted upon.

5.6.7 Settlement/Communities

5.6.7.1 Methodology

Settlements concern not only the impacts on towns and villages – which have largely been obviated by avoidance – but also impacts on rural housing.

This section sets out the likely impact and effect of the identified UGC option and converter stations on the amenity of settlements close to the cable route.

The UGC option has been examined from the point of view of its proximity to the towns and villages identified in the original Constraints Report[64] prepared for the Grid West project. In addition, using information from "Geodirectory", calculations were made of the number of rural houses located within certain distances (100m and 500m) of the route. These two distances were considered to give a reasonable measure of houses that might be impacted upon by the proposed cable route to a greater (100m) or lesser (500m) degree.

In addition, information was used from the report concerning the underground option with regard to the need to provide converter stations at either end of the underground line (see Appendix 8). This included information on the number of houses within the identified locations or within 1km of such locations.

[64] Appendix 16 The Grid West Constraints Report, August 2012

5.6.7.2 Review of UGC Route and Converter Stations

The identified UGC route follows the public road network. The UGC option will be relatively close to roadside houses along the route. The separation distances between the cable and the existing houses will result in little impact as the cable will be underground. The statistical figures for the identified UGC route are as follows:

- There are 648 residential buildings within 100m of the route; and
- There are 1,193 residential buildings within 500m of the route.

The route generally avoids towns and villages but, in following roads, this cannot always be possible. The route passes through three villages; Moygownagh and Ardagh in Co. Mayo and Curry in Co. Sligo.

There can be issues arising from the construction phase of the development of an UGC route along a public road:

- Excavation is required along the entire length of the cable and therefore on the public road;
- The excavation works will generate a significant amount of traffic congestion, diversion and delay; and
- Excavation for the UGC will be close to houses in some areas and therefore there may be excavations and associated potential impact on residential amenity.

The number of houses within the vicinity of the preferred converter station locations is as follows:

- There are 11 houses within 1km of the centre of the identified preferred converter station location, DCB2, at north Mayo; and
- There are 8 houses within 1km of the centre of the preferred location DCF7 at Flagford.

There is also the possibility that, in the future, a second converter station may be required for reasons of security of supply and future growth. The converter station has the potential to have a significant impact on established residential amenity, primarily by reason of visual impact and noise, particularly during the construction stage of such facilities.

It is also noted that the Flagford converter station will be in an area that accommodates the Flagford 220kV/110kV existing substation and its associated OHL. The north Mayo converter station location would incorporate the new north Mayo substation and the lines coming into that from various windfarm developments. The converter stations could, therefore, generate additional impact on established amenities in locations that are already the most affected of the entire line route.

5.6.7.3 Mitigation Measures for Settlements and Communities – UGC Option

Disruption to settlements and communities on the UGC route will largely be due to construction works and traffic, but this will be temporary. Mitigation Measures are proposed under the sections detailing Noise, Visual Impact and Traffic.

5.6.8 Air Quality

5.6.8.1 Methodology

In the absence of national guidance, publications from international organisations, such as the Institute of Air Quality Management (IAQM) provide guidance on construction dust and traffic assessments (IAQM, 2014). The IAQM represents a large body of international experts on the assessment of air quality impacts, and has published guidance on the assessment of construction dust.

The general methodology used in this appraisal is as presented in the National Road Authority's Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes. The appraisal includes:

- The identification of base case air quality conditions;
- Confirmation of the presence of sensitive receptors within the study area;
- Consideration of the potential for construction phase dust impacts with incorporated mitigation;
- Consideration of the potential for significant effects to be experienced at sensitive receptors as a result of a 10% change in Annual Average Daily Traffic (AADT) traffic flows (5% change for ecological receptors); and
- Assessment of the relative significance of air quality effects as a result of the UGC option.

The potential impacts from dust emissions generated during the construction phase of the UGC development are considered using an approach based on the Institute of Air Quality Management Construction Dust Assessment (i.e. screening assessment and risk based approach) (IAQM, 2014).

Construction plant emissions are not explicitly modelled, as these are considered to be a small emission source relative to ambient conditions.

The construction impact on road traffic is also considered, including the effect of HGVs. The assessment takes into consideration the construction phasing of the proposed development in order to ensure that the assessment is robust.

Sensitive receptors are considered during the appraisal. Sensitive receptors considered include both human and ecological receptors along the route of the proposed development, using the screening methodology set out in guidance published by the NRA and the IAQM. The guidance from the IAQM sets a distance of 350m from the construction site boundary, and 50m from any road extending 500m from the site entrance. This is a greater distance than that given in the NRA guidance, and includes a greater number of receptor locations. The construction assessment is based on the assumption that there will be receptors located close to the site boundary (or boundaries), as this provides a conservative assessment of dust and traffic related impacts.

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 PM_{10} and $PM_{2.5}$ respectively), which can have an impact on sensitive receptors (both human and ecological) in the vicinity of the works.

Data sources that are considered in the assessment include EPA monitoring results, and published background information. There is currently no local monitoring data along the route of the proposed development; however monitoring data has been reported for the wider study area (EPA, 2014).

5.6.8.2 Base Case Conditions

The current air quality in the area of the proposed development is reported as 'good' by the Environmental Protection Agency (EPA). One rural monitoring site is in operation in the rural west region, located in Claremorris. This site reports PM_{10} and $PM_{2.5}$, both of which are well below the air quality standard set out in the Air Quality Standards Regulations above.

At present, existing sources of dust contribute to the base case rates of dust deposition experienced by receptors within the study area. These sources include long range transport of $PM_{2.5}$, the formation of salts from gaseous emissions, dust emissions from agricultural activities and urban areas. Receptors are accustomed to the base case conditions and may be able to perceive changes in the dust deposition rate if these changes are large enough. There is no evidence that base case dust deposition rates cause annoyance to receptors within the study area.

5.6.8.3 Review of UGC Route and Converter Stations

The construction of the UGC and converter stations has the potential to impact on local air quality. During the operational phase, there will be no emissions and therefore no impact on air quality. This assessment will focus on the construction phase, with operational phase emissions being scoped out.

5.6.8.3.1 <u>Potential Impacts</u>

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 of the development.

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 road network over an extended area.

5.6.8.3.1.1 Construction Impacts and Effects

Demolition:

There is no demolition work anticipated to be required along the UGC route.

Earthworks:

The principal earthworks associated with the UGC are the excavation of a trench along the length of the construction site, and the 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). The associated converter station sites at either end of the cable route will, however, fall into the large category of site (>10,000m^2) although they will be further removed from receptors than the excavations along the cable route itself.

The potential for stockpiles of materials to generate dust depends on the nature of the material. Earth is soft and friable compared to hard-core. However, hard-core generally has a lower moisture content than soil, and consequently they can both be a potential source of dust.

Construction:

Dust emissions during construction can give rise to elevated dust deposition and PM_{10} 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 cable 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 PM_{10} concentrations at any nearby receptors.

The converter station sites will be large but will not be as close to sensitive receptors as the cable route works. Nonetheless these sites will present a higher risk to any nearby sensitive receptors. Again, with good site practice the construction work will have an imperceptible impact on dust deposition rates and short-term PM_{10} concentrations at any nearby receptors

Track-out of Material:

The number of vehicle movements at each cable-laying site associated with the development is likely to be low due to the scale and nature of the works required. 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 the cross country sections at the crossing of the River Moy and River Lung, and at the converter station sites, 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.

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 PM_{10} concentrations at any nearby receptors.

5.6.8.3.1.2 Construction Traffic Impacts and Effects

The construction phase of the development is likely to lead to a small increase in the number of vehicles on the local highway network, for the duration of the construction works only. Research conducted in the UK by Environmental Protection UK (EPUK) (EPUK, 2010) set criteria to establish the need for an air quality assessment for the construction phase of a development:

> *"Large, long-term construction sites that would generate large HGV flows (>200 per day) over a period of a year or more."*

It is unlikely that a development of this size would lead to this number of vehicle movements at any one point along the length of the line. The additional number of vehicle movements is therefore not considered to be high enough to have the potential to cause a significant adverse effect to any local air quality sensitive receptor.

The development has the potential to cause disruption to traffic along roads affected by construction, and change traffic flows along roads in the vicinity. As the background levels of pollutants are very low, it is unlikely that such disruption would significantly contribute to pollutant levels in the vicinity of the construction works. It is therefore unlikely to exceed the air quality standards.

The UGC option will consist of a series of construction sites, which for the most part will follow the route of the existing road network. This is likely to take it close to a number of sensitive receptors along the route, increasing their exposure to dust and air pollutants.

Overall, the effect on local air quality as a result of the works along the cable route and at converter station sites will be negligible. It also has the potential to affect traffic flows due to construction, which, in turn, has the potential to increase pollutant concentration at sensitive receptors over a wider area than in the vicinity of the construction sites.

Underground Cable Route Option (Impacts and Effects)
The majority of construction works will take place at sites located along roads, potentially over a long distance, closer to receptors; large sites at converter stations, further removed from receptors. Potential impact on humans and environmental features such as ecology. Impact of dust, air borne pollutants will have a temporary, negative impact during the construction phase.
Large potential to impact traffic flows and cause diversions for commuters and a temporary increase in traffic and vehicle emissions to the alternative routes.
Impacts from construction can affect receptors over a wide area due to changes in traffic flows.

Table 5-12 Summary of Potential Air Quality Impacts and Effects for the UGC Route Option

5.6.8.4 Mitigation Measures for Air Quality – UGC Option

Mitigation measures/ good practice 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 the converter station sites and other relevant locations along the route, particularly where the cable route travels across country at the crossings of the River Moy and River Lung, south of Lough Gara.

The local external road network will be swept and washed regularly using a specialist vehicle. Site roads will be regularly cleaned and maintained as appropriate.

Placing activities which are a potential source of PM_{10} such as cutting and grinding of materials and cement mixing (if there is any) away from boundaries would minimise the possibility of exposure to PM10 at receptors within 30m of the site boundary.

These measures will be outlined in further detail in a Dust Control Plan. The plan will also address the storage of construction vehicles, plant and machinery, un-surfaced roads and speed restrictions, material handling and storage to avoid exposure to wind.

5.6.9 Climatic Factors

5.6.9.1 Introduction

As with the majority of large civil engineering projects using plant and equipment, emissions to air are inevitable during the construction phase. However, this relatively short-term impact should be considered alongside the long-term benefit of the development. The Grid West project will have net positive impacts in allowing the development of renewable energy sources in the west of Ireland, thereby reducing the national dependence on fossil fuels. This in turn yields a relative reduction in the emission of airborne pollutants, and a consequent improvement in air quality (as discussed in Section 5.6.8).

The study area for this assessment considers an area of approximately 2km either side of the indicative UGC route.

5.6.9.2 Global Warming

The management of emissions with the potential to contribute to global warming is increasingly important nationally and internationally.

Ireland's 2020 target, according to the EU Climate Change and Energy Package, is to reduce CO_2 emissions by 20% and to increase renewable energy production by 16%. The main policies implemented by Ireland are to source 40% of national electricity requirements from renewable energy by 2020. Other policies include improving the quality of and participation in public transport, use of bio-fuels, higher energy conservation in building standards, schemes to improve recovery/recycling of waste streams and better agricultural and forestry management.

5.6.9.3 Review of UGC Route and Converter Stations

5.6.9.3.1 Transmission Energy Efficiency

The UGC option will facilitate the development of renewable power generation in north Mayo, by enabling the installation and integration of renewable energy sources. It will also reduce the overall consumption of fossil fuels in Ireland therefore having a net positive benefit of reducing carbon emissions. The proposed development will comprise a major improvement in electricity transmission system infrastructure.

5.6.9.3.2 Emissions from Construction Traffic

Construction traffic associated with the construction of the UGC will contribute to existing traffic levels on the surrounding road network. However, these will be short lived and will not be of sufficient numbers to adversely affect climate.

5.6.9.3.3 Sulphur Hexafluoride (SF_6)

SF_6, which is a potential pollutant, is used as an insulating gas in substations and as an insulating and arc quenching medium in switchgear for high and medium voltage applications. These are all closed systems, which are extremely safe and unlikely to leak. SF_6 is non-flammable.

$SF_6$is a powerful greenhouse gas but very little is released into the atmosphere, so the contribution to the greenhouse effect is low. Global SF_6, that is SF_6released to the atmosphere, is a very stable gas. However calculations show that SF_6contributes less than 0.1 per cent to the total greenhouse effect.

On-site equipment which contains SF_6will be hermetically sealed to prevent leakage. Specialised gas handling equipment is used when recovering contaminated SF_6 gas from electrical equipment and the gas loss to atmosphere is minimal.

For each of the options considered there is no significant difference in the amount of SF_6 filled equipment required. Hence, each option can be considered equally impacted.

5.6.9.4 Mitigation Measures for Climatic Factors– UGC Option

It is anticipated that the project in general will have a positive impact on the climate and is not in need of mitigation.

5.6.10 Material Assets

5.6.10.1 Methodology

This section of the report reviews the UGC option and its potential impacts on material assets and land use. Impacts during both construction and operational phases are assessed. The construction phase is predicted to last approximately 36 months. The operational phase of a major power transmission project such as Grid West could be expected to be 50 to 80 years, during which there will be routine maintenance and refurbishment of the infrastructure.

The scope of the evaluation of this report is confined to material assets and land use including:

- agricultural land;
- horticultural land;
- forestry;
- bogs/peat;
- land;
- houses; and
- commercial properties and community properties (e.g. sports grounds, golf courses, churches, community centres).

This evaluation identifies locations along the proposed UGC route option where potential significant impacts may occur.

Road side surveys were conducted in September 2014 and consultations were held with project public liaison personnel. In addition, the following information sources were referred to:

- Examination of aerial photography;
- Central Statistics Office (CSO) data from the 2010 Census of Agriculture;
- Soils & Subsoils Class digital data downloaded from the EPA website in September 2013;
- National Forestry Inventory (2007) (Republic of Ireland);
- Electricity Supply Board (ESB) and Irish Farmers Association (IFA) (October 1985). Code of Practice for Survey, Construction and Maintenance of OHL in Relation to the Rights of Landowners;
- ESB and IFA (September 1992). Agreement on Compensation for Loss of Tree Planting Rights; ESB Networks;
- *Farm Well, Farm Safely* (http://www.esb.ie/esbnetworks/en/safety-environment/safety_farm.jsp)*;*
- Categories of Disadvantaged Areas on the Department of Agriculture Food and Marine Website (http://www.agriculture.gov.ie/farmerschemespayments/singlepaymentschemedisadvantagedar easschemebeefdataprogrammebdp/categoriesofdisadvantagedareas/);
- Environmental Protection Agency (EPA) (2002), Guidelines on the Information to be contained in Environmental Impact Statements; and
- Design Manual for Roads and Bridges (UK) Vol 11, Section 2 Part 5, Determining Significance of Environmental Effects (2008), published by the UK Highway Authority

The methodology for the evaluation of the sensitivity of the base case environment refers to guidelines for sensitivity categorisation set out in the *Environmental Protection Agency (EPA) (2002), Guidelines on the Information to be contained in Environmental Impact Statements*. The relevant categories for this evaluation are:

- Very Low sensitivity – cut away bogs and very poor agricultural land;
- Low sensitivity – bogs where there is active turf extraction and poor quality agricultural land;
- Medium sensitivity – non-dairy livestock enterprises on medium and good quality land;
- High sensitivity – dairy livestock enterprises on medium and good quality land; and,
- Very High sensitivity – forestry, stud farms, horticultural enterprises, intensive livestock enterprises (pigs & poultry), houses, commercial properties, community properties, quarries and landfill site.

The above sensitivity categories are subject to professional judgement and there may be site specific factors which may alter the above general classifications; for example a non-intensive dairy enterprise in poor quality land may be classified as medium sensitive or a small scale commercial property may be classified as high sensitivity.

The methodology for the evaluation of the significance of impact refers to guidelines for sensitivity categorisation set out in the *Environmental Protection Agency (EPA) (2002), Guidelines on the Information to be contained in Environmental Impact Statements* and *Design Manual for Roads and Bridges (UK) Vol 11, Section 2 Part 5, Determining Significance of Environmental Effects (2008), published by the UK Highway Authority.* The significance categories in this evaluation are:

- An 'Imperceptible' impact is either an impact so small that it cannot be measured or is capable of measurement but without noticeable consequences;
- A 'Slight Adverse' impact causes noticeable changes in the operation of a material asset in a minor or slight way;
- A 'Moderate Adverse' impact changes a material asset, causing operational difficulties that require moderate changes in the management and operational resources;
- A 'Major Adverse' impact changes a material asset so that the asset cannot be continued, or if continued will require major changes in management and operational resources; and
- A 'Profound Impact' changes the material asset in a way that it obliterates the sensitive character of a material asset.

The material asset in this evaluation is agricultural land (including farm yards), houses, commercial property, community property, quarry, forest, bog and landfill site.

5.6.10.2 Review of UGC Route Option and Converter Stations

5.6.10.2.1 Existing Environment

The UGC route will cross through Mayo, Sligo and Roscommon for approximately 52.5%, 7.5% and 40% respectively of its total length and will be built mainly on public road carriageway. It will be constructed on agricultural land, bog, forestry and private access roads in the following areas:

- Doonanarroo Lower, Co. Mayo – the UGC will be constructed from the identified converter station for approximately 170m on a private access road;
- Carrowkeribly, Co. Mayo (River Moy crossing) – the UGC will be constructed for approximately 500m on agricultural land and for approximately 390m on a privately owned entrance road;
- Tullaghanrock, Banada and Keelbanada, Co. Roscommon the UGC will be constructed on a privately owned track for approximately 120m, agricultural land for approximately 530m, bog for approximately 690m and commercial forestry for approximately 140m.

5.6.10.2.2 Agricultural Land (Farms)

The townlands in Mayo, Roscommon and Sligo along the UGC route are all categorised as "Severely Disadvantaged" according to the database on the Department of Agriculture Food and Marine Website indicating poor and medium land quality. Farm types in Counties Mayo, Roscommon and Sligo are shown in the table below.

	Mayo	Roscommon	Sligo	State
Average Size	22.4 ha	27.1 ha	26.3 ha	32.7 ha
Relative Economic Output[65] (compared to state average)	37%	44%	39%	100%
Dairy[66]	2.5%	1.5%	3%	11%
Non-dairy grazing livestock and hay & silage crops[67]	97%	98%	96.5%	84.5%
Other[68]	0.5%	0.5%	0.5%	4.5%
Forestry (% total land cover)[69]	8%	7.5%	9.7%	9%

Table 5-13 Agricultural Statistics for County Mayo, County Roscommon, County Sligo and the State Along the UGC Route (Central Statistics Office 2010 Agricultural Census, Tables 1, 2 and 3.)

Based on the farm types, the sensitivity of the agricultural environment at each side of the UGC route is mainly medium. In Carrowkeribly, Tullaghanrock, Banada and Keelbanada the UGC route will cross approximately 1,030m of medium and poor quality grassland. The sensitivity of this section of the UGC is medium.

In addition, the road side surveys along the UGC route and examination of aerial photography indicated that:

- The land West and north west of Ballina (along the UGC route), although mixed in quality, has a higher proportion of medium to good quality land and dairy enterprises;
- In addition to approximately 680 houses, many of which have associated farmyards, there are approximately eighty farmyards without houses with access on to the UGC route;
- There is a pet farm in Lissymulgee, Co. Mayo which is classified as very high sensitivity;
- There were no intensive livestock (pigs or poultry) enterprises along the indicative UGC. These are generally classified as high or very high sensitivity;
- There is one mushroom enterprise in Fairfield Lower, County Mayo and a horticultural enterprise (farm shop) in Corroy, Co. Mayo. The sensitivity of these two horticultural enterprises is high and very high respectively. No other horticultural enterprises were noted; and
- There were no yards, stud railing or farm layouts which might indicate intensive equine enterprises or stud farms. A small equine enterprise with exercise area was noted in Cloonshaghan, Co. Roscommon.

65 Table 3 of 2010 Agricultural Census.
66 Column 3, table 2 of 2010 Agricultural Census.
67 Columns 4, 5, 6, 7 & 8, table 2 of 2010 Agricultural Census.
68 Columns 1 & 9, table 2 of 2010 Agricultural Census.
69 Table 2.1.3 *National Forestry Inventory* (2007)(Republic of Ireland)

5.6.10.2.3 Bogs/Peatland

Approximately 11% (12.3km) of the UGC route adjoins bog/peatland. The UGC will cross approximately 690m of bog in Keelbanada, Co. Roscommon. These areas are very low - low sensitivity from a material assets assessment point of view.

5.6.10.2.4 Forestry

Approximately 5% (5.3km) of the UGC route is adjacent to forestry plantations which are classified as very high sensitivity. The UGC will cross approximately 140m of forestry in Keelbanada, Co. Roscommon. The forestry plantations are very high sensitivity from a material assets assessment point of view.

5.6.10.2.5 Other Land Use (Quarry Sites)

There are entrances to three quarry sites along the UGC route at Bunnafinglas, Corradrishy and Boherhallagh, Co. Mayo. These quarries are high - very high sensitivity from a material assets assessment point of view.

5.6.10.2.6 Private Residential Properties

There are approximately 680 houses with entrances on to the UGC route (many of these have associated farm yards). The sensitivity of houses is very high.

5.6.10.2.7 Commercial Properties and Other Community Properties

There are approximately sixteen commercial and twenty community properties, listed in Appendix 13, with access on the UGC route. The sensitivity of commercial and community properties is very high.

5.6.10.3 Potential Impacts and Effects

5.6.10.3.1 Agricultural Land (Farms)

Potential construction phase impacts of the UGC option are:

- There may be temporary disturbance caused due to the restriction of access to agricultural land (including farmyards) with roadside access;
- Where the UGC is constructed on agricultural land (1% of the route), there will be significant, temporary disturbance to livestock and farm operations for the duration of construction, which will be approximately six to eight weeks at the site in Carrowkeribly and ten to twelve weeks at Tullaghanrock /Banada/Keelbanada;
- Additional land may be required for the duration of the construction period for;
    - Material construction yard;
    - Alternative temporary access routes which may be required;
    - Small construction sites may be required along the length of the UGC route for the delivery of material and parking machinery and equipment;
    - Working sites at the river crossings; and
    - Working sites at the cable joining bays.
- At the site of converter stations construction activity will occur over approximately 18 - 36 months with the consequent potential for disturbance near the boundary of these sites;

- Land drainage may be affected due to excavations at construction sites on agricultural land; and,
- Other potential construction phase impacts include damage caused due to fuel and/or concrete spillages at construction sites and contamination of drinking water sources due to surface water run-off.

Operational phase impacts are:

- Permanent agricultural land area reductions will occur at the two converter station sites (approximately 9.6 ha) and there may be small additional land requirements for the construction of the cable joint bays and inspection kiosks along the UGC route – an assumption of up to 4ha has been made for these;
- Some residual soil damage will occur at the construction sites and where the UGC crosses agricultural land.

After consideration of these potential impacts, in general, the significance of impact is expected to be imperceptible for the majority of the agricultural land on the UGC route. At the two converter station sites the potential impacts are in the slight adverse to profound adverse range.

5.6.10.3.2 Bogs/Peatland

Land drainage may be affected where excavations occur on bogs (approximately 690m in Banada and Keelbanada, County Roscommon). There may be small additional land requirements for the construction of the cable joint bays and inspection kiosks along the UGC route – an allowance of up to 1ha has been made;

After consideration of these potential impacts, in general, the significance of impact is expected to be imperceptible for bogs on the UGC route.

5.6.10.3.3 Forestry

When the UGC is constructed on existing roads there is no requirement to clear trees in adjoining commercial forests because an existing set-back exists along the road - 10m and 20m for deciduous and conifer plantations respectively. Therefore for the majority of the 5.3km of forests adjoining the UGC route there will be an imperceptible impact. The UGC will be constructed on 160m of forestry in Keelbanada, County Roscommon and the impact here will be slight adverse – moderate adverse in significance.

5.6.10.3.4 Other Land Use (Quarry Sites and Landfill)

The UGC route will cross the entrance to three quarries in Bunnafinglass, Corradrishy and Boherhallagh County Mayo. The road works may cause a low level of temporary disturbance to traffic in and out of the quarries with an imperceptible impact (i.e. continuous access is maintained).

5.6.10.3.5 <u>Private Residential Properties</u>

The road works during construction phase along the public road and along privately owned access roads will cause a temporary disturbance to the approximately 680 houses with accesses on the UGC route. There will be periodic maintenance work which will require access to the UGC line which may also cause disturbance. Many of the roads along the route have carriageway widths of 2 – 2.5m and therefore the entire width of the road will be required for the construction works. This will result in road closures and diversions with subsequent high levels of temporary disturbance for some local houses.

The majority of impacts will be imperceptible.

5.6.10.3.6 <u>Commercial Properties and Other Community Properties</u>

The road works during construction phase along the public road and along privately owned access roads will cause a temporary disturbance to the sixteen commercial properties and twenty community properties with accesses on the UGC route. There will be periodic maintenance work which will require access to the UGC which will also cause disturbance.

Assuming industry standard mitigation measures are employed and continuous access is maintained the impact will be imperceptible.

5.6.10.4 Conclusions

Material Asset	UGC Potential Impact/Effect
Agricultural Land	Sensitivity of agricultural environment is medium – low. UGC route is non-agricultural for >98% of its length. Temporary soil disturbance during construction will have a high level of impact on 1,030m where UGC crosses agricultural land. Permanent land requirement = approximately13ha. Temporary disturbance to access along public and private roads. Overall impact on majority of agricultural land is imperceptible. Impacts in the slight adverse–profound range may occur at two converter station sites. There will be no cumulative impacts at locations where the existing OHLs cross the proposed UG.
Bog	Approximately 11% of the UGC route adjoins bogs. Sensitivity of bogs/peat land is low or very low. UGC route will cause minimal disturbance. Permanent land requirement will be very low – approximately 1ha. Overall impact on majority of bogs/peat land is imperceptible.
Forestry	Approximately 5% of the UGC route adjoins forestry plantations. No additional set back distance required for existing forestry along public roads. Overall impact on forestry plantations is imperceptible.
Quarries & Landfill Site	Imperceptible impact on three quarries.
Private Houses	High level of temporary disturbance to approximately 680 houses with accesses on public roads. When considered over the total operational phase the impact will be imperceptible.
Commercial Properties	High level of temporary disturbance to approximately16 commercial properties with accesses on public roads. When considered over the total operational phase the impact will be imperceptible.
Community Properties	High level of temporary disturbance to approximately 20 community properties with accesses on public roads. When considered over the total operational phase the impact will be imperceptible.

Table 5-14 Summary of Potential Impacts and Effect on Material Assets from the UGC Option

5.6.10.5 Mitigation Measures for Material Assets – UGC Option

The material assets impacts are closely related to the landscape and visual impacts and the construction traffic impacts and as such the mitigations relevant to these areas apply equally to impacts on material assets.

5.6.11 Recreation and Tourism

5.6.11.1 Methodology and Background

The value of overseas tourism for each county in Ireland is available from statistics published by Fáilte Ireland[70]. The figures for Counties Roscommon and Mayo are presented in the table below, along with figures for Counties Dublin and Longford, in order to give an indication of the value of tourism to the area within a wider context.

County	Overseas Visitors ('000)	Associated Revenue (€ M)
Roscommon	35	13
Mayo	218	60
Dublin (Highest)	3,998	1,251
Longford (Lowest)	22	6

Table 5-15 Overseas Visitors Numbers and Economic Value

Figures for domestic tourism for each county are not available as statistics are only collected in relation to overseas visitors. However, the importance of domestic tourism is highlighted by the fact that Fáilte Ireland estimated that domestic visitors took almost 7.1 million trips and generated expenditure of €1.4 billion in Ireland in 2013.

Recreation and Tourism considerations include:

- Landscape/Visual Impact;
- Recreation and Sports Amenities;
- Fishing/Angling Clubs; and
- Traffic Diversions during the construction phase.

5.6.11.2 Review of UGC Route and Converter Stations

5.6.11.2.1 <u>Landscape/Visual Impact and Effect</u>

As Tourism primarily derives from Landscape features and characteristics, please refer to Section 5.6.5 for Landscape and Visual impact and effect.

[70] http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/2_Regional_SurveysReports/Regional-tourism-performance-in-2013.pdf?ext=.pdf

5.6.11.2.2 Recreation and Sports Amenities

All residential and commercial centres (towns/villages and areas of high population relative to the surrounding environment), recreational facilities and parks and sports amenities, including golf courses and sports clubs such as GAA clubs, were avoided during the route selection stage of the UGC option i.e. the cable route does not directly cross any of these amenities.

5.6.11.2.3 Fishing/Angling Clubs

Both Roscommon and Mayo have areas of valuable angling tourism. The construction of the UGC route option will involve construction of the cable along local roads (primarily) which may result in surface water runoff and disturbance to nearby drainage ditches and streams if not mitigated during the construction phase. Horizontal directional drilling is also proposed in order to route the cable across a number of water features located along the route, including the River Moy and River Lung, as described in the UGC Report[71]. Careful mitigation will be required during the construction phase to ensure that surface or groundwater runoff from the construction works, possibly containing a high volume of suspended solids and/or contaminants, does not enter any water course untreated and potentially impact on the quality of the salmonid waters along or in proximity to the route.

5.6.11.2.4 Construction Works

During the construction phase of the UGC route, works will take place primarily within local roads. As a result construction activities and localised traffic diversions will be visible at varying locations along the route throughout the construction phase of the development. It is anticipated that the longest of these diversions will last up to two or three months. These diversions may impact on tourists visiting the area, although this would depend upon the timing of road closures. Impacts and effects from maintenance traffic during operation will be sporadic and temporary and are considered to be negligible with regard to tourism locations.

5.6.11.3 Mitigation Measures for Recreation and Tourism – UGC Option

Recreation and tourism impacts will arise primarily from the landscape and visual impacts of the converter stations and the disruption during construction of the cable and the stations. The visual impacts of the converter station sites, which are not located in tourist areas, will be mitigated through landscaping and screening. Traffic disruption will be mitigated by planning and management as described below, taking cognisance of local tourism and recreation events such as sporting occasions, fairs, and parades.

5.6.12 Traffic

5.6.12.1 Methodology

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

[71] Appendix 8 Underground Route Options Preliminary Evaluation Report, July 2014

mitigation measures along national or regional roads or at points where these roads are crossed are also considered.

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. 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.

5.6.12.2 UGC Route

Where possible, the preferred UGC route follows local roads in order to minimise disruption to traffic on national 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 fully upgraded.

5.6.12.3 Cable Construction Methodology and General Comments

Details of the construction methodology for the UGC can be found in the UGC Report[72].

Significant disruption to traffic is expected 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.

Where the cable is routed off road, construction of temporary access roads will be required to allow construction crews access with heavy machinery. In particular, locations requiring horizontal directional drilling works will require sufficient access and surrounding areas will experience an increase in traffic from construction vehicles. The size and location of these areas will vary depending on the complexity of the crossing point, increasing in size from minor streams and rivers to larger river crossing points such as the River Moy, Owengarve River, Lung River, and the Owenmore River.

[72] Appendix 8 Underground Route Options Preliminary Evaluation Report

5.6.12.4 Population Centres

As part of the route selection process towns and villages were avoided where possible. There are, however, some areas where the route passes close to or through towns or villages or runs along or across roads which carry traffic to these population centres. There may, therefore, be traffic impacts some distance from the cable route itself, depending on the volumes of traffic and the time of year during which construction takes place.

Towns and Villages:

At construction stage there will be a general increase in the number of construction vehicles on the main routes to the site, with some impact to traffic in nearby towns and villages expected.

Traffic travelling to and from the towns and villages listed below may experience an impact during construction along the roads indicated:

- **Towns:**
  - Carrick-on-Shannon (R370);
  - Boyle (N61 crossing);
  - Frenchpark (R361);
  - Ballaghaderreen (R293);
  - Charlestown (N17 crossing);
  - Swinford (no likely impact);
  - Foxford (N26 crossing);
  - Ballina (N26 and N59 crossings and R310 from Knockmore); and
  - Crossmolina (N59 crossing).
- **Villages:**
  - Curry (N17 and L4902);
  - Knockmore (R310);
  - Knockanillaun (N59 crossing and Local access road to south of village); and
  - Moygownagh (R315).

Construction activity at the identified converter stations in north Mayo and Flagford will also generate significant traffic disruption from construction vehicle movements and from the transportation of abnormal loads to the station.

5.6.12.5 Route Intersections with National or Regional Roads

There are a number of key sites along the UGC route at which national or regional roads will be intersected.

Many of these locations are single carriageway roads and may require full or partial closure of the road. This will result in significant impact to local traffic, and regional traffic. Each location has been considered individually and possible traffic management has been suggested in order to determine the potential impact on traffic whilst the works are carried out.

In some cases the road may have sufficient width to allow phasing of the works to accommodate a partial closure of the road together with a Stop/Go system. STOP & GO/Téigh discs, using trained Traffic Management Operatives (TMO) to manually control the shuttle operation, will be employed to allow the traffic flows to move according to the demand. This allows one carriageway to remain open to traffic throughout the duration of the works, hence reducing the overall traffic impact. However it is envisaged that temporary closures are likely in all locations due to the nature of the works. In these instances a diversion to the adjacent local road network will be required.

5.6.12.6 Local Roads

The route of the UGC generally follows local roads which are likely to have low traffic volumes. This approach should keep impact on traffic to a minimum, as due to the dense local road network in the area diversion routes should be possible without significant affect to local journey times.

5.6.12.7 Rivers

It is intended that rivers along the cable route will be crossed using the horizontal directional drilling technique. Further details of this method of drilling can be found in the UGC Report[73]. Whilst river crossings will not directly affect traffic, where the cable route intersects some of the larger rivers the required works may last an extended period of time, and require additional site traffic and works areas. At these locations it is envisaged that the local area will experience an increase in site traffic for the duration of the works. Major river intersections have been identified as listed below; minor rivers and streams have not been listed but there are 43 in total, including:

- The Breedoge River at R361 (Breedoge Bridge);
- The Lung River north of Ballaghaderreen;
- The Owengarve River at Carracastle;
- The River Moy East of Killasser, north east of Foxford and north of Knockmore; and
- The Owenmore River at Moygownagh.

5.6.12.8 Railway Lines

The UGC route crosses an existing railway line (single track to Ballina), close to the townland of Shanlogh. The crossing of the railway line will be carried out by horizontal directional drilling.

The route then follows along the R310 Regional road to Ballina, running parallel to the existing railway line for approximately 3.5km as noted above.

The route crosses a disused railway north of Charlestown, near the village of Curry. This may be crossed using horizontal directional drilling, if required, and it should not have significant traffic issues or affect the road network.

At these locations, trenchless techniques (horizontal directional drilling) will be used to install the duct underneath the railways. Whilst site access will be required for this process with possible increase in

[73] Appendix 8 Underground Route Options Preliminary Evaluation Report, July 2014

traffic due to site vehicles, it is envisaged that the operational railway line will remain open throughout installation.

5.6.12.9 Mitigation Measures for Traffic – UGC Option

While the UGC construction works would be temporary and short-term, the main impacts along the route will be possible temporary traffic diversions and short-term access limitations. In addition, construction works will result in some disruption to traffic due to temporary road closures, temporary traffic lights and detours.

A detailed Traffic Management Plan (TMP) will be developed prior to construction in consultation with Mayo, Sligo and Roscommon County Councils and in accordance with Department of Transport Guidelines. 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. 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.

5.6.13 Noise

5.6.13.1 Introduction

It is considered likely that the UGC route option and converter stations will result in noise (and possibly vibration) effects at nearby sensitive receptors during the construction and operational phases.

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. 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.

Operational noise impacts and effects from the converter station are long-term and any identified significant impacts should be mitigated, if possible, at the design stage. Noise impacts may result from operation of the converter stations. There is no noise from the operational UGC.

The assessment of noise and vibration of the final scheme will comprise:

- The identification of base case noise conditions and affected sensitive receptors;
- Estimation and assessment of construction phase impacts;
- Estimation and assessment of operational phase impacts;
- Estimation and assessment of traffic noise changes during the construction and operational phases on affected roads as determined by the traffic assessment; and
- Identification of mitigation measures required to control short-term and long-term noise and vibration impacts resulting from the construction and operation phases.

5.6.13.2 Sensitive Receptors

Sensitive receptors include residential, community, religious and educational premises within the route corridor. 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.

5.6.13.3 Base Case

Specific base case noise level data is currently not available for the UGC option. However, considering that the UGC route passes through rural areas, ambient noise levels are likely to be low, particularly at night time, but will be slightly higher in areas closer to the road network.

5.6.13.4 Construction Noise and Vibration, including Converter Stations

In addition to works along the route, the construction and operation of converter stations at each end of the route will also be required.

Noise generating activities are likely to include (but are not restricted to):

- Enabling works including; vegetation removal, construction compound site development;
- Trench excavations;
- Horizontal directional drilling at major river and stream crossings along the route;

- Cable installation and backfilling;
- Road surfacing;
- Construction traffic;
- Re-distribution of network traffic due to road closures;
- Extension/construction of substation/converter station infrastructure; and
- Discrete or 'one-off' construction activities such as the transportation of abnormal loads e.g. transformers, to substation locations will also require consideration.

The locations and intensity of UGC laying works have the potential to result in significant short-term noise impacts to sensitive receptors. The resulting impacts would be related to the activities and plant employed to implement the selected cable installation method.

5.6.13.5 Operational Noise and Vibration, including Converter Stations

Operational noise sources relating to the underground option are restricted to fixed noise sources, and scheduled or emergency maintenance/repairs. Operational noise from the cable is not a consideration for the UGC option.

5.6.13.6 Fixed Noise Sources

Fixed noise sources relevant to the UGC option will include converter station infrastructure. Early detailed assessment and the specification of any required mitigation for incorporation in the design process should eliminate / minimise any potential noise impacts.

5.6.13.7 Scheduled and Emergency Repairs

Power failure incidents on UGC 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.

5.6.13.8 Summary of UGC Noise Impacts and Effects

In summary, the UGC option follows the existing public road network, and therefore passes close to existing sensitive receptors within the settlements linked by the road network. The displacement of traffic during the underground construction may result in temporary increases in road traffic noise at receptors; however the resurfacing of roads following cable laying is likely to improve road conditions and could be seen as a beneficial effect overall. Underground lines produce no audible noise.

Phase	Underground Cable Option Summary (Including Impacts and Effects)
Construction	Continual line of construction works, potentially over a long distance.
	Prolonged construction activities along length of route.
	Located along roads, closer to receptors.
	Located close to settlements and potentially affecting more receptors.
	Potential to temporarily impact traffic noise due to traffic displacement.
	Impacts from construction can affect receptors over a wider area due to changes in traffic flows and construction activity.
Operation	No audible noise from UGC – positive effect.
	Converter station noise – potential negative effect.
	Maintenance and repair over extended amounts of time – long –term, temporary negative effect.

Table 5-16 Summary of Potential Noise Impacts and Effects from the UGC Option

5.6.13.9 Mitigation Measures for Noise – UGC Option

Noise generating activities are likely to occur predominantly during the trenching works and the construction of the converter stations in the initial 12 months of development. 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 British and/or 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.

The converter station designs will incorporate noise attenuation such that during operation, noise associated with building services and operational plant in totality will be controlled and will not exceed a contributory noise level at the boundary of the proposed development site. No noise will be generated from operation of the cable.

5.6.14 UGC Option Residual Effect

Detailed environmental assessment will be carried out following selection of the preferred option that will inform an EIS and AA in accordance with the Habitats Directive. At this stage it is considered appropriate only to provide a high level environmental appraisal of potential significant impacts and effects, mitigation measures and any associated residual effects, based on desktop studies and fieldwork completed to date.

On the basis of the identified possible mitigation measures, the anticipated residual effect on each environmental parameter as a result of the UGC option, as developed to date, is presented in the table below.

5.6.15 Summary of the Environmental Analysis of the HVDC UGC Route

	HVDC UGC		
	Significance of Impact/Effect	**Ease of Mitigation**	**Residual Effect (following mitigation)**
Biodiversity, flora and fauna;			
Water[1]			
Soil			
Landscape and Visual			
Cultural Heritage			
Settlements and Communities			
Air Quality[1]			
Climatic Factors			
Material Assets			
Recreation and Tourism			
Traffic and Noise[1]			
Noise[2]			

Notes:

1. During construction
2. During operation

More significant
Difficult to Mitigate
More Likely

Less significant/
Possible to Mitigate
Less Likely

Table 5-17 Summary of the Environmental Analysis of the HVDC UGC Route

The summary of the environmental analysis of the UGC option, as shown in the table above, highlights the fact that the assessment of this option is influenced by the intention for the cable route to be primarily located along existing public roads but that significant construction works will be required along the route. Permanent surface structures will include converter stations at each end of the route.

Overall, the anticipated environmental impacts and effects of the UGC option are considered at this stage to be most significant for Biodiversity, Flora and Fauna, Water and Traffic and Noise (during the construction phase).

The impacts and effects on Soils/Geology and Air Quality are classified as "mid-range"/moderate as the significant impacts/effects on these parameters will be primarily temporary in nature during the construction phase of the development, with sub-surface permanent impacts and effects. Significant Cultural Heritage impacts and effects are unlikely as the route is proposed primarily along roads that have already been disturbed.

The majority of the potential impacts and effects on Landscape, Settlement/Communities, Material Assets and Noise will be temporary and will principally relate to the construction phase of the development. The clear exception to this concerns the related (though localised) impacts and effects from permanent converter stations which will be required at each end of the route.

The residual effect on the environment following implementation of mitigation measures is anticipated to be low.

5.7 TECHNICAL COMMENTARY ON HVDC UGC OPTION

5.7.1 Compliance with Health and Safety Standards

Discussion

It should be noted that most technical standards for high voltage equipment, whether for HVDC or HVAC equipment are inherently based on safety requirements and therefore, as a general rule, compliance with recognised technical standards will mean that the equipment is designed and manufactured so as to be safe.

For HVDC UGC, safety is inherent within all technical equipment standards. The applicable standards originate from the European Committee for Electro-technical Standardization or a similar internationally recognised standard is applied. These standards take into account the integrity of installations and systems by operating conformity assessment systems to verify plant and systems perform to acceptable technical and safety standards.

All materials shall be designed, manufactured, tested and installed according to relevant IEC or CENELEC standards. Where no IEC or CENELEC standards have been issued to cover a particular subject, another internationally recognised standard shall be applied. The latest edition and amendments to standards and specifications shall apply in all cases.

Regardless of the technical solution chosen, the Grid West project by shall be designed, constructed and maintained in accordance with applicable Irish and EU Health and Safety Regulations and Approved Codes of Practice. In undertaking a project, EirGrid is at all times aware of and complies with the applicable Health & Safety Legislation, Approved Codes of Practice and Industry Standards and all subsequent modifications or amendments in relation to same. To achieve this, EirGrid operates a formal legal compliance process as part of its health and safety management system.

All prospective technical solutions shall comply with the Safety, Health and Welfare at Work (General Application) Regulations 2007, in particular Part3: Electricity.

All designs shall meet the requirements of the EirGrid Functional or Operational Specifications which incorporate CENELEC standards and contain specific national requirements e.g. environmental conditions, procedures and system network parameters. All equipment shall be Grid Code compliant (EirGrid, 2014)

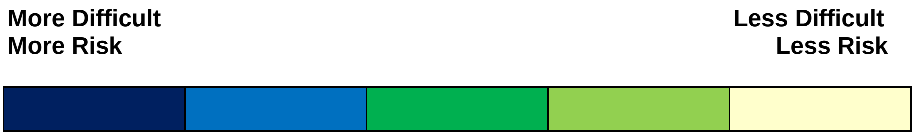
Designs shall also be reviewed by appointed Project Supervisors for Design Stage (PSDP) as required by the Safety, Health & Welfare at Work (Construction) Regulations 2013.

Where any commissioning may involve connections to existing Transmission infrastructure, then such commissioning is conducted in accordance with ESB Networks “Electrical Safety Rules 2006”.

The principal document required at Project Completion / Handover is the completed Health & Safety File, required under the Safety, Health & Welfare at Work (Construction) Regulations 2013 [S.I. No. 504 of 2006]. This document is required irrespective of the technical solution adopted.

<u>Conclusion</u>

	HVDC UGC
Compliance with system reliability and security standards	



This option will be compliant with the relevant safety standards, and therefore is at the lowest level on the difficult/ risk scale.

5.7.2 Compliance with Reliability and Security Standards

<u>Discussion</u>

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

- The Transmission Planning Criteria (TPC)[74];
- The Operational Security Standards (OSS)[75]; and

Any HVDC UGC solution proposed will comply with both the TPC and OSS.

In the context of the industry accepted standard for the overall system availability of 99.99% and taking into account the inherent redundancy designed into the transmission network, the inclusion of a single UGC circuit has limited effect on the overall system availability and hence the UGC option is able to comply with the Reliability and Security standards for the network as a whole.

[74] EirGrid, Transmission Planning Criteria, 1998 (http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf)
[75] EirGrid, Operational Security Standards, 2011 (http://www.eirgrid.com/media/Operational%20Security%20Standards.pdf)

Conclusion

	HVDC UGC
Compliance with system reliability and security standards	

More Difficult
More Risk

Less Difficult
Less Risk

The option will be compliant with the relevant system reliability and security standards, and therefore rated at the lowest point on the difficult/ risk scale.

5.7.3 Average Failure Rates, Repair Times and Availabilities

Discussion

Unplanned outages

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

	220kV-500kV Cables
Reliability (Unplanned outages/100km/year)	0.277
Mean time to repair (days)	25 – 45 days[76]
Unavailability (days/100km/year)	7.5 – 13.5

Table 5-18 Average Failure Rates, Repair Times and Availabilities

The above table shows the statistics for reliability (based on international failure statistics of cables[77]), the mean time to repair such outages and the availability in days per 100km per year for HV cables. These statistics, given that they apply to XLPE cables, are taken to be equally applicable for HVDC cables.

The PSC report[78] suggests that the mean time to repair cables may be lower than those given above and range from a few days to 14 days in total.

[76] Dependant on whether method of cable installation is direct lay or in ducts respectively
[77] Cigre, TB379 Update of service experience of HV underground and submarine cable systems, 2009
[78] Appendix 5 - PSC, Grid West Project HVDC Technology Review, Reference JA4846, 17 December 2014

Combination of the planned and unplanned outages

The PSC report also researched publically available information on the overall availability of circuits using VSC technology, which is very limited. EirGrid is not aware of publically available information that differentiates between planned and unplanned outages. However the resulting 3-4% combined forced and scheduled maintenance rate as stated in the PSC report (Appendix 5) would equate to c. 11-15 days per annum.

However EirGrid has policies in place for routine preventative maintenance for AC cables of 2-3 days per annum (dependant on the number of joint bays). Given that any cable requires many similar features in their installation, i.e. joints, earths, telecommunications it is reasonable to assume a similar value will be required for a HVDC UGC.

Common to all of the options is the need to perform planning maintenance for the associated substation switchgear and equipment. Each year an operational test is performed, and periodically a routine service is also undertaken. These maintenance outages equate to a total unavailability of 0.65%, or c.2.5 days per annum

It is also important to consider that, since the grid is designed to provide a specified level of redundancy as a result the failure of individual components or elements does not normally result in any loss of supply. The longer the time to repair, though, the longer the system is in a state where there is no redundancy and therefore the greater the risk of a significant loss of supply.

Conclusion

	HVDC UGC
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option	

More Difficult
More Risk

Less Difficult
Less Risk

Given the availability of a UGC circuit is approximately 98% and well below the industry norm of 99.99%, the average failure rate and time to repair would be considered high and consequently the availability of the circuit would be considered to be low. However in the overall system context, the UGC option has been scored as mid-level on the difficult/risk scale.

5.7.4 Reliability of Supply

<u>Discussion</u>

The primary driver for Grid West is to facilitate wind generation from north Mayo. Secondary benefits include improved security of supply to Mayo. Therefore impact of unavailability is primarily wind generation constraint, due to the reliability of their network connection.

The basic configuration of the Grid West project is compliant with the Transmission Planning Criteria and Operation Security Standards and therefore meets the minimum acceptable reliability criteria. This configuration is not altered for any of the options considered.

However the Transmission Planning Criteria provides a balance between security of supply (reliability) and development cost, and therefore only plans a resilient network for a justifiable range of events. Where opportunities exist to provide a higher security of supply at minimal or zero cost then inherently these options become more preferable, as this improves the quality of supply to customers and reduces financial costs to consumers or losses to the economy.

<u>Conclusion</u>

	HVDC UGC
The expected impact on reliability of supply of unavailability of the development	

More Difficult
More Risk

Less Difficult
Less Risk

The relatively low availability associated with both the UGC and HVDC technology exposes the network to both additional constraint costs and security of supply issues. Hence, the extension of the network is required to increase the reliability or system reserves may need to be increased or there is an acceptance that the system Loss Of Load Expectation rate of 8hrs per year may rise. This would be considered mid-level on the difficult/ risk scale.

As part of the wider system the use of a HVDC circuit reduces system strength, and due to the relatively high unavailability, the loss of generation (when the generation is close to the equivalent of the largest generation on the system) presents a high risk to network stability. Given the scale of the impact of the risk but their relative low likelihood of occurrence, this would be considered mid-level on the difficult/ risk scale.

Therefore, in aggregate, a mid-level score is appropriate.

5.7.5 Implementation Timelines

<u>Discussion</u>

The construction of HVDC projects in the electricity transmission sector are typically implemented under an Engineer, Procure and Construct (EPC) form of contract 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 the 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 high voltage projects, like Grid West, involving large and complex equipment, commissioning is a complex process requiring significant planning and 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 concerning the timeline for HVDC UGC:

- It is based on the indicative project duration estimate provided in the PSC report[79]. The only change has been to extend the design and manufacture activity to allow for the detailed design and manufacture of the HVDC Converter Stations but this has not affected the overall implementation period.
- The long-lead items in the above timeline will be the converter stations, including the associated transformers, and possibly the HVDC cable itself. There are a limited number of manufacturers of HVDC cable and the manufacturing time will be dependent on the level of orders placed internationally. There are currently a large number of HVDC projects being implemented internationally, which is leading to extended cable delivery times.
- The installation of the ducts in the roads will be a major activity requiring a considerable time for the construction. For the purpose of this report it has been estimated that the complete UGC route can be constructed in a 30 month period, allowing six months for the completion

[79] Appendix 5 The Grid West Project HVDC Technology Review Report (PSC)

of the cable laying and termination. This period would then align with the time required for the design, manufacturer, supply and installation of the converter stations.

- It has been assumed that a 3 month commissioning period will be required. The HVDC system is relatively complex to commission but at this early stage it has been assumed that some commissioning could take place before practical completion of the construction and installation works.
- As discussed in sub-section 5.7.7 below, VSC HVDC technology is relatively new and as such there is a relatively high risk of programme over-runs.

Conclusion

	HVDC UGC
Implementation timelines	

More Difficult
More Risk

Less Difficult
Less Risk

There are two aspects to implementation timelines; the estimated implementation timeline, and the certainty of achieving the target completion date.

The construction of the HVDC option is expected to take approximately 36 months. Globally there are a limited number of HVDC cable manufacturers and therefore the number of orders placed internationally, if co-incident with the Grid West procurement, could prolong the construction schedule.

In aggregate the implementation timeline for the UGC option would be considered to be at the moderate / low level on the difficult/ risk scale.

5.7.6 Future Reinforcement of Transmission Network

Discussion

This option provides limited flexibility for the future reinforcement of the grid in the north west region. It does provide a new corridor where generation can gain access. The inflexibility in modification of HVDC equipment means that future expansion needs to be specified as part of the initial project and subsequent changes to either projections or locations may not be catered for without significant replacement and cost.

As an appropriate HVDC development at the maximum currently employed size (500MVA) there is limited capacity for future demand or generation development within the north Mayo region without a new circuit, with the associated significant additional works and costs.

Selection of a different technology to the lowest cost symmetrical monopole option chosen to meet the immediate needs of the Grid West project would provide a higher cost but more flexible solution. Notably a 500MVA monopole option designed to be converted to a bi-pole option (which would be more comparable to the ultimate capacity possible with the alternative technical options) would allow for a later increase in capacity using the same cabling and limiting additional works to within the planned transmission stations. This option would incur a cost premium of c.40%[80].

Regardless of the HVDC technology chosen, in the event of another connection along the circuit being required this could be only be achieved at significant additional cost.

Grid infrastructure is expected to have a design life in excess of 50 years, with some of the current infrastructure in place for significantly more years than this. Given the level of applications for connections received in the area it is reasonable to expect that over the next 50 years and beyond the grid will need to expand and adapt to accommodate increasing and changing demand for electrical power.

International standards for inter-operability for HVDC equipment is in the process of being developed and have not yet been fully defined. In a network where there are increasing transmission users and network devices using HVDC equipment. It creates a high risk of unintended responses from these devices. There are concerted efforts in progress to define these standards but these have not been published to date.

Conclusion

	HVDC UGC
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated	

More Difficult
More Risk

Less Difficult
Less Risk

There are four aspects to future reinforcement and connection to the transmission network:

- The extent to which future generation capacity is catered for with further reinforcement;
- The extent to which future generation capacity is catered for without further reinforcement ;
- The ability to add new stations; and

80 Appendix 5 The Grid West Project HVDC Technology Review Report (PSC)

- The capacity that can be provided for into or out of the NW region (Roscommon, Leitrim, Donegal, Sligo and Mayo).

The HVDC VSC symmetrical monopole option proposed will have a 500MVA rating. As the initial requirement is for 410MVA and the LSI is currently 500MVA, this option provides 90MVA of spare capacity above the current need, as this option would cater for only c.5% of those further generators seeking connection in Co. Mayo at this time, it is therefore considered to be at the mid-level on the difficult/ risk scale.

To convert this HVDC circuit to a higher capacity would require both new cabling and converters to be installed. For example, a rating of 1,500MVA rating will require additional duplicate circuits. Therefore based on the cost; the need for additional routes; flexibility and deliverability, the rating is considered to be between the highest level and mid-level on the difficult/ risk scale.

To increase capacity in the region further, while continuing to comply with the requirements of the TPC, additional further infrastructure is needed. Therefore, based on cost, the need for additional routes, flexibility and deliverability; this option would be rated between the highest level and mid-level on the difficult/ risk scale.

The ability to add further connection points along the circuit is restricted by the technology and the rating of the circuit. Therefore, in this respect, the option would be rated between the highest level and mid-level on the difficult/ risk scale.

In aggregate the highest level and mid-level on the difficult/ risk scale is appropriate.

5.7.7 Risk of Untried Technology

Discussion

VSC HVDC technology is a new technology was used by EirGrid for the East West Interconnector (EWIC). The technology is internationally at an early point in the development cycle and the utilisation of an HVDC solution in this application, within a small island system, has had limited application internationally. Internationally, the industry is in a period of learning, and this is best evidenced by the number of delays and early operational problems that have been experienced with a number of recent HVDC projects.

The prospect of the HVDC scheme not performing as specified, given its size proportional to the network, presents a risk of a disturbance on the network that could potentially result in an interruption of supply to customers impacting security of supply. The number of customers lost would be dependent on the nature of the unexpected response of the HVDC system.

Another consideration is the ability of a technology to withstand short-term over-loads. In order to achieve reasonably cost effective cables, the insulation is operated much closer to the point where permanent damage occurs and the cable is less able to withstand short-term overloads. The properties of the cable mean that once the temperature inside the cable exceeds a particular point, there is a danger of the heat generated exceeding the capacity of the surrounding material to conduct the heat away and the temperature builds up exponentially until the cable suffers failure. The power electronics used in the HVDC converter stations have a limited overload capability.

The short-term overload capability is utilised when an item of plant and equipment is lost and the power that was being transmitted through it is transferred to other parts of the network, until the network is reconfigured. The time taken to do this may vary from milliseconds to minutes. Without this short-term overload capability the need to further reinforce the network will be increased.

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

The interaction of an HVDC UGC system with the existing HVAC grid system is complex. If the Grid West project were to be implemented as a HVDC UGC, the following interactions are likely to require specific mitigation. Many of these interactions cannot be studied until the full details of the systems being connected to the Grid West line are known, in particular the wind turbines being used in the windfarms:

- Short Circuit Ratio (SCR):
  The Irish grid is a relatively small electrical system characterised by relatively low fault levels/short circuit capacities. It is therefore likely that there will be a low SCR, which could be a potential source of difficulty. However this is mitigated by utilising VSC technology which is able to operate at low SCR levels.
- AC circuit overload:
  The generation and HVDC power transfer needs to be controlled (or ‘dispatched’) in a way that ensures the AC transmission circuits connected to the HVDC link are not overloaded. This needs to be achieved during normal operation as the demand changes through the day, and also during outages, when the power flows through the network may abruptly change. This is achieved through the control available within the HVDC converter stations but requires more complex operator action to ensure that overloads do not occur, particularly during abnormal operating conditions.
- AC system voltage:
  The VSC converters proposed for the Grid West project are able to supply and consume reactive power as directed by the operator and are consequently able to contribute to maintaining the voltage, improving the balance between the use and supply of reactive power in the local area and hence facilitating the control of the AC system voltage. In this respect the HVDC can offer greater control than the HVAC OHL where the control available through tap changers is less responsive with larger steps between control actions.
- DC faults affecting operation of AC system:

The majority of OHL faults, whether AC or DC, are transient faults caused by lightning or other incidents which create a fault but are then cleared rapidly allowing the line to be re-energised after a short delay (typically a few seconds). A fault in a DC cable does not provide the opportunity to rapidly clear the fault and the protection systems will trip the link. This can result in a permanent interruption to DC power transfer until the fault is repaired and the link restarted.

- AC faults interrupting DC power transfer:
  In the event of a fault on the AC system, a VSC converter can supply the AC system and recover from the AC fault provided the converter is rated to supply the steady state active and reactive power demand as well as any additional, short duration, active and reactive power demand following fault clearance. After the fault is cleared the DC power transfer in the VSC scheme tends to recover relatively quickly, minimising the impact of the AC fault on the DC system.
- Distortion in AC voltages:
  Alternating Current (AC) has a nominal frequency of 50Hz, or 50 cycles per second. A harmonic current has a multiple of this nominal 50Hz, i.e. a 2nd harmonic at 100Hz is twice the 50Hz. Due to the power electronics in the HVDC converters, harmonic currents are injected into the AC network. The harmonic currents result in harmonic voltage distortion in the AC network which impacts a range of plant and equipment connected to the system. The harmonics can be reduced by using harmonic filters. Filtering is more difficult on schemes with a low SCR, although VSC converters typically generate significantly lower level of harmonics than an LCC HVDC system. The filters need to be carefully designed to handle not only the HVDC harmonic currents but also any background harmonics already existing on the AC system.
- Sub-synchronous interactions with generators:
  The power electronics of HVDC converter stations can potentially result in a sub-synchronous resonance with local generator turbines with long shafts and are also possible with wind generators that use power electronics to connect to the AC system. This would need to be properly studied once the full details of both the HVDC converter stations and the wind turbines being used in the windfarms are available. If sub-synchronous resonance is found then additional filter units will be required to mitigate this.
- Interactions between multiple HVDC schemes, power electronic devices, and special protection schemes:
  In the same way that the power electronics in the converter stations can adversely interact with the power electronics in certain wind turbines, similar interactions can occur with other power electronic systems in the area, including any future HVDC schemes. The impact has to be studied on a case by case basis but, in general, the presence of one HVDC scheme will limit the potential for the connection of future HVDC schemes, with studies required to establish mitigation measures to eliminate any adverse effects of these interactions.

Thus, although all the different potential adverse interactions of the HVDC system with the grid system operation can be mitigated, the extent of these interactions and the complexities involved can be significant.

Conclusion

	HVDC UGC
Risk of untried technology	

More Difficult
More Risk

Less Difficult
Less Risk

Application of this technology would drive an on-going risk to effective network operation and planning. The controls and ancillary equipment for the HVDC is designed on a set of parameters which, over time, will change, most likely requiring retuning and modification. Identifying, scheduling and achieving these changes will become an increasing challenge as the network becomes ever more dynamic. There is a risk that resultant control mal-operation would compromise the security of supply of the transmission network. The highest documented loss of demand customers in Ireland was as a result of the mal-operation of the Moyle[81] HVDC Interconnector control system. This type of mal operation[82] could not have occurred on an AC system which naturally and automatically operates to balance itself.

Modern control theory and duplication mitigates this risk but given its complexity and continuing nature it is still considered to be mid-level on the difficult/ risk scale.

Therefore a mid-level score is appropriate.

5.7.8 Compliance with Good Utility Practice

Discussion

Good utility practice is to develop a flexible, robust and cost-effective reinforcement solution accounting for environmental constraints.

Based on current knowledge, the HVDC UGC option is assessed as rating unfavourably in respect of the good utility practice criteria mentioned above. While this option can be installed it does not provide a high level of flexibility and as a relatively new technology, presents some notable risks. This is supported by the low percentage of HVDC circuits within Europe where the majority of HVDC circuits are also subsea cables where an OHL is not a viable alternative.

Conclusion

[81] HVDC Interconnection between Northern Ireland and Scotland

[82] The faults refers to were reverse power flows, which drew power from a stressed area of the network.

	HVDC UGC
Compliance with good utility practice	

More Difficult
More Risk

Less Difficult
Less Risk

TSOs have similar mandates to deliver a cost effective, efficient, flexible network. HVDC VSC symmetrical monopole used in a meshed configuration given its high cost, low adaptability and relatively untried technological track history, only meets this mandate considering the options available in specialised circumstances. Therefore although this option may be used in some circumstances and considered good utility practice in these circumstances, it is not the conventional selection and therefore is considered to be the mid-level on the difficult/ risk scale.

5.7.9 Summary of the Technical Analysis of the HVDC Underground Option

The table below summarises the technical assessment of the HVDC UGC Option.

	HVDC UGC
Compliance with all relevant safety standards	
Compliance with system reliability and security standards	
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option	
The expected impact on reliability of supply of unavailability of the development	
Implementation timelines	
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated	
Risk of untried technology	
Compliance with good utility practice	

More Difficult
More Risk

Less Difficult
Less Risk

Table 5-19 Summary of the Technical Commentary of the HVDC Underground Option

5.8 ECONOMIC ANALYSIS

The economic appraisal of the reinforcement option was completed in compliance with the requirements of the IEP Terms of Reference and the results are summarised below.

5.8.1 Approach

The connection of renewable generation, i.e. wind generation, displaces conventional generation, changing the overall production costs that are incurred. Since each option connects the same wind generation, which would not otherwise have been connected to the grid, the benefits are the same for each reinforcement option. Therefore, for the purposes of this evaluation, quantification of the benefits is excluded. Similarly, the impact of the proposed reinforcement on the Public Service Obligation (PSO) levy is the same for all options and therefore is excluded from the assessment.

The economic assessment measures the impact of the reinforcement project on the Irish economy, rather than on the company responsible for making the capital investment. The approach represents the case of the Transmission Asset Owner (TAO) financing the investment with the benefits accruing to society.

The costs, together with a regulated return, are then recovered from consumers through the tariff structure and would correspond to an increase in the Transmission Use of System (TUoS) tariff component of a consumer's electricity bill. The regulated return is the real, pre-tax Weighted Average Cost of Capital (WACC) of 5.2%[83] approved by the Commission for Energy Regulation (CER). Similarly, any benefits resulting from a reduction of production costs or greater system efficiency would translate into a reduction in the cost of energy, also represented on the consumer's electricity bill.

The approach is consistent with that endorsed by the Office of Gas and Electricity Markets (Ofgem) in the United Kingdom for cost benefit analysis and referred to as the Spackman Approach[84]. Using this approach, all the costs (including the costs of financing the assets together with the actual cost of the assets) and benefits are considered annually over the useful life of the new asset.

5.8.2 Time Value of Money

The Discounted Cash Flow (DCF) analysis method is used to evaluate the economic merits of a reinforcement option. It uses the concept of the time value of money in which all future cash flows are estimated and discounted using an approved Net Discount Rate (NDR) to calculate their equivalent present values. The method facilitates the consistent representation of all the values that are associated with each of the alternative reinforcements.

[83] Commission for Energy Regulation, Mid-Term Review of WACC Applying to the Electricity TSO and TAO and ESB Networks Ltd for 2014 to 2015, CER/14/026, 31 January 2014.

[84] Ofgem, *RIIO-T1: Consultation on our assessment of National Grid Electricity Transmission's proposed National Development Policy for the Electricity Transmission Price Control*, 3 May 2013; and Joint Regulators Group, *Discounting for CBAs Involving Private Investment, but Public Benefit*, 4 October 2011.

The NDR is taken to be the real societal discount rate, which is interpreted to be the Test Discount Rate specified by the Department of Finance for use in cost benefit analysis and cost effectiveness analysis for public sector projects, i.e. 5.0%[85] in real terms (i.e. excluding projected inflation).

All financial values are represented in the current year's Euro and are expressed in real terms (i.e. excluding projected inflation).

5.8.3 Duration of Evaluation and Terminal Values

The start date of the economic assessment is taken as the current year and all future values are referred (or discounted) to that year. The duration of the evaluation is taken as the regulatory authority-approved useful life for Transmission assets, i.e. 50 years[86].

5.8.4 Input Costs

Each reinforcement incurs incremental costs (e.g. project implementation costs, incremental maintenance costs) and has an impact on the overall transmission system efficiency (e.g. total generation production costs, transmission system losses and system reliability costs).

HVDC reinforcements are typically delivered through the appointment of an Engineer, Procure and Construct (EPC) contractor. As a result of the proprietary nature of the technology involved in delivering an HVDC reinforcement, the EPC contractor is usually the owner and manufacturer of the equipment, referred to as an Original Equipment Manufacturer (OEM).

All cost estimate inputs are sourced from the PSC report[87]. The costs considered in this assessment are consistent with the Terms of Reference and are described in the sections below.

5.8.4.1 Project Pre-Engineering Costs:

The pre-engineering costs refer to the costs associated with the design and specification, route evaluation and management of the statutory planning application. The costs are capital in nature and are estimated to be €17.2 million. This amount includes a contingency provision of €0.4 million to account for the risk that the amount may vary.

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[85] Department of Finance: http://www.per.gov.ie/project-discount-inflation-rates/

[86] Decision on TSO and TAO transmission revenue for 2011 to 2015, CER/10/206, 19th November 2010: "...the CER stated its intention to continue using average assets lives of 50 years for the TAO's network assets".

[87] Appendix 5 – PSC, *Grid West Project HVDC Technology Review, January 2015*

The phasing of the costs is as follows:

	2015	2016	2017	2018	2019	2020
Pre-Engineering Costs	64%	26%	5%	5%	0%	0%

Table 5-20 Phasing of Pre-Engineering Costs

The present value of the project pre-engineering costs was calculated using the estimated value of €17.2 million, phased according to the table above. The capital amounts are discounted at the Test Discount Rate, resulting in a present value of €16.5 million.

5.8.4.2 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 reinforcement's scope.

The estimated capital cost is categorised into its general components and is summarised in the table below:

Cost Category	Project Implementation Cost (€ M)
Overhead Line[88]	9.1
Stations[89]	145.8
Underground Cable	175.7
Reactive Compensation	0.0
Other	
Flexibility Payments, Proximity and other allowances	2.5
Non-EPC Costs	54.2
SUB-TOTAL	**387.3**
Contingency	38.7
TOTAL	**426.0**

Table 5-21 Summary of Project Implementation Costs for the HVDC Option

[88] Costs associated with OHL link to the 110kV network

[89] The "stations" category refers to all HVDC converter stations and HVAC substations required by the option

Station costs include the cost of the HVDC converters and the HVAC transmission station modifications required to connect the HVDC system into the transmission system.

In the table above, the category "Other" is comprised of provisions for flexibility payments, proximity allowance, community fund amounting to €2.5 million and the engineering costs that are not covered by an EPC contractor (i.e. "Non-EPC" costs) amounting to €54.2 million. The "Non-EPC" costs would typically refer to front-end project development, licenses, permits, external advisors and consultants, grid connection studies, finance, insurance, test energy and O&M facilities, not already accounted for in the pre-engineering costs. There may also be some engineering, design and construction costs that are excluded from the EPC contract for the project. These costs can occur where the risk profile makes it difficult or impossible for the EPC contractor to accurately price the work or where the work needs to be performed on the assets of the project owner or another party. The total value for "Other" amounts to €56.7 million.

A contingency provision of 10% is included to address the likelihood that costs may increase. The contingency amount is therefore €38.7 million and the total project implementation, inclusive of contingency provision is then €426.0 million.

The phasing of the costs is as follows:

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Project Implementation Costs	0%	0%	33.4%	33.3%	33.3%	0%

Table 5-22 Phasing of Project Implementation Costs

The present value of the project implementation costs was calculated using the estimated value of €426.0 million, phased according to the table above. The capital amounts are discounted at the Test Discount Rate, resulting in a present value of €353.1 million.

5.8.4.3 Project Life-Cycle Costs

Life-cycle costs refer to the costs incurred over the useful life of the reinforcement and include the on-going cost of ensuring that it remains viable for the evaluation period.

The useful life of the HVDC system, based on the CER permitted depreciation of transmission assets, is 50 years. The useful life is the same as the evaluation period and as a result, no replacement costs are considered for the option.

Similarly, no residual value is considered for the mid-life replacement of equipment typically associated with the upgrading or replacement of control systems since the residual value is seen to be zero once the useful life of the primary equipment is exceeded.

In accordance with the Terms of Reference, the life-cycle costs include:

- Cost of 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 losses it incurs.

  The cost of electrical losses is calculated for each year following commissioning for the lifetime of the HVDC scheme. The estimated electrical losses are taken from the PSC report (Appendix 4), which discusses the expected losses in the converter stations and DC cables for the chosen HVDC technology. Estimating the cost of losses however depends greatly on a number of factors including the forecast power flows across the HVDC scheme over the year (determined by the assumed dispatch of the connecting generation) and the cost of power at the connection point. Since the same generation dispatch assumptions apply for each of the options considered, the same loading assumptions and cost of power is used for each of the options considered.

  The cost of electrical losses is determined using the cost of producing the next unit of electrical power i.e. marginal cost of generation. For this analysis, the average System Marginal Price (SMP) is used to represent the marginal cost of generation and is calculated to be €60.66/MWh. The figure has been derived from the average system marginal price for Ireland over the last five years, which was sourced from information published on the Single Electricity Market Operator (SEMO) website[90]. It is acknowledged that the electrical losses will tend to be accrued when it is windy, when the SMP is typically low; and an interruption to the connection is likely to occur when the SMP could be quite high. For the purposes of this analysis, given that the line loading for each option is assumed to be the same, the SMP is sufficient for the analysis and the only reasonable assessable proxy available.

[90] SEMO System Marginal Price (EP2) from 11 December 2007 to 18 February 2013: http://www.sem-o.com/Publications/General/SMP2007-2014.zip.

The losses and the corresponding cost of losses associated with the HVDC scheme is summarised in the table below.

	HVDC Circuit Losses (MWh/yr)	Converter Losses (MWh/yr)	Total Losses (MWh/yr)	Annual Cost of Losses (€ M/a)
HVDC Option	2,465	7,889	10,354	0.6

Table 5-23 Summary of the Annual Cost of Losses

The electrical losses are estimated to be 10,354MWh/yr which translates into an annual cost of €0.6 million per annum. Assuming the annual cost of losses is constant for the duration of the evaluation, and then discounting those annual costs at the Test Discount Rate, results in a present value of €9.0 million.

- Operating and maintenance cost:
  Specialist repair teams are required for this option and these costs are included in the operating cost estimates provided by PSC.

  PSC estimate the annual operating expenses, as a percentage of capital cost, as 0.4%-0.5% of the capital cost of converter stations and 0.025% of the capital cost of UGC. This translates into an estimated annual cost €5.0 million for the annual operating and maintenance costs for the HVDC system. This figure includes a provision for risk which is assumed to be 10%, i.e. €0.5 million per annum in total.

  Discounting the annual operating expenses, which are assumed to be constant in real terms for the duration of the evaluation, results in a present value of €71.7 million including a contingency provision of 10%.

  For HVDC schemes, mid-life refurbishment typically consists of a control and protection systems refurbishment at the mid-life of the HVDC transmission scheme (15 – 20 years). This is often driven by issues such as technical obsolescence and the availability of spare parts, in which case the actual timing of the refurbishment will be dependent on the life cycle of the control and protection system used.

  The control system refurbishment plan for the HVDC UGC option, estimated by PSC, is split into three stages, namely:
  - Stage 1 - 7-15 years, estimated at €4 million;
  - Stage 2 - 15-25 years, estimated at €5 million; and
  - Stage 3 - 20-40 years, estimated at €7 million.

The costs, for the purpose of the evaluation are treated as being capital in nature and are assumed to be fully depreciated over the remaining useful life of the HVDC scheme. All control system refurbishments require re-commissioning activities, coordination and control and project management activities by the owner and/or operator.

The present value of the refurbishment costs, phased according to the three stages listed above is €3.9 million.

- Replacement cost, including the cost of decommissioning:
  The useful life is the same as the evaluation period and as a result, no replacement costs are considered for the option.

5.8.4.4 Cost of Unreliability:

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 system would be interrupted and would be replaced with alternative generation, including more expensive conventional plant. The average daily benefit attributed to the renewable generation connected to the power system is calculated to be €0.122 million. This value is calculated as a result of detailed market simulations that considered combinations of different wind profiles for the area for five different representative years. The studies showed that without Grid West the annual production cost would increase by approximately €39.0 million using a replacement energy cost equivalent to the average SMP of €60.66/MWh. If the circuit was unavailable during a period of particularly high wind availability then the real cost of circuit unavailability would be higher and 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, the use of this average figure is considered adequate.

The 8km of cable on the Flagford - Srananagh line is not included in this part of the calculation as its reliability will not impact on the availability of the Grid West circuit.

The reliability of transmission infrastructure is separated into those that are planned and those that are unplanned, both of which are discussed below.

- Unplanned outages:
  Unplanned outages are normally associated with faults that routinely occur and are specific to the equipment type, technology employed (including voltage level, OHL, UGC etc.) and environmental conditions. Associated with the occurrence of an unplanned or "forced" outage is the mean time to repair.

The availability of the HVDC system attributed to unplanned outages is sourced from the PSC report[91] and is summarised in the table below. Using the average daily benefit attributed to having the reinforcement available, the cost of the unplanned outage is calculated as €0.8 million per annum and is summarised in the table below.

Outage Type	Average Outage Rate (%)	Days Un-Available Per Annum (Days)	Annual Cost (€ M/a)
Unplanned Outage	1.73%	6.31	0.8

Table 5-24 Summary of the Unplanned Outage Statistics and Resulting Annual Cost

The calculation of the present value of unplanned outages assumes that the annual cost is constant in real terms for each year of operation and is calculated to €11.0 million.

- Planned outages:
  Planned outages are normally associated with routine maintenance.

  The availability of the HVDC system attributed to planned outages is sourced from the PSC report and is summarised in the table below. Using the average daily benefit attributed to having the reinforcement available, the cost of the planned outage is calculated as €0.8 million per annum and is summarised in the table below.

Outage Type	Average Outage Rate (%)	Days Un-Available Per Annum (Days)	Annual Cost (€ M/a)
Planned Outage	1.83%	6.66	0.8

Table 5-25 Summary of the Planned Outage Statistics and Resulting Annual Cost

The calculation of the present value of planned outages assumes that the annual cost is constant in real terms for each year of operation and is calculated to €11.6 million.

5.8.5 Estimate of Cost Uncertainty:

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

[91] Appendix 5 The Grid West Project HVDC Technology Review Report (PSC)

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 cost estimates include a contingency. The contingency allowance for the project reinforcement costs are assumed to be 5% of the remaining projected spend and 10% for the project implementation costs. Similarly, a contingency allowance of 10% is provided for in the average maintenance costs that have been calculated and represented above.

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

5.8.6 Present Value Summary of Costs:

The abovementioned costs for the reinforcement are summarised in present value terms in the table below.

	Present Value (€ M)
Pre-Engineering Costs	16.1
Project Implementation Costs	
Overhead Line	7.5
Stations	120.9
Underground Cable	145.6
Reactive Compensation	0.0
Other	47.0
Project Life-Cycle Costs	
Cost of Losses	9.0
O&M	65.2
Decommissioning & Replacement	3.9
Cost to SEM from Development Unavailability (Reliability)	
Cost of Unplanned Outages	11.0
Cost of Planned Outages	11.6
Contingency Cost Provisions	
Pre-Engineering Costs	0.4
Project Implementation Costs	32.1
O&M	6.5
Decommissioning & Replacement	0.0
TOTAL	**476.8**

Table 5-26 Summary of Present Value of Costs Associated with the Reinforcement

The total present value of this option amounts to €476.8 million. The cost per MVA of capacity is €0.954M/MVA.

6. 400kV HVAC OVERHEAD LINE OPTION

6.1 DESCRIPTION OF OPTION

The proposed technology for an OHL solution is HVAC technology. The 400kV HVAC OHL option is designed with a rated capacity of 1,580MVA and covers a distance of c.103km.

The proposed route as shown in Figure 6-6 commences at a new substation 2.5km north west of Moygownagh in north Mayo and runs through the counties of Mayo and Roscommon, to the existing substation in Flagford. Analysis of the constraints identified on the approach to the existing Flagford substation found the approach to be highly constrained, and it was deemed appropriate to consider undergrounding the final 8km of the Grid West 400kV circuit.

In order to comprehensively investigate the feasibility of HVAC UGC, EirGrid commissioned engineering consulting firm, London Power Associates (LPA), to complete a review of the maximum amount of HVAC UGC that could be utilised and assess the extent to which it meets the project need.

It can be concluded from the LPA report[92] that 8km to 10km of 400kV HVAC UGC in the region is not feasible. Hence, on the outskirts of Flagford, an existing 220kV line will be undergrounded for a distance of approximately 8km, largely along local roads, from its intersection with the Grid West line to the Flagford substation.

This compensatory undergrounding measure i.e. undergrounding on a different lower voltage circuit, will not increase the wirescape in the area but preserve the number of lines entering Flagford substation at the current total. The eisting 220kV line would then be upgraded to 400kV.

The 400kV HVAC OHL option defined for the Grid West project is summarised as:

- **A new 110kV GIS substation**: in north Mayo, including a 500MVA 400kV/110kV transformer; 110kV switchgear to connect the wind generation applicants in the area; and switchgear to connect to the existing 110kV network;
- **c.103km of 400kV twin conductor OHL:** installed between a new 400kV substation in north Mayo and the existing 220kV Flagford substation in Roscommon;
- **c.8km of 220kV XLPE HVAC cable:** installed into the first section of the existing Flagford – Srananagh 220kV line; and
- **Modification to the 220kV Flagford station:** to install a 500MVA 400/220kV transformer and associated equipment to connect the Flagford – north Mayo 400kV circuit to the 220kV busbar.

The Stage 1 Report[93] noted that standard lattice towers are the most commonly used technology for high voltage transmission lines internationally. If a 400kV HVAC OHL is selected as the preferred

[92] Appendix 11 – LPA Report, Cable Studies for Grid West – Partial AC Underground Solution, January 2015
[93] Appendix 2 - EirGrid Grid West Stage 1 Report – Section 3.2 Technical Foundation Report, March 2013

option, EirGrid will engage with the public and stakeholders on feasible tower types. Tower types are still under consideration and EirGrid will re-examine all available tower types as the project progresses.

6.2 400KV HVAC OHL OPTION – INDICATIVE ROUTE CORRIDOR AND INDICATIVE LINE ROUTE

6.2.1 Indicative Route Corridor

Work to date on the indicative route corridor is as follows:

- **The Stage 1 Report**:
  The report identified sixteen OHL route corridor options. One of these corridors was identified as the Least Constrained Route Corridor, the pink corridor as shown in Figure 6-1, i.e. the corridor that achieved the most acceptable balance between competing constraints, while meeting the needs of the project.

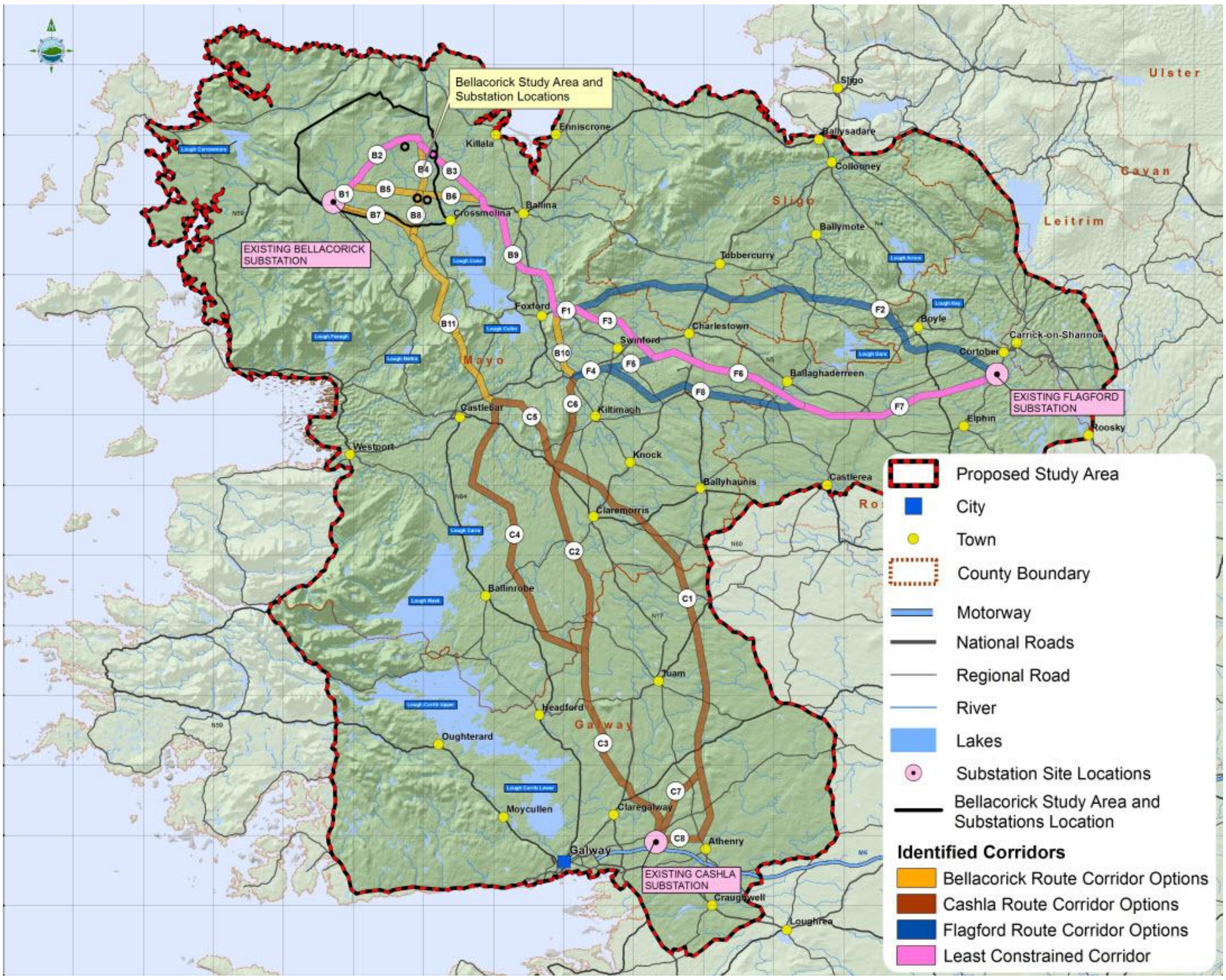

Figure 6-1 OHL Route Corridors and Least Constrained Corridor – March 2013

- **Route Corridor and Substation Evaluation Report[94]:**
  Based on information collated at the March 2013 open days and a review of aerial photography and further more detailed studies, the project team proposed a number of modifications to refine the Least Constrained Route Corridor. An Emerging Preferred Route Corridor (ERPC) and substation locations were identified, as shown on Figure 6-2.

  This report confirmed the Least Constrained Corridor identified in the Stage 1 Report remained the preferred corridor, now referred to as the EPRC.

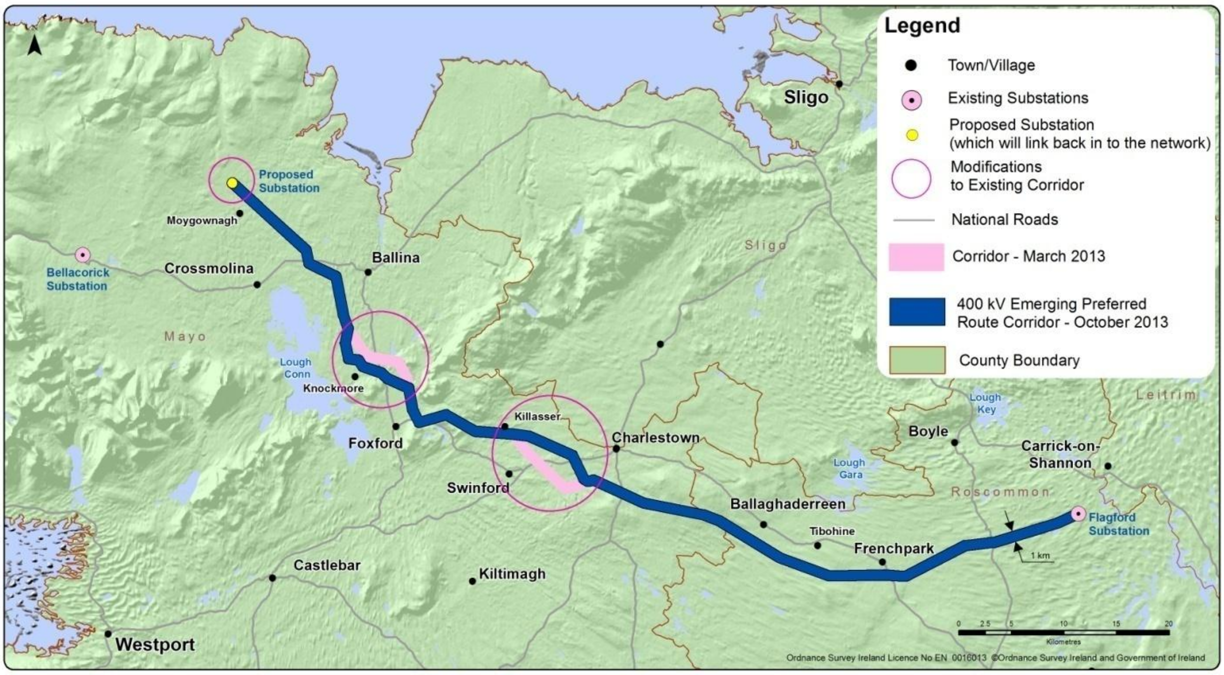

Figure 6-2 Emerging Preferred Route Corridor and Substation Locations - October 2013

- **Proposed Modifications to EPRC[95]:**
  Based on information collated at open days in October 2013 and further studies carried out, the project team proposed a number of modifications to further refine the EPRC, as shown in Figure 6-3. This included a proposal to underground approximately 8km of the existing 220kV Flagford - Srananagh OHL as far as the Flagford substation where it intercepts the proposed 400kV HVAC OHL. The existing 220kV towers would be rebuilt to 400kV specification for the Grid West project.

94 Appendix 3 - EirGrid Grid West Route Corridor and Substation Evaluation Report, October 2013
95 Appendix 8 - Underground Route Options Preliminary Evaluation Report, July 2014

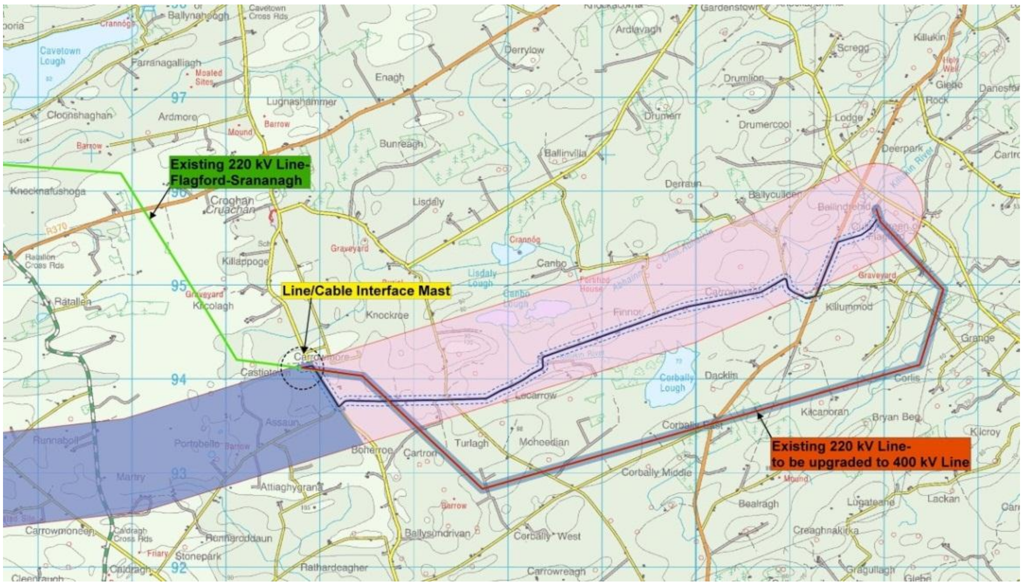

Figure 6-3 **Alternative OHL route at Approach to Flagford**

- **Proposed Modifications to the EPRC at Foxford and Ballaghaderreen:**
  Based on information collated from open days in October 2013 and further studies carried out, the project team proposed two further localised modifications to the corridor to the north east of Foxford and south east of Ballaghaderreen, as shown on Figure 6-4 and Figure 6-5.

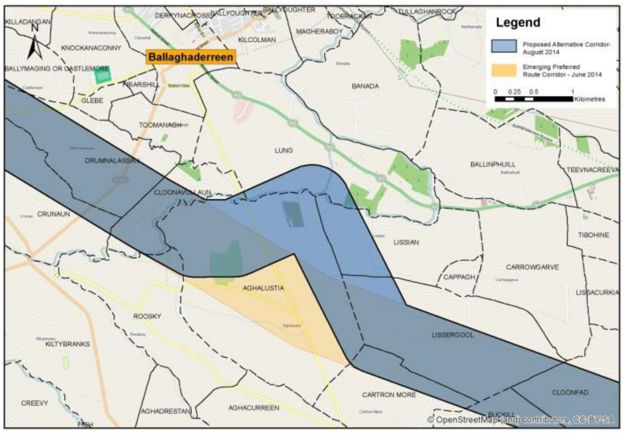

Figure 6-4 Local modification to EPRC at Ballaghaderreen

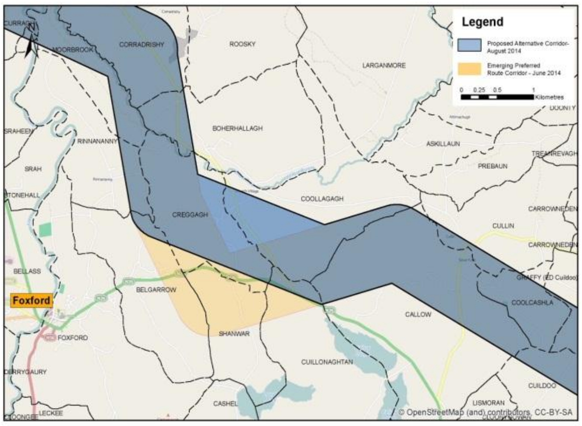

Figure 6-5 Local modification to EPRC at Foxford

6.2.2 Indicative Line Route

Upon identification of the initial EPRC in October 2013, an indicative line route was developed within that corridor for discussion purposes with landowners. This line route was presented on individual maps and was issued in November 2013 to landowners whose lands were crossed by the route and also to those landowners within 50m of the route.

Following the announcement of local modifications, a second phase of landowner engagement commenced and continued until the end of September 2014. The purpose was to consult with affected landowners on the modified indicative OHL route and indicative tower locations.

The line route shown in Figure 6-6 is presented solely for the purposes of this report. The study and refinement of the indicative OHL is not yet complete. If the HVAC OHL solution is ultimately identified as the preferred solution for Grid West, then EirGrid will continue to consult with directly affected landowners, the public and all interested people throughout the process as we confirm and refine our design.

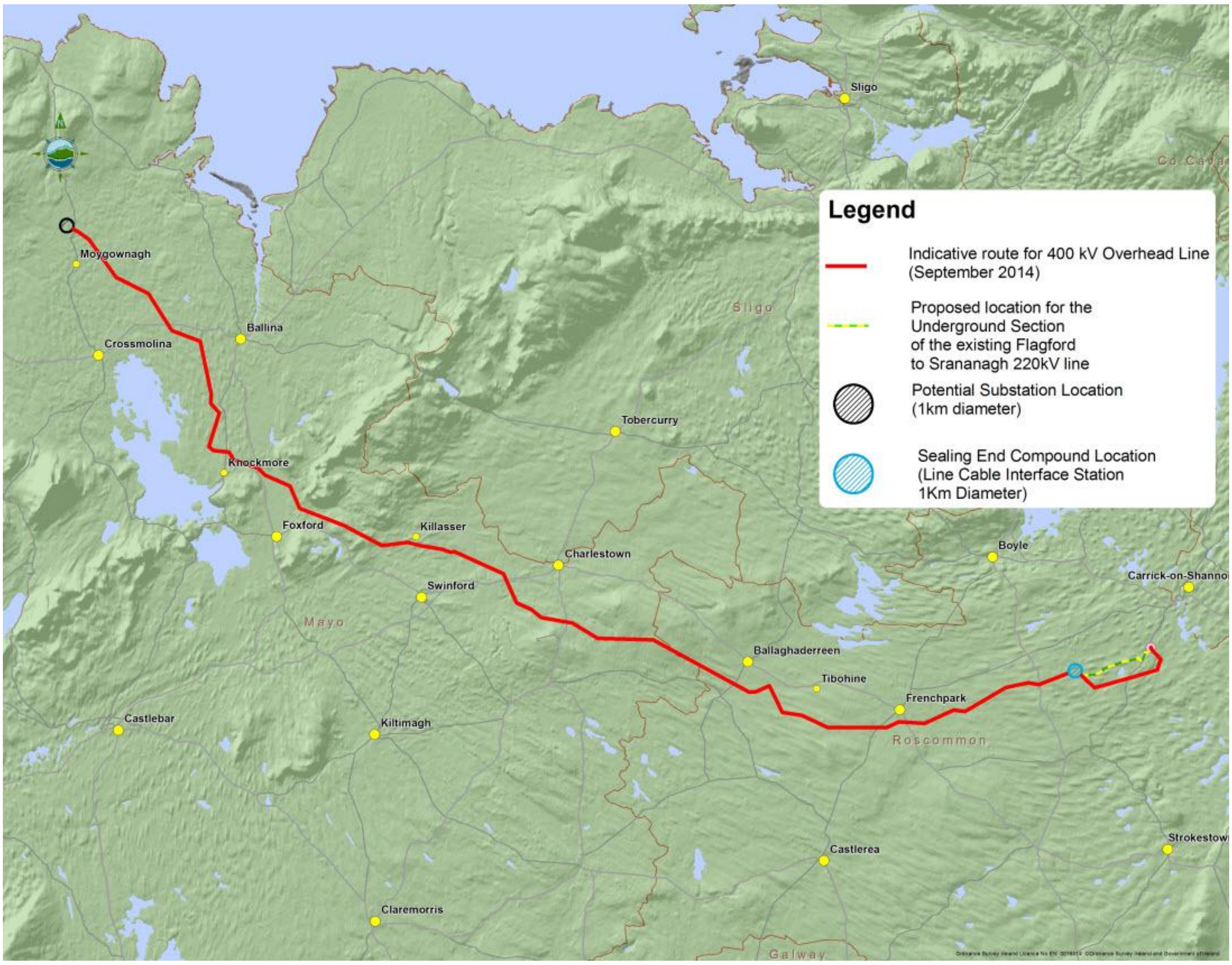

Figure 6-6 **Overview Map of the 400kV HVAC OHL Option**

Detailed maps of the indicative OHL are shown on Drawing Nos. 6424-1500 to 6424-1531[96].

[96] Volume 3 of this IEP report

6.3 IDENTIFICATION OF PREFERRED SUBSTATION LOCATIONS

6.3.1 Identification of Preferred Substation Location: North Mayo

The Route Corridor and Substation Evaluation Report[97] identified Location SB2 as the least constrained substation location for the termination of the western end of the OHL in the north Mayo area.

Following the publication of the report feedback was received from stakeholders and the public, and the project team were asked to consider a number of alternative locations for this substation.

These alternative locations were set out in the Alternative North Mayo Substation Sites Review Report[98]. The different substation locations considered are illustrated in Figure 6-7 below. While no final decision has as yet been made on the location of a substation in this area SB2 is taken as the preferred location for the purposes of this report.

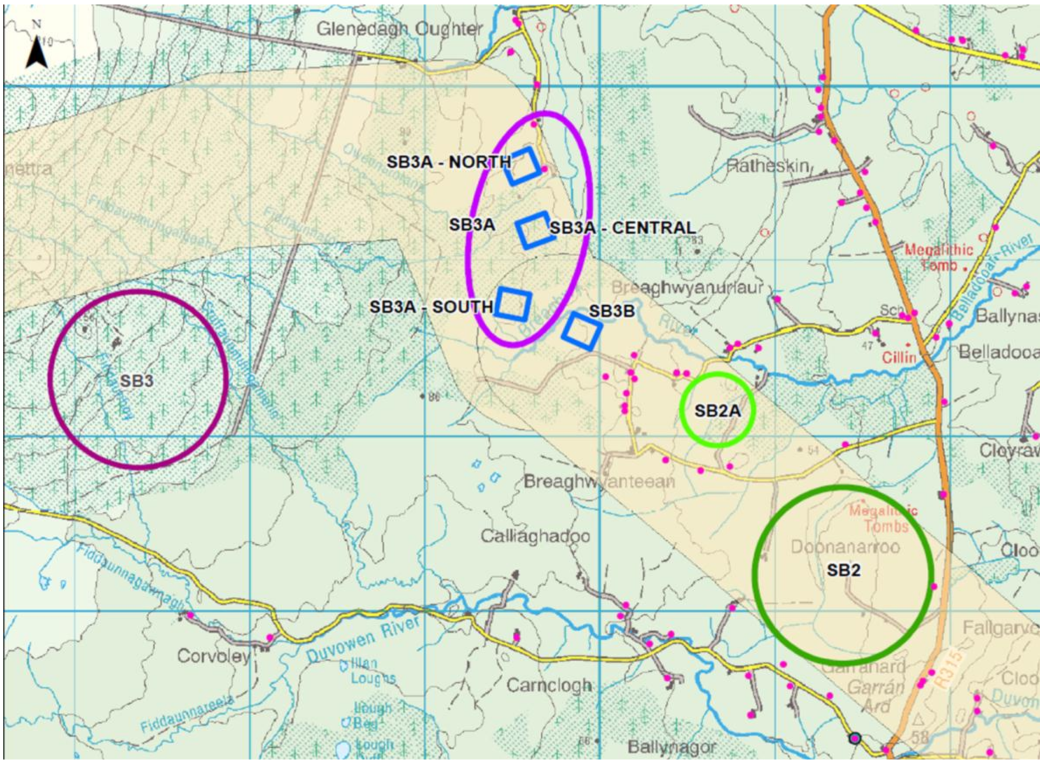

Figure 6-7 Potential Alternative Substation Locations in North Mayo

[97] Appendix 3 - EirGrid Grid West Route Corridor and Substation Evaluation Report, October 2013

[98] Appendix 10 - Alternative North Mayo Substation Sites Review Report, January 2014

6.3.2 Identification of Preferred Substation Location: Flagford

The Stage 1 Report considered two locations for the new 400kV/220kV substation at Flagford:

- ***Adjacent substation location zone***, where the new 400/220kV substation would be located adjacent to the existing substation and will be developed as an extension of this substation; and
- ***Remote substation location zone***, where the new 400/220kV substation would be located at a site within 1km of the existing substation but not directly adjacent to it. This option requires the development of a complete new substation including 220kV busbars, feeders and a connection via a 220kV OHL or UGC to the existing substation.

These two location zones are illustrated in Figure 6-8 herein, where adjacent sites will be located within the inner zone and remote sites within the outer zone.

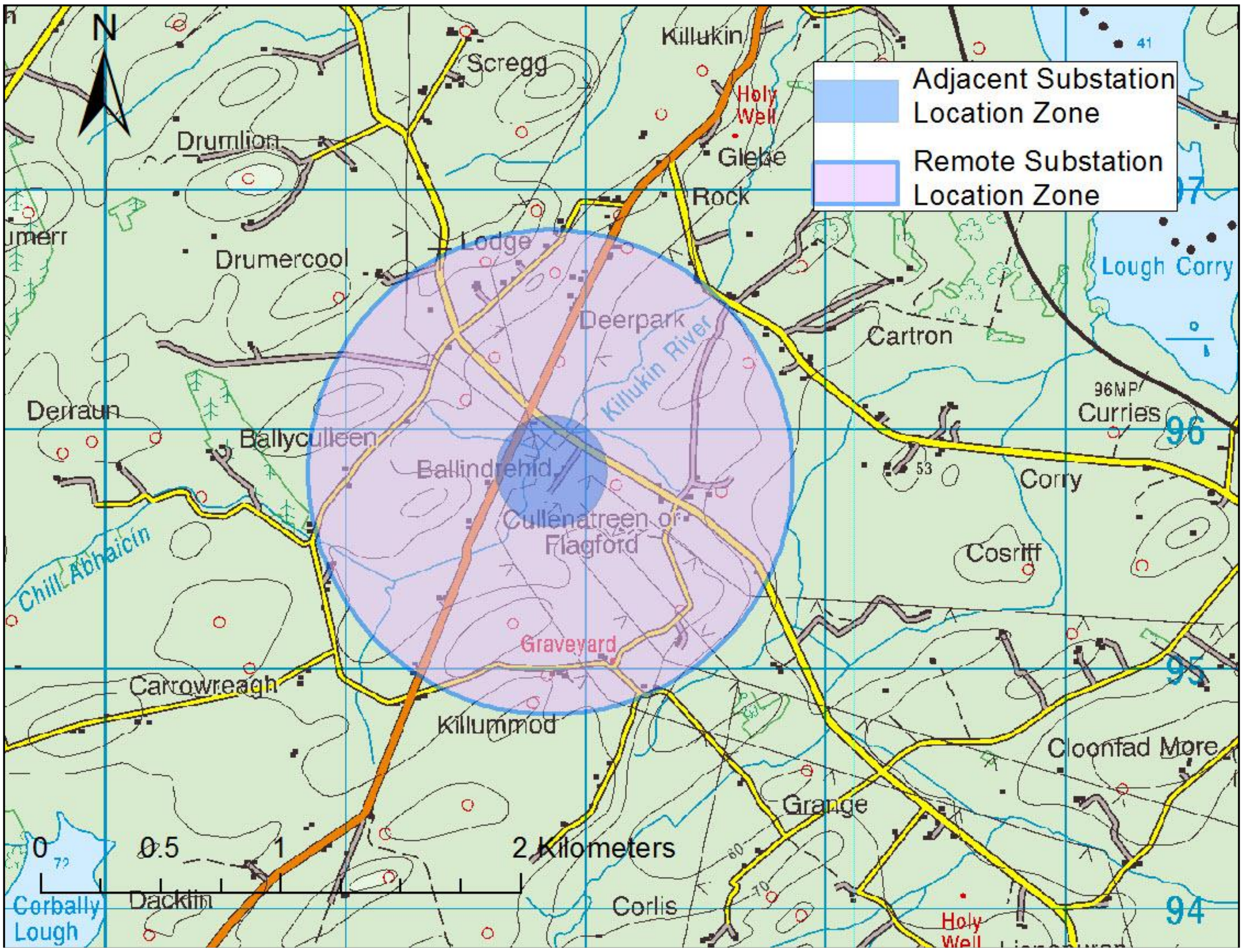

Figure 6-8 **Potential Flagford Substation Location Zones**

Within these zones a number of areas that met the basic requirements for a substation were identified as potential substation site areas. A total of six potential substation site areas were identified, of which four are located within the adjacent zone. The remaining two are within the remote zone. These site areas are areas of land suitable for the development of the substation; specific sites have not been identified.

Evaluation of these six site areas in the Stage 1 Report found that the 3 least constrained substation site areas considered most suitable for the construction of a 400kV/220kV GIS substation are located adjacent to the existing Flagford substation. The report noted that all three site areas were relatively similar in ranking on the environmental and technical constraints and the final selection would be reviewed depending on site investigation results and consultations with landowners. For the purposes of this report the location is taken to be adjacent to the existing Flagford substation.

6.4 ENVIRONMENTAL ANALYSIS

6.4.1 Introduction

For the 400kV HVAC OHL option, the environmental appraisal was been carried out using the same methodology as that detailed in the UGC section of this report, Section 5.6.1.

The OHL option will include a substation in north Mayo and an alteration to the existing substation at Flagford, Co. Roscommon. The environmental appraisal of the substation sites was completed as part of the Route Corridor and Substation Evaluation Report (October 2013) and the Alternative North Mayo Substation Sites Review Report.

Also as set out in Section 5.6.1, at this stage of the Grid West project it is only possible to provide a high level appraisal of possible mitigation measures, based on desktop studies and fieldwork completed to date. The mitigation measures for the OHL are set out below.

No matter which option emerges as the preferred solution for Grid West, a Construction Management Plan (CMP) will be prepared. The CMP is a live document that will be continuously reviewed, improved and updated throughout construction. Revisions will also include any changes and improvements made during the works from an environmental point of view.

The principal controls for environmental management are identified and controlled primarily through the CMP and Method Statements for the construction phase of the project. The contents and aims of the CMP are listed in Section 5.6.1 of this report.

The contractor will be required to agree the CMP in consultation with EirGrid's project management team and relevant local authorities and statutory bodies.

All reports will be available to EirGrid to assist in monitoring and evaluating the environmental performance of the project.

The environmental mitigation measures that can be identified at this stage of the project are generally related to standard best practice for infrastructure projects and are not unusual. As such, the costs associated with the mitigation measures described are included in the construction costs estimates for the OHL option.

6.4.2 Biodiversity, Flora and Fauna

6.4.2.1 Methodology

The general methodology followed in identifying the potential impacts on flora and fauna of the HVAC OHL option is similar to that described in Section 5.6.2.1 for the UGC option and includes:

- A desktop study;
- Examination of OSI maps and aerial photography;
- Review of datasets and reports held by the National Parks and Wildlife Service (NPWS), National Biodiversity Data Centre (NBDC) and Birdwatch Ireland amongst others; and

- Field surveys including the 2013, 2014 land access surveys (habitats, flora, mammals, invertebrates etc), breeding birds (Summer 2013, 2014), wintering birds (Winter 2012/2013, 2013/2014), bats (Summer 2014) and marsh fritillary butterfly (September 2013, 2014).

6.4.2.2 Review of Overhead Indicative Line and Substations

The identified OHL route has been selected to avoid the most sensitive ecological receptors. The route will cross a predominantly agricultural landscape and includes groundworks associated with the construction of an OHL, towers and substations/substation works together with access routes.

A summary description and high level appraisal of impacts to identified key ecological receptors in the vicinity of the proposed OHL route is described in a similar manner to that detailed in Section 5.6.2.2.

6.4.2.2.1 <u>Designated Sites</u>

The OHL route has been subject to careful consideration and several iterations have been reviewed which have led to the current design and location. The avoidance of potential significant impacts on European Designated Sites (Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) and National Sites designated for nature conservation (Natural Heritage Areas (NHA's) and proposed Natural Heritage Areas (pNHA's) has been a key consideration informing the current route.

River Moy SAC:

The route of the OHL is located predominantly within the catchment of the River Moy SAC (site code 2298) and includes the same qualifying interests as described in Section 5.6.2.2.1.

The OHL route passes through the River Moy SAC at locations where direct impacts and effects on qualifying interests will be avoided. Indirect impacts and effects such as disturbance of sensitive species and construction-related sediment or pollutant run-off to watercourses, which may have a negative effect on the population of sensitive species, will be a key consideration.

The potential impacts and effects of the final design on European Designated Sites will be considered in detail in the Appropriate Assessment process as required under Article 6(3) of the E.U. Habitats Directive.

Specific locations within the SAC are detailed further in the table below where direct and indirect impacts and effects to qualifying habitats and species may arise.

Location	Ecological Receptor Description
River Moy c.5km north of Foxford in the Curragh Bog Area	Where the OHL crosses the river Moy the proposed tower location on the western side of the river is on the SAC boundary. The eastern tower is immediately to the east of the SAC boundary. Habitats potentially impacted include improved grassland and hedgerows. The semi-natural habitats associated with the river banks will not be impacted. No Annex I qualifying habitats will be impacted. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.
Yellow River (between Ballina and Swinford)	Where the OHL crosses the SAC at the Yellow River both associated towers are outside the SAC boundary in agricultural grassland. No Annex I qualifying habitats will be impacted. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.
River Moy at Loobnamuck	The OHL runs immediately to the south of the River Moy SAC boundary at Loobnamuck. No towers are located within the SAC boundary. Habitats in the area comprise improved and wet grasslands. No Annex I qualifying habitats will be impacted. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.
Sonnagh River	The OHL crosses the SAC at three points; two towers are within the SAC designation, while one tower sits on the SAC boundary. Habitats in the area, which border the River Sonnagh, comprise wet and improved grasslands, scrub and woodland. Qualifying Annex II species potentially occurring include salmon, crayfish, lamprey and otter.

Table 6-1 Crossings of the River Moy SAC by the Proposed OHL Route

Tower locations have been selected to avoid Annex I habitats and to avoid river riparian zones. The locations of the towers adjacent to river crossings are not in qualifying Annex I habitats. Direct impacts to qualifying Annex I habitats and Annex II species are therefore not anticipated.
Potential indirect impact of diffuse water pollution/sedimentation from works at tower locations near river crossings, and further upstream in the catchment, require consideration. The OHL route passes through the wider River Moy catchment and crosses thirty five identifiable river crossings. While not all streams feeding into the River Moy are designated they may still support populations of protected aquatic species connected with the designated sites. The large number of tower/structure locations within the catchment and required access tracks require careful pollution controls.

Given the long linear nature of the proposed OHL route, towers are located on numerous habitat types. Many are on sloping upland terrain with peat soils with limited existing access (roads required) and a number are located in commercial forestry (which will require clearance). Site clearance / construction of towers in these cases may lead to a temporary (during construction) high risk of sediment runoff from multiple sites within the River Moy catchment. There is potential that localised temporary adverse effects (associated with sediment runoff) could impact breeding salmon and associated spawning habitat/ nursery areas in streams linked to the River Moy SAC during the construction phase.

To minimise this risk, all towers and access routes will be offset from identified streams, though drainage ditches will be close to some works areas and adequate control of soil/peat runoff is critical. Careful mitigation controls will minimise risk to other protected aquatic species within the SAC and its tributaries including white-clawed crayfish and lamprey species, which are also sensitive to excessive sedimentation of watercourses.

The indirect impacts and associated potential adverse effects may have implications for the conservation status of qualifying habitats/species and the overall integrity of the River Moy SAC.

Other Designated Sites:
The OHL route passes close to Cloonshanville Bog SAC (Site Code 614), approximately 0.5km to the east of Frenchpark, which is designated for raised bog and bog woodland, the final specific locations of structures will avoid impacts to this site.

While no Natural Heritage Areas (NHAs) are crossed by the OHL route, 1.09km of proposed NHA is crossed (Moy Valley pNHA 002078). The Moy Valley pNHA was identified for protection of corncrake, a species now extinct in the area, but the location of proposed works will minimise impact here.

6.4.2.2.2 Aquatic Ecology

In total, the OHL route crosses 64 identifiable rivers including the River Moy SAC. The western sections of the OHL route and the north western substation are located in the Cloonaghmore river catchment (predominantly Good or High water quality/ WFD status[99]).

The OHL route also crosses through the Moy-Deel Margaritifera Sensitive Area between Moygownagh and Ballina. While not a qualifying interest of the River Moy SAC, freshwater pearl mussel are an Annex II species protected under the Habitats Directive and the population in the River Deel is of International importance.

The majority of the route, and most sensitive section, is within the River Moy catchment (predominantly Good or High water quality/ WFD status). Toward the eastern part of the corridor, the route enters the River Shannon catchment (predominantly Poor/ Moderate water quality/ WFD status) in the vicinity of Ballaghaderreen and crosses the Lung and Breedoge Rivers. The eastern catchment and sub-basins are in predominantly low-lying areas with less risk of soil water runoff and therefore lower potential risks to sensitive aquatic species.

Access to tower locations and the requirement for access tracks, many on sensitive peat habitats/forestry uplands with high risk of silt runoff, means that there is potential for localised pollution associated with excessive sedimentation to salmonid spawning streams including those linked to the River Moy SAC. All towers and access routes will be offset from identified streams, though drainage

99 http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True

ditches will be close to some works areas and adequate control of soil/peat runoff is a critical consideration. Potential impacts and effects to key aquatic ecology receptors are as shown in the table below.

Receptor	Potential Impact	Potential Effect
Freshwater Pearl Mussel	Increased sediment load causing a decline in water quality. Minimum Q4-5 required	Smothering of mussel beds, loss of individuals and spawning beds. Resulting decline in population, recruitment, abundance, extent and/or distribution.
Salmon and Trout	Increased sediment load causing a decline in water quality. Minimum Q4 required.	Smothering of spawning beds. Resulting decline in population, recruitment, abundance, extent and/or distribution.
Brook and Sea Lamprey	Increased sediment load causing a decline in water quality.	Smothering of spawning beds (lamprey require gravel spawning beds). Resulting decline in population, recruitment, abundance, extent and/or distribution.
Crayfish	Increased sediment load causing a decline in water quality and loss of habitat heterogeneity. Minimum Q3-4 required.	Loss of suitable habitat. Resulting decline in population, recruitment, abundance, extent and/or distribution.

Table 6-2 Key Aquatic Ecology Receptors and Potential Impacts and Effects

Pollution control will be required at all stream, river and drainage ditch crossings, in particular where linked to the River Moy SAC. Detailed and potential species specific surveys will be required for aquatic fauna in order to inform specific mitigation measures (if required).

6.4.2.2.3 <u>Habitats</u>

Many of the towers required will be located on habitats of low ecological value such as improved grassland, however extensive areas of bog (high value habitat), also will be impacted and areas of commercial forestry will require clearance.

There is potential for habitats listed on Annex I of the EU Habitats Directive to be impacted along the route in areas outside of designated sites. These habitats may include the following:

- Owenmore River (Ballintober Townland, south east of Moygownagh);
- Semi natural woodland (approximately 460m south of N59 crossing;
- Potential fen (Ballyderrig);
- Degraded Bog/ Marsh Fritillary recorded (west of Currabaggan);
- Bog/ heath (Lisaniska West, west of N26);
- Semi natural woodland (Curragh, east of N26);
- River Moy and Yellow River crossing; towers located in managed farmland. Protected flora identified in area which can be avoided through careful design;
- Yellow River at Moorbrook;
- Semi natural woodland (Creggagh Townland);

- Semi natural woodland (Coolagagh Townland);
- Wet Heath (Knockaglanna Townland);
- Wet heath, fen, potential *Vertigo* spp. habitat (Coolcashla);
- Fen (edge crossed in Rubble/Blackpatch);
- River Moy near Tumgesh townland; towers located in managed farmland;
- Raised bog near Carton/Sonnagh;
- Sonnagh River valley – SAC river habitat and unimproved wet grassland/ semi natural woodland;
- Degraded Bog (Carrownlacka / Skeheen Townlands);
- Unimproved grassland/ wet heath (west of Barnaboy);
- Unimproved grassland/ wet heath (Barnaboy);
- Raised Bog at Cloonavullau/Lung River;
- Raised Bog at Aghalustia;
- Raised Bog at Lissergool;
- Degraded raised bog near Mullen Cross Rd;
- Bog lands around Breedoge River; and
- Patches of degraded Raised Bog at Ardagh.

Additional, degraded bog sites are crossed throughout the route. It is noted that these habitats may be classified as Annex I non-priority bog habitats.

Indirect impacts to habitats as a result of personnel and vehicle movement around the construction locations will also occur (e.g. compression, rutting, hydrological changes, pH changes as a result of imported construction materials).

6.4.2.2.4 Birds

Potential impacts to bird species are a key consideration in the development of any overhead transmission line. The key potential impacts are collision with the conductor or shield wire elements resulting in direct mortality of birds and potential displacement of birds from areas impacted by the alignment.

The OHL route passes through several areas with populations of wintering bird species known to be sensitive to OHL developments. It also passes close to or through areas with breeding bird species of high conservation concern potentially sensitive to the development. Species identified during surveys (2012 – 2014 inclusive) as potentially sensitive to the effects of the development in the area include; Hen Harrier (wintering), Whooper Swan (wintering), Greenland White Fronted Geese (wintering), Curlew (breeding), Lapwing (breeding), Woodcock (wintering and possibly breeding) and wintering duck species (Wigeon, Tufted Duck and Teal).

Breeding Birds:

Over eighty species were identified as potentially breeding in the study area (which includes the proposed OHL route and up to 3km either side). These included 11 red listed species[100] of which 6 no. (Black-headed Gull, Curlew, Lapwing, Meadow Pipit, Grey Wagtail and Red Grouse) showed strong evidence of breeding. Thirty three amber listed species (species of moderate conservation concern) were recorded including Kingfisher (species listed on Annex I Birds Directive), and most of these species potentially breed in the area. The remainder are common breeding species not currently of conservation concern.

Key important breeding bird sites identified (during desk study and consultation) in the study area are avoided. These include SPA's, coastal areas, lakes and extensive blanket bogs:

- Potential target species identified and surveyed for in the study area (2013 and 2014) include breeding waders (Curlew, Dunlin, Lapwing, Woodcock, Redshank, Common Sandpiper, Snipe and Golden Plover), raptors (Sparrowhawk, Kestrel, Buzzard, Hen Harrier and Merlin) and waterfowl (duck species including Teal, Tufted Duck, Mallard, Little Grebe, Great Crested Grebe, Mute Swan and Moorhen). All passerine species were also recorded including riparian species such as Kingfisher, Dipper and Grey Wagtail;
- Potential wader sites surveyed such as River Moy grasslands (callows) are not used by significant numbers of breeding waders – none recorded in 2014. No Corncrake were recorded in the River Moy pNHA (2013 and 2014 surveys). They have not bred regularly in this area for many years (at least since mid-1990's) and it is not proposed to designate this area in the future (NPWS 2014)[101];
- One extensive area of degraded bog, north east of Swinford, was identified as a breeding location for Curlew with one pair of Curlew (and possibly 2) recorded in 2014. This species is a very rare breeding bird in Ireland now (potentially < 200pairs; source Birdwatch Ireland[102]);
- Lapwing were located at three locations > 500m from the nearest structure locations. These territories (possible nest sites) were all displaced (predation/ disturbance) during 2014.
- Snipe are widespread on degraded bogs throughout the study area;
- No breeding Hen Harrier sites were identified in the study area to date and this is consistent with national surveys and designated sites for this species;
- No Merlin were recorded; and
- No significant locations for breeding species of high conservation concern were recorded relative to the route corridor. Species currently listed as being of conservation concern including Meadow Pipit (Red listed), Stonechat and Skylark are very common and widespread in bog and marginal farmland (wet grassland) throughout the study area.

The key potential impacts identified are:

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[100] Colhoun K. & Cummins S. (2013). *Birds of Conservation Concern in Ireland 2014-2019. Irish Birds 9:523-544 (2013).*
[101] http://www.ahg.gov.ie/en/Heritage/NationalParksandWildlifeService/A%20Framework%20for%20Corncrake%20Conservation%20to%202021%2011-04-14.pdf.
[102] http://www.birdwatchireland.ie/Publications/eWings/eWingsIssue22July2011/CatastrophicCurlewdeclinesuncovered/tabid/1189/Default.aspx.

- Construction Phase: Disturbance to breeding habitat and nest sites, in particular where woody vegetation clearance is required and disturbance to bog, scrub and wet grassland habitats. Displacement of sensitive bird species may arise in some areas during construction (temporary impact).
- Operational Impacts: Collision with conductors and earthwire where alignment crosses flightlines.

Wintering Birds

With respect to wintering birds, the key findings of studies to date are as follows:

- The OHL route avoids key international and nationally important sites in the wider study area;
- The vast majority of the OHL route crosses farmland with smaller areas of degraded bog. These areas have very low concentrations of wintering birds;
- Low numbers of wintering Hen Harrier are widely dispersed, in particular in the Frenchpark Bogs area. Potential winter roost sites occur at some of the less disturbed bog sites;
- The OHL route avoids typical areas where wintering birds congregate such as turloughs and lakes in the wider region; and
- The OHL route is located relatively close to a number of SPAs for birds including Lough Conn, Lough Gara and Bellanagare Bog. These areas were the focus for surveying to date.

The key observations from the Winter Bird Surveys to date, as relevant to a OHL route option, are summarised in the table below.

Site	Corridor Comments	Potential Species at Risk (Collision, Displacement)	Potential Effect of Collision
The River Moy Crossing (north of Foxford)	The OHL route crosses the Moy valley at a location with relatively low winter bird activity. Whooper Swans use areas north and south of here. **It is likely that flightlines cross the corridor at least occasionally.**	Whooper Swan, Cormorant, Mute Swan	Increased mortality rates for the local Whooper Swan, Cormorant and Mute Swan populations. Displacement unlikely to be an issue.
Cuilmore Lough (area)	A flock of Whooper Swan were observed using this area within 1km west of the OHL route. No flights were observed or are likely across the corridor though further survey is advised.	Whooper Swan	Increased mortality rates for the local Whooper Swan populations. Displacement unlikely to be an issue.
The Lung River area (south of Ballaghaderreen)	A small flock of Whooper Swan (maximum = 15) regularly use fields beside the Lung River. This was observed in 2012/2013 and previous surveys in 2009 and 2010. **A flightline was confirmed across the corridor in 2013/2014.**	Whooper Swan	Increased mortality rates for the local Whooper Swan populations. Possible implications for favourable conservation status of this species in Lough Gara SPA (unlikely) as linkage identified. Displacement unlikely to be an issue.
Frenchpark Bogs (located to east of the bogs)	These extensive bogs are former roost and foraging areas for Greenland White Fronted Geese. It is evident from surveys conducted that small flocks still occasionally use at least one of these bogs. This is a difficult species to survey and establish site usage. In this regard it is recommended that more focused surveys be conducted in 2014/ 2015 for this species around Frenchpark as Greenland White Fronted Geese are highly sensitive (high conservation concern) and these birds may be linked to the population at Lough Gara SPA.	Greenland White fronted Geese Hen Harrier	Increased mortality rates for the local Greenland White Fronted Geese populations. Possible implications for conservation status of this species identified as the route crosses these two SPAs. No Greenland White Fronted Geese have been recorded to date flying relative to the proposed route. Displacement unlikely to be an issue. Potential disturbance during construction to winter roost sites for Hen Harrier. Collision is not considered an issue for Hen Harrier.

Table 6-3 Summary of Key Flightline Observations

6.4.2.2.5 <u>Other Fauna</u>

A variety of protected and more common fauna will potentially be disturbed or be more directly affected through habitat loss as a result of the OHL route. Key habitats where protected fauna (e.g. Marsh Fritillary and *Vertigo* spp.) will require consideration include fens, unimproved wet grassland, raised bogs and springs. Marsh Fritillary larval webs were located in recovering cutaway bog at two townlands (Gortaskibole and Corraveggaun) in September 2014. These areas are crossed by the OHL route.

Mammals including pine marten, red squirrel, badger and bats are dispersed throughout the study area and will require mitigation consideration for potential disturbance effects. Sites with high potential as bat roosts (old bridges, buildings, caves etc.) will be avoided.

6.4.2.3 Summary of Overhead Indicative Line Route Option – Biodiversity, Flora and Fauna

A summary of the key considerations with respect to the biodiversity, flora and fauna of the OHL study area is provided below. These comments are based on the results of initial desktop and field studies and are an indication only of potential impacts and effects. The potential impacts of the scheme will be fully assessed as part of the Ecological Impact Assessment and Appropriate Assessment of the eventual EIS for the identified preferred design and route option for the Grid West project.

Ecological Receptor	OHL – Summary of Impacts and Effects
European Sites (SAC/SPA)	1.07km of SAC crossed. No SPAs crossed. Towers and tracks will be off-set as much as possible from rivers and associated riparian habitats. There is flexibility to locate the development away from sensitive habitats and existing access tracks used. There is high potential for temporary adverse impacts associated with deterioration of water quality, due to uncontrolled sediment release during construction works at multiple structure sites, throughout the River Moy catchment. Potential impacts to qualifying interests of European Sites will be considered in detail in the Appropriate Assessment Process required under Article 6(3) of the Habitats Directive.
NHA/ pNHA	1.09km of the Moy Valley pNHA is crossed. This pNHA was identified in 2000[103] as suitable for designation for protection of breeding Corncrake. This species does not now breed in the area and this area does not now warrant designation as a pNHA (NPWS 2014)[104].
Aquatic Ecology	OHL towers, in particular on sloping peat soils with forestry, present a significant temporary sediment runoff risk (during construction/ site clearance) at multiple work area locations. Many of these sites are “off-road” which will require new access roads and potential drainage and additional sediment runoff impacts. Forestry areas will require clearance along the route corridor which will increase sediment runoff at these locations. Upland watercourses are highly sensitive and many are important spawning areas for salmon. Increased rainfall and sensitive peat soils in upland areas also contribute to the risk of adverse effects on sensitive species. Operational risks are not likely to be significant with OHL.
Habitats	Towers locations have been selected to avoid the most sensitive habitats associated with European and National designations, and to avoid where possible other high value habitats. Direct habitat loss will mostly be within low ecological value agricultural habitats, however semi-natural habitats of higher ecological value in a local or county context will also be lost. There will also be indirect effects to habitats as a result of construction activities.
Birds	The OHL passes through several areas where birds sensitive to OHL development overwinter. It also passes close to or through areas with breeding bird species of high conservation concern potentially sensitive to the development including Curlew. The primary concern is collision with the conductors and/or earth wire component of the OHL which would results in mortality of birds. There are also potential displacement risks, where birds abandon an area due to the presence / disturbance effect of the infrastructure. Other impacts may include increased predation associated with predator perch in open habitats as afforded by new structures.
Other Flora/Fauna	The key concern is the potential for localised permanent direct impacts to protected species habitats (in particular Marsh Fritillary and possibly *Vertigo* spp) due to habitat being disturbed, resulting in a decrease in the population of the species in the area. There will potentially be temporary disturbance impacts to protected mammal species including Pine Marten and Red Squirrel due to forest clearance during the construction / site clearance phase.

Table 6-4 Summary of Biodiversity Considerations for the Proposed OHL Route

[103] Heath, M.F., and M.I. Evans, editors. 2000. Important bird areas in Europe: Priority sites for conservation. 2 vols. Birdlife International, Cambridge, UK.

[104] National Parks & Wildlife Service, Department of Arts, Heritage & the Gaeltacht. April 2014. A Framework for Corncrake Conservation to 2021

6.4.2.4 Mitigation Measures for Biodiversity Flora and Fauna – OHL Option

Preconstruction surveys and the implementation of seasonal working restrictions, as well as the supervision of works by an experienced ecologist will allow for appropriate biodiversity protection. Detailed mitigation measures will be developed and set out in specific procedures for the protection of flora and fauna in a CMP for the project. Any unavoidable residual disturbance identified in relation to sensitive bird and mammal populations will be carried out only under licence from the National Parks and Wildlife Service.

The prevention of pollution to watercourses and subsequent impacts on the River Moy, River Lung and other rivers and streams is very important in particular for species of conservation importance such as Salmon, Crayfish, Lamprey, Otter and Kingfisher.

Markers/ bird flight diverters will be placed on overhead lines located at observed sensitive bird flight lines.

Construction work in sensitive environmental areas will be supervised by an ecologist. The ecologist will carry out preconstruction surveys and advise, as necessary, on ecological issues. The ecologist will liaise with the National Parks and Wildlife Service on relevant issues and report on the progress and success of the relevant mitigation measures.

The contractor will be instructed to minimise hedgerow loss and in particular to avoid mature trees. Care is required when cutting gaps in hedgerows. The removal of hedgerow will always be the minimum width required and any tall trees present will preferably be left in situ. However, it will be necessary to remove trees at certain locations. The ecologist will monitor the removal of any trees that have the potential of containing bats.

6.4.3 Water

6.4.3.1 Methodology

The methodology described in Section 5.6.3 was also used for the OHL route option environmental appraisal of surface water and groundwater.

6.4.3.2 Review of Overhead Indicative Line and Substations

6.4.3.2.1 <u>Surface Water</u>

6.4.3.2.1.1 River Crossings

The OHL route crosses 64 identifiable surface water features (i.e. rivers & streams).

The western sections of the OHL route and the north western Mayo potential substation locations are located in the Cloonaghmore river catchment (predominantly Good or High water quality WFD status[105]).

[105] http://watermaps.wfdireland.ie/NsShare_Web/Viewer.aspx?Site=NsShare&ReloadKey=True

Most of the OHL route then passes though the wider River Moy catchment, with 35 identifiable river crossings within this catchment. The River Moy catchment has predominantly Good or High water quality WFD status.

The eastern section enters the River Shannon catchment in the vicinity of Ballaghaderreen, crossing the Lung and Breedoge Rivers.

Given the number of tower and access tracks required, many on sensitive peat / forestry uplands with risk of silt runoff, it is likely that localised risk will arise to salmonid spawning streams linked to the River Moy SAC. All towers and access routes will be offset from identified streams, though drainage ditches will be close to some working areas and adequate control of soil/peat runoff is a critical consideration. Careful mitigation controls would be expected to minimise risk to the River Moy and nearby water features.

The eastern River Shannon catchment and sub-basins are in predominantly low-lying areas with less risk of soil water runoff and therefore lower potential risks to surface water bodies.

As the works will be quite localised and short-term, it is unlikely that flow rates in rivers and lakes will be affected by the OHL option. In addition, it is proposed that construction works will take place at a set-back from water features (including rivers, lakes, wetlands etc.) and the OHL will traverse water features at a height (minimum of 9m above ground level) where they cannot be avoided e.g. across the River Moy.

6.4.3.2.1.2 Lakes

Lough Conn, Lough Cullin and a number of smaller lakes dominate the western section of the OHL route, as far east as Callow. The OHL route is >1.5km (at its closest) from Lough Conn. A small lake, Lough Alick, is located between Lough Conn and the OHL route, at an approximate distance of 550m from the OHL route. Ballycong (Carrowkeribly) Lough is located approximately 2km north of the OHL route (north of Foxford). At Callow, the OHL route runs north of the Callow Loughs, at a distance of >1.1km (at its closest point).

Lough Gara and a number of smaller lakes dominate the eastern section of the OHL route. The OHL route is >6km (at its closest) from Lough Gara. Towards Flagford, the smaller Corbally Lough (located east of Springfield) is located within 330m north of the OHL route. The small lakes – Canbo Lough and Lisdaly Lough are located to the northwest of Corbally Lough, at a distance of 1.5km and 2km distance of the OHL route respectively.

Given the number of towers and access tracks required, many on sensitive peat / forestry uplands with risk of silt runoff, it is likely that localised risk will arise to lakes within 1km of the works, particularly if linked by rivers, streams or drainage ditches. Construction methodologies carried out according to best practice will minimise the risks of any potential adverse impacts on the lakes.

6.4.3.2.2 Groundwater

6.4.3.2.2.1 Aquifer Potential & Characteristics

The Bedrock Geology/Bedrock Aquifer type along the OHL route (from west to east) is presented in the table below. Information was attained from the National Aquifer Map prepared by the GSI.

Approximately 61.1km of the OHL route is located on karstified Pure Bedded Limestone, which is a Regionally Important Aquifer that is very vulnerable to pollution.

It is unlikely that works associated with the OHL option will impact on aquifer recharge due to the localised and short-term nature of the works. However, if groundwater is directly/indirectly impacted by construction works or from repair works during the operational phase of the development the effect may be that the quality of groundwater deteriorates and indirectly effects downstream water supplies and/or groundwater dependent ecosystems.

Bedrock Type	Aquifer Type	Approx. Length of OHL Route (km)
Sandstones, Shales, Limestones	Pl	3.1
Impure Limestones	Ll	4.6
Pure Bedded Limestones (Karstified)	Rk	20.5
Granites & Other Igneous Intrusive Rocks	Pl	11.5
Sandstones	Lm	1.5
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	5
Shales & Limestones	Ll	4.8
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	2.8
Volcanics	Pl	9.3
Mixed Sandstones, Shales & Limestones	Ll	7
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	14.6
Mixed Sandstones, Shales & Limestones	Ll	3.3
Pure Bedded Limestones (Karstified, with Conduits)	Rkc	18.2

Where:
Pl Poor Aquifer - Bedrock which is generally unproductive, except for local zones;
Ll Locally Important Aquifer - Bedrock which is moderately productive, only in local zones;
Lm Locally Important Aquifer - Bedrock that is generally moderately productive;
Rk Regionally Important Aquifer - Karstified;
Rkc Regionally Important Aquifer - Karstified, with conduits.

Table 6-5 Bedrock and Aquifer Classification along the OHL Route

6.4.3.2.2.2 Karst Features

From north Mayo to Ballaghaderreen, the OHL route does not pass within 5km of any recorded karst features. The OHL route east of Ballaghaderreen to Flagford passes through a richly karstified area, passing over and close to numerous karst features, including turloughs, potential turloughs, enclosed depressions, springs, swallow holes and caves.

Karst features leave the groundwater below very vulnerable to pollution and all construction works carried out in the vicinity of such features must be strictly managed to protect the groundwater. The limited nature of the construction works along the OHL route (i.e. at tower locations only) limits the area of potential contaminants reaching the karst features/groundwater.

6.4.3.2.2.3 Groundwater Vulnerability

The Groundwater Vulnerability along the OHL route is recorded as follows:

Groundwater Vulnerability	Approx. % Along OHL Route
Low	23.1%
Medium	31.2%
High	37.8%
Extreme	6.8%
X(Rock at or near surface OR Karst)	1.1%

Table 6-6 Groundwater Vulnerability along the OHL Route

The High, Extreme and X Vulnerabilities recorded mainly relate to the karstified Pure Bedded Limestone Bedrock, which is a regionally important aquifer that is very vulnerable to pollution.

Construction on the OHL route will be restricted to tower locations (at approximately 350m intervals), thus reducing the area of potential pollution from construction.

6.4.3.2.2.4 EPA/GSI Source Protection Zones

According to the EPA/GSI Source Protection Zone Map[106], the OHL route does not intercept any Source Protection Zones (SPZ).

Rockingham SPZ is located (at its closest) 6.5km north of the OHL route. This SPZ is in place to protect Rockingham Springs (located east of Boyle town, Co. Roscommon), which is the source for the Boyle/Ardcarne Regional Water Supply Scheme (which serves Boyle town).The OHL route is at a great enough distance from the SPZ, to ensure that construction works on the route will have no impact on the SPZ.

6.4.3.3 Mitigation Measures for Water – OHL Option

Mitigation measures will be put in place to prevent or minimise pollution of watercourses and loss of habitat, in particular at the River Moy and River Lung, as agreed with relevant local authorities. Best operational practices will ensure the OHL development is not likely to give rise to pollution of soil or

[106] http://www.gsi.ie

groundwater. Spill containment will be carried out according to best practice guidelines and codes of practice and will be inspected and maintained regularly.

Storage areas, machinery depots, site offices, temporary access roads or the disposal of spoil will be located as far as is practicable from watercourses. Storage areas for potentially polluting substances will be bunded. Fuels, lubricants and hydraulic fluids for equipment used on the construction site, as well as any solvents, oils, and paints will be carefully stored in containment areas and fuelling and lubrication of equipment will also not be carried out close to watercourses. Fuelling of vehicles and transfer of other potentially polluting liquids shall be undertaken on a suitably sized concreted area.
Where dewatering is necessary, management of dewatering discharge will be essential to mitigate potential impacts to receiving streams. Where necessary, discharge licences will be obtained by application to the relevant Authority.

A Pollution Incident Response Plan (or Pollution Control Plan / Emergency Response Plan) will be in operation and appropriately trained personnel and spill containment equipment shall be maintained at the site throughout the construction phase.

There is an approximately 8km section of 220kV HVAC UGC currently identified as part of the OHL solution. It is anticipated at this stage that the majority of river and stream crossings on an UGC route will be carried out using horizontal directional drilling or other trenchless technique. A method statement on watercourse crossings will be included in the CMP.

Minor river and stream crossings not directly discharging to SAC will be carried out by trenching across the channel bed, employing temporary diversion and other mitigation methods. Unless otherwise agreed with the IFI, if dewatering takes place, the area to be dewatered should be electrofished to remove any fish present and transfer them to a suitable adjacent habitat. Disturbance to the dewatered stream bed will be kept to a minimum, and machinery crossing will be by way of temporary bridging structures.

Disturbance of bankside soils and in-stream sediments will be kept to the minimum level required. Banks and stream beds will be reinstated in a manner that will minimise the potential for erosion and return the river/stream to as close to its original condition as possible.

6.4.4 Soils and Geology

6.4.4.1 Methodology

The same methodology as that set out for assessing the UGC option is used to access the OHL option.

The relevant key criteria identified in the Grid West Constraints study are described in Section 5.6.4.

6.4.4.2 Review of Overhead Indicative Line and Substations

6.4.4.2.1 Soil/Subsoil Geology

Along the most western stretch of the OHL route, the soil/subsoil geological environment is dominated by low to medium quality farmland, as far south as Knockmore, Co. Mayo. The section between

Knockmore and the Foxford area contains large areas of cutover bog. Bedrock outcrop is prominent in the Foxford area (from Knockmore to Callow). From Callow eastwards, the OHL route crosses predominantly poorly drained agricultural landscape, with extensive patches of wet grassland, cutover bog and forestry. There is an area of blanket bog to the south of Charlestown. The OHL route crosses the northern tip of this area of blanket bog. The route has the potential to negatively impact soils and geology along the route by disturbing insitu geology and, in localised areas for example where the towers are located, having a permanent impact.

As part of the eventual EIS and Appropriate Assessment for the identified preferred design and route option for the Grid West Project, additional assessments including landslide and slope stability risk assessment and the potential for bog bursts and landslide hazards will be considered, particularly if the final route option is proposed in areas of elevated and sloping ground.

6.4.4.2.2 Bedrock Geology

The bedrock geology along the OHL route (from west to east) is presented in the table below.

Over half of the OHL route, approximately 61.1km, is located on karstified Pure Bedded Limestone, which is a Regionally Important Aquifer that is classified by the GSI as highly vulnerable (as discussed in the Water Section of this report).

Bedrock Type	Approx. Length of OHL Route (km)
Sandstones, Shales, Limestones	3.1
Impure Limestones	4.6
Pure Bedded Limestones (Karstified)	20.5
Granites & Other Igneous Intrusive Rocks	11.5
Sandstones	1.5
Pure Bedded Limestones (Karstified, with Conduits)	5
Shales & Limestones	4.8
Pure Bedded Limestones (Karstified, with Conduits)	2.8
Volcanics	9.3
Mixed Sandstones, Shales & Limestones	7
Pure Bedded Limestones (Karstified, with Conduits)	14.6
Mixed Sandstones, Shales & Limestones	3.3
Pure Bedded Limestones (Karstified, with Conduits)	18.2

Table 6-7 Bedrock Classification along the OHL Route (West to East)

The OHL route has the potential to negatively impact bedrock along the route by potentially disturbing insitu geology, and in localised areas for example where the towers are located, having a permanent impact.

It is noted that there are a number of quarries located along the OHL route option, particularly in the area of Bunnafinglas, Corradrishy and Boherhallagh in County Mayo. These quarries have the potential to be valuable resources for aggregate, both locally and regionally, and are considered in the route corridor assessment and indicative line design to date. All relevant sites identified as having potential aggregate or mineral potential will be considered further at EIS stage when a preferred option is selected.

6.4.4.2.3 Irish Geological Heritage Sites

The OHL route does not pass over any proposed geological Natural Heritage Areas (NHA's). It does pass close to one NHA (i.e. within 1 – 1.5km), the 'River Moy - Fluvial and Lacustrine Geomorphology', which is located north of Foxford*)*.

The OHL route does not pass over any County Geological Sites (CGS). It does pass close to one CGS (i.e. within 1km), *the "Knock Airport Road Cutting - Precambrian - Devonian Palaeontology',* south of Charlestown*.*

The OHL route passes over to one Unidentified Geological Site (U), south east of Charlestown. This site is described as *'Uggool, Charlestown - Precambrian - Devonian Palaeontology).*

The OHL route does not pass over nor is it close to any Roscommon/Leitrim IGH Sites.

No impact is anticipated from the OHL route on proposed geological Natural Heritage Areas (NHA's).

6.4.4.2.4 Karst Features

As described in the water section, the OHL route does not pass within 5km of any recorded karst features for the western section of the line, as far as Ballaghaderreen. The route east of Ballaghaderreen to Flagford passes through a richly karstified area, passing over and close to numerous karst features, including turloughs, potential turloughs, enclosed depressions, springs, swallow holes and caves.

There is potential risk from construction works in the vicinity of karst features as construction-related pollutants may enter the underlying groundwater and have a negative impact on water supplies and ecological habitats in the area.

6.4.4.3 Mitigation Measures for Soils and Geology – OHL Option

It is anticipated that the construction of the majority of the OHL route and associated towers will be carried out in peat or soft ground that will need to be removed and disposed of appropriately. With the exception of the substation site north west of Moygownagh, the areas of excavation for the OHL are small and generally some 350m apart. The potential risk to surface and groundwater from excavation works will be mitigated with best construction practice and the use of silt traps appropriate for the particular site being excavated. Following final line design and prior to commencement of construction, comprehensive site surveys will be undertaken to establish ground conditions along the route.

6.4.5 Landscape/Visual

The landscape criteria that form the basis of appraisal in this section are based on the classification of landscape constraints in work to date on Grid West and are described in Section 5.6.5. A detailed description of the relevant landscape character areas identified along the overhead line route (sourced from the Landscape Character Assessments of the relevant county development plans) is included in Appendix 14. This information supports the Landscape Character Assessment data included in Appendix 8.1 of the Constraints Report (2012).

6.4.5.1 General Landscape Constraints

Apart from the constraints referenced above, more general landscape factors have been considered such as topography, landscape scale, landscape complexity, rarity, open or horizontal landscapes, and areas of wilderness. Lakes, the coastline, major rivers and ridgelines were considered landscape constraints due to their sensitive qualities, although it may not be possible to avoid impact on such landscape features completely.

The relationship between plains and mountains is considered, for example the extent of visual influence of the Nephin Mountains. The extent of views across lakes is also to be considered, for example views westwards across Lough Conn.

Many areas, particularly to the west and in elevated areas, exhibit characteristics of wilderness with very little evidence of human impact. These areas will be sensitive to the inclusion of new elements in the landscape. Other parts of the study area display patterns of human habitation and agriculture that may also be sensitive to the inclusion of electricity infrastructure.

Parts of the study area already contain significant electricity infrastructure including transmission lines and substations. These locations are noted and will be assessed on a site by site basis in terms of the potential for over concentration of ‘wirescape’.

While the introduction of high voltage transmission lines has adverse effects on landscape character in close vicinity to the line, transmission lines are features that are not uncharacteristic in the modern rural landscape. Power infrastructure is common throughout the rural landscape, but a 400kV transmission line is of a different order of scale throughout most of the study area, with the exception of the area around Flagford where there are existing 220kV towers in the landscape.

A draft National Landscape Strategy, launched in July 2014, will change the Landscape Character Assessment (LCA) process in Ireland and studies to date for the Grid West project have made every effort to "future proof" the constraints assessment by including constraints not only listed in public sources, but also recorded on the ground.

6.4.5.2 Review of Overhead Indicative Line and Substations

The structures associated with the proposed OHL route option for the Grid West project include both substations (a new substation in north west Mayo and a potential minor extension to the existing Flagford substation south of Carrick-on-Shannon) and overhead structures/towers.

Overhead electricity transmission lines are large linear elements in the landscape and have the potential to adversely affect landscape character.

6.4.5.3 Landscape Effects of the Overhead Indicative Line

Following a detailed assessment of the landscape constraints within the study area, the key Landscape effects arising from the emerging preferred OHL have been identified. These are as follows:

- Permanent adverse effects on areas with characteristics of wilderness at the edge of the Bellacorick basin west of Moygownagh, Co. Mayo;
- Permanent adverse effects on the character of areas north and east of Foxford, Co. Mayo, particularly the flat areas north of Foxford and the foothills of the Ox Mountains;
- Permanent adverse effects on the upland character of the higher parts of the landscape between Ballaghaderreen and Charlestown, Co. Roscommon;
- Permanent adverse effects on the open character of the landscape south of Boyle, Co. Roscommon;
- Permanent adverse effects arising from vegetation clearance and maintenance at new heights of higher hedgerows and woodland, as well as the more temporary effects of hedgerow and other vegetation clearance at construction stage;
- Permanent adverse effects on the landscape character of a series of small valleys north of Swinford, Co. Mayo; and
- Permanent adverse effects potentially along the whole route on the character of the landscape up to 500-600m from the line route.

6.4.5.4 Visual Effects of the Overhead Indicative Line

While landscape effects are concerned with the changes to the fabric and character of the landscape, visual effects result from changes to views.

The key potential permanent negative visual effects arising from the indicative OHL are:

- Open visibility of the line route where the land is flat and vegetation is low e.g. an area at the edge of the Bellacorick basin, an area on the western side of the upland ridgeline west of Ballaghaderreen, an area north of Foxford, and an area south of Boyle;
- Visibility of the line route where it crosses relatively elevated land, for example on the uplands west of Ballaghaderreen and east of Foxford;
- Where the line crosses or parallels key routes, along the full length, but particularly north and east of Foxford and in the open landscape south of Boyle; and
- Views within 500-600m of the line route where there is no intervening screening or vegetation.

6.4.5.5 Mitigation Measures for Landscape and Visual – OHL Option

The OHL option has a high visual impact which, as far as possible, is mitigated during the route selection process and landowner engagement regarding tower locations. Once the line is selected and tower locations finalised it is difficult to mitigate the visual impact of the line any further. Screening and landscaping can be employed at the substation site to reduce its visual impact.

Lighting control features will be established on site during the construction of the substations and any compounds along the route. Lighting will be used only when required for security and safety during night-time operations and will be kept to the minimum level necessary.

External lighting will be designed to avoid unnecessary stray illumination beyond the site boundary or skywards which might otherwise give rise to light pollution (sky glow, glare and light trespass) and which could cause visual intrusion. The level of illumination will be appropriate to the operations in an area and in accordance with recognised international standards. Overlighting will be avoided and glare will be kept to a minimum by placing down-lighting on tall posts.

Specifically designed lighting equipment will be installed where required to minimise the spread of light above the horizontal.

An emergency lighting system consisting of individual self-contained emergency lights will be provided where required including at the substations. These will provide illumination for essential operations and for access.

6.4.6 Cultural Heritage

6.4.6.1 Introduction

The recorded cultural heritage resource along the identified OHL route is set out below along with a preliminary analysis of the potential impacts.

6.4.6.2 Methodology

The methodology used in appraising cultural heritage impacts of the OHL is the same as that used in appraising the UGC option, as described in Section 5.6.6. The review of the cultural heritage resource is based on a desktop study of published and unpublished documentary and cartographic sources, followed by a windscreen survey and site inspections where access was permitted.

6.4.6.3 Review of Overhead Indicative Line and Substations

6.4.6.3.1 <u>Inventory of Archaeological Sites</u>

6.4.6.3.1.1 World Heritage Sites

There are no UNESCO World Heritage sites within 100km of the OHL development. In closer proximity to the development are two Candidate World Heritage Sites, which were submitted in 2010 by the then Minister for Environment, Heritage & Local Government as part of a tentative list of sites that Ireland would be considering for World Heritage listing. The sites include the Rathcroghan Complex, as part of the Royal Sites of Ireland and the Cèide Fields and north Mayo Boglands.

The Rathcroghan Complex is located approximately 5.8km to the south of OHL route. The site is associated with the kingship of Connaught and comprises a complex of 114 Recorded Monuments, of which 39 are in state care. The Cèide Fields, a Neolithic landscape consisting of megalithic burial monuments, houses and enclosures within an integrated system of stone walls defining fields, are located approximately 12km to the north of Moygownagh.

6.4.6.3.1.2 National Monuments in the Ownership or Guardianship of the State

There are eleven National Monuments in the ownership or guardianship of the State within 5km of the proposed OHL route.

The closest of these is Cloonshanville High cross (Nat. Mon. 608, RO015-029) near Frenchpark, Co. Roscommon, located approximately 540m north of the route. Just west of Ballina there is an unclassified megalithic tomb (Nat. Mon. 519, RMP MA030-073) located just over 2km from the proposed line route. The remainder are located over 2km from the proposed line route and include the ecclesiastical sites at Errew on the western side of Lough Conn, the church at Kildermot, ringforts at Barnacahoge and Kilcashel and standing stones, an ogham stone and a ringfort at Drummin. Other notable concentrations of National Monuments in the wider landscape include the megaliths, a stone row and a number of ringforts in the vicinity of Bunnyconnellan, 8.2km to the north east of the line route.

Site Name	Townland	County	Nat. Mon. No.	SMR No	Classification	Distance
Ballina	Ballina (Tirawley By.)	Mayo	NM00519	MA030-073	Megalithic tomb - unclassified	2km
Barnacahoge	Barnacahoge	Mayo	NM00524	MA072-092	Ringfort - rath	3.5km
Errew Abbey	Errew (Tirawley By.)	Mayo	NM00537	MA038-129001	Religious house - Augustinian canons	4.8km
Templenagalliaghdoo	Errew (Tirawley By.)	Mayo	NM00538	MA038-129002	Religious house - unclassified	4.8km
Kilcashel	Kilcashel	Mayo	NM00547	MA073-028	Ringfort - cashel	3km
Kildermot	Kildermot	Mayo	NM00548	MA040-074001	Church	4.5km
Cloonshanville	Cloonshanville	Roscommon	NM00658	RO015-029	High cross	540m
Drummin	Drummin	Roscommon	NM00659	RO015-051001	Ogham stone	2.9km
Drummin	Drummin	Roscommon	NM00659	RO015-051002	Ringfort - rath	2.9km
Drummin	Drummin	Roscommon	NM00659	RO015-051003	Standing stone	2.9km
Drummin	Drummin	Roscommon	NM00659	RO015-051004	Standing stone	2.9km

Table 6-8 National Monuments in the Ownership or Guardianship of the State Located within 5km of the Proposed OHL Route

6.4.6.3.1.3 National Monuments in the Ownership of a Local Authority/Religious Sites

Within the National Monuments Act, archaeological monuments in the ownership of a local authority can be afforded the same level of protection as those in the ownership or guardianship of the State. The most common monuments in the ownership of local authorities consist of historic graveyards that were vested to the Burial Boards by the Church Temporalities Commission. Vesting of these sites took place during the disestablishment of the Church of Ireland towards the end of the 19th Century. The modern day successor to the burial boards are the local authorities.

There are 44 religious sites (church/graveyards) in the Archaeological Survey Database located within 2km of the proposed line route. All are detailed in Appendix 14. Of particular note is the graveyard and holy well at Templemoyle/Coolagagh (MA049-078001 and 002) which are located just over 100m north of the proposed line route. Other sites in the vicinity of the line route include the ecclesiastical site at Cloonshanville which is located 700m to the north, an ecclesiastical enclosure and graveyard at Kilcanoran, approximately 130m south of the line route (these features are no longer visible, but an oval grass-covered enclosure [RO011-099003] survives) and a graveyard (RO011-106) located roughly 360m west of the proposed line route at Killumid.

6.4.6.3.1.4 Monuments Subject to Preservation Orders

There are seven sites contained in the list of monuments covered by preservation orders located within 2km of the proposed OHL route including castle sites and two ringforts.

6.4.6.3.1.5 Sites and Monuments Record (SMR)

There are 1,099 recorded monuments within 2km of the OHL route, as listed in Appendix 14. This includes a wealth of prehistoric cultural heritage sites ranging from stone circles, isolated megaliths and, most notably, the Celtic Royal assembly complex at Rathcroghan and associated monuments. From the historic period there are scattered ruins of early Christian churches followed by the later ecclesiastical buildings of new monastic orders including the Dominicans at Frenchpark. The Norman conquest has left a rich legacy of medieval earthworks and castles. From the post Cromwellian period through to the Protestant ascendancy (17th -19th Century) the loss and acquisition of property have resulted in the field patterns that are familiar to us today and the development of many big houses with their associated gardens and demesnes. Overall the study area has a rich and varied archaeological and cultural heritage resource with multi-period monuments ranging from humble sites of local interest to large complexes of international significance.

As dwelling patterns tend to remain uniform, the highest frequency of monuments is on the more fertile land and along river banks. This is the case to the east, particularly south of Boyle and north of Elphin. Towards the west there is also an increased frequency of monuments around Swinford. Other notable concentrations are around the shores of Lough Conn and in the vicinity of Foxford in the foothills of the Ox Mountains.

6.4.6.3.1.6 Additional Unrecorded Sites

A review of first edition and second edition OSI mapping was undertaken as well as a review of several sources of aerial and satellite photography. A windscreen survey and site inspections (where access was permitted) were also carried out. Any sites of archaeological, architectural or cultural heritage potential were noted and mapped in GIS. In all, eight sites were recorded in the vicinity of the proposed OHL route. An additional six aerial anomalies were identified in the wider landscape, along with a number of no longer extant clachans[107]. Of particular note are the potential enclosures in the immediate vicinity of the proposed line route at Graffy and Drumalassan townlands.

Description	Townland	County	Type
Possible enclosure	Gran	Mayo	Field survey
Lime Kiln	Coolagagh	Mayo	Field survey
Church	Ballyderg	Mayo	Cartographic feature – 2nd. ed. OS Map
RC church	Carrowcrin	Mayo	Cartographic
Clachan	Ballyderg	Mayo	Cartographic
Mill race	Cartron	Mayo	Cartographic
Aerial Anomaly	Graffy	Mayo	Aerial anomaly - Possible Enclosure
Aerial Anomaly	Drumalassan	Roscommon	Aerial anomaly - Possible Enclosure

Table 6-9 Potential Archaeological, Architectural and Cultural Heritage Sites Noted from Cartographic and Aerial Sources and Fieldwork/Windscreen Survey

6.4.6.3.2 Inventory of Architectural Sites

6.4.6.3.2.1 Architectural Conservation Areas

There are seven ACA's or proposed ACA's within 5km of the OHL route. These sites are listed below.

Name	County
Ballina (1)	Mayo
Ballina (2)	Mayo
Ballina North (1)	Mayo
Ballina North (2)	Mayo
Ballaghaderreen ACA 2008-2014	Roscommon
Elphin ACA 2009-2015	Roscommon
Charlestown Proposed ACA	Mayo

Table 6-10 Architectural Conservation Areas Located Within 5km of the Proposed Line Route

6.4.6.3.2.2 Records of Protected Structures and the National Inventory of Architectural Heritage

The NIAH survey of counties Mayo and Roscommon and the Record of Protected Structures for both counties were referenced as part of this report. As to be expected, there is a significant overlap between the inventories. There are thirty seven protected structures and sixty seven sites listed in the NIAH within 2km of the OHL route (all rated of Regional importance). These sites range from demesne houses, railway structures and buildings, bridges, churches, houses and street furniture.

[107] A traditional rural settlement type possibly dating to the Medieval period comprising a cluster of single story cottages.

6.4.6.3.2.3 Demesne Landscapes and Historic Gardens

Demesne landscapes and historic gardens appear as shaded areas on the OSI first edition mapping. In the preparation of this assessment, OSI first edition mapping was used in conjunction with the NIAH Garden Survey to map all demesne landscapes and historic gardens within the original constraints study area. During the course of this evaluation, it was found that a number of gardens that appear in the OSI first edition mapping do not appear in the NIAH Garden Survey and, similarly, there are a number that do not appear on the mapping but are noted in the survey. It appears that the NIAH Garden Survey was undertaken using either a more contemporary map source than the OSI first edition survey or multiple map sources. All demesne landscapes and historic gardens from both the Garden Survey and the OSI first edition mapping have been included in this survey.

There are twenty three demesne landscapes found within 2km of the OHL route. These demesne landscapes are listed in Appendix 14. Of particular note in close proximity to, or traversed by, the route, are Greenwood demesne, Nettlepark House demesne, Rappacastle demesne, Deel Castle demesne, Carrowmore House demesne, Mount Falcon demesne (all of which are described as having their main features unrecognisable with peripheral features visible) and Beechabbey (virtually no recognisable features).

6.4.6.4 Impact and Effects from the OHL

The majority of potential impacts in terms of the OHL route option will be impacts on the setting of cultural heritage sites. During the earlier stages of this project, sites where there was a high potential for impacts on their setting were highlighted so that they are avoided as far as practicably possible, taking into account other constraints within the region. Despite this, given the large influence of an upstanding linear development such as a high voltage OHL and the other competing environmental and social factors, it is not possible to prevent all impacts on setting. Neither is it possible to further mitigate the impacts on setting that may occur. The OHL route directly over-sails six recorded archaeological monuments or their zones of notification and passes close to a number of additional cultural heritage sites including previously unknown sites identified through fieldwork, analysis of aerial photography or review of historic mapping.

While the OHL route will not have a direct physical impact on the upstanding remains of any known archaeological sites or architectural features, it will have a long-term negative impact on the setting of a number of cultural heritage sites (in some cases this impact may be deemed significant).

Although there are no predicted direct, physical impacts on the upstanding remains of designated cultural sites, there is the potential that associated subterranean remains or archaeological deposits associated with previously unrecorded archaeological sites or other sites of indeterminate archaeological potential, such as cartographic and aerial anomalies, could experience direct physical impacts.

Overhead lines have a relatively small physical footprint and avoidance of all direct impacts upon known archaeological and architectural sites is usually achievable. However, given their upstanding linear form, their potential to impact upon the setting of cultural heritage sites is relatively high. Construction activity associated with gaining access to tower locations also has the potential to impact on previously unrecorded archaeological, vernacular and architectural features. In the event of encountering cultural heritage remains during the course of construction works it may not be possible to move a tower location in order to avoid impacting on same, thus necessitating removal.

Based on a review of all the available inventories, it is the considered opinion of the archaeology specialist that the long-term effects of an OHL route on the setting of monuments will be significant.

6.4.6.5 Mitigation Measures for Cultural Heritage – OHL Option

Continuing consultation with the Department of Arts, Heritage and the Gaeltacht (DAHG) and other relevant stakeholders is necessary throughout the project timeline. Typical mitigation measures include the following:

- Avoidance – movement of the line route to avoid cultural heritage remains;
- Archaeological testing – in areas of high archaeological potential, pre-construction archaeological testing is recommended;
- Archaeological monitoring – monitoring of construction works by a suitably qualified archaeologist in areas of moderate archaeological potential, or areas of particularly high archaeological potential where preconstruction archaeological testing has been undertaken but there is still the potential that archaeological deposits could be discovered during the construction phase;
- Demarcation to prevent any inadvertent damage – where there is the potential that an archaeological site or potential archaeological site will be impacted upon;
- Archaeological excavation in the event of archaeological deposits being discovered where avoidance is not possible; and
- The OHL development will not have a direct, physical impact on any designated architectural sites, including sites contained in the RPS, NIAH and Garden Surveys. There is the potential that some previously unrecorded architectural sites will experience direct, physical impacts in gaining access for construction. These sites will be highlighted for the contractor during the construction phase to ensure that they are not inadvertently impacted upon.

6.4.7 Settlement/Communities

6.4.7.1 Methodology

This section considers the likely impacts and effects on settlements and communities arising from the identified 400kV HVAC OHL and substations. The methodology used is the same as that described in Section 5.6.7.

Settlements concern not only the impacts on towns and villages – which have largely been obviated by avoiding– but also impacts on rural housing.

6.4.7.2 Review of OHL and Substations

The selection of the route for the OHL sought to avoid all significant towns/villages along the route as identified in the Stage 1 Report[108]. These were regarded as 'primary constraints' in the initial identification of corridors. None of the identified towns/villages fall with the 1km wide OHL emerging preferred overhead route corridor. The closest is Frenchpark, Co. Roscommon.

Having avoided towns and villages, the analysis of alternative corridors during the early development of the OHL option sought to minimise impacts on rural housing. House numbers within the 1km wide corridors were calculated and is was one of the factors used to identify the emerging preferred corridor; seeking to impact on the fewest possible number of houses while also considering all other relevant constraints – ecology, archaeology etc. The current indicative OHL route has no houses within 50m of the centre of the line, twenty seven houses within 100m and seven hundred and eighty eight within 500m.

It was considered that the impact of the OHL on houses within such distances is a factor in the analysis of the OHL. There is no set distance at which the impact suddenly ceases; the reduction in impact is a gradual one, but these two distances (100m and 500m) were considered to give a reasonable measure of houses on which there might be some impact and on those most impacted upon. A particular effort made to minimise the number of such houses.

6.4.7.3 Impact and Effects from the Overhead Indicative Line

Construction impacts on houses are relatively low. There will be an impact arising from construction traffic and some noise and visual impact from excavation and the erection of the towers and line. These topics are addressed in the relevant sections of this report. Some construction will be associated with access routes. These impacts are generally considered to be modest, short-term and mostly relatively distant from houses.

There will also be additional impacts at either end of the line arising from the need for a new substation at north Mayo and an extension/alteration to the existing substation at Flagford. The area at north Mayo is rural, with little development and a new substation may have an impact with respect to visual amenity and noise, particularly during the construction phase of the development.

Because of the density of rural housing in the study area as well as the need to avoid other features (ecological, archaeological etc.) and because of the constraints of technical requirements, it is not possible to identify an OHL route that avoids rural housing completely. It is possible to keep the affected houses to a minimum and that, within the context of other constraints, is what has been sought to date.

The most significant negative impact on houses is the visual impact, from structures and new or extended/altered substations. This arises along the entire length of the line, but the extent of the impact

[108] Appendix 2 - EirGrid Grid West Stage 1 Report – Chapter 5: Constraints, March 2013

varies in relation to the density of rural housing in the surrounding area and is described in the Landscape section of this report. The greater the housing density, the greater the impact and, as a general rule, such areas are avoided. There is also a potential noise impact on settlement from overhead lines addressed in the noise section of this report.

6.4.7.4 Mitigation Measures for Settlements and Communities – OHL Option

Disruption to settlements and communities on the OHL route will largely be due to the landscape and visual impact and to construction works and traffic, although the latter of these will be temporary. The project traffic management plan will set out provisions for traffic diversions and maintaining access residences, farms, businesses and community facilities to minimise disruption.

The visual impact of the substations will be permanent but will be mitigated by landscaping and screening at the sites, as described in the landscape section.

6.4.8 Air Quality

6.4.8.1 Methodology

The general methodology used in this assessment is as presented in Section 5.6.8.

6.4.8.2 Review of OHL and Substations

The construction stage of the OHL has the potential to impact on local air quality, whereas during the operational phase, there will be no emissions and consequently no impact. As such, this appraisal focuses on the construction phase.

6.4.8.3 Impact and Effects from the OHL

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 of the development.

During the construction phase, the OHL will be constructed at a number of discrete sites along its length, located in isolated positions.

Demolition:
There will be little or no demolition work on the OHL option, with the exception of dismantling the existing 220kV towers on the 8km section of the Flagford - Srananagh line (the route of which will be upgraded to a 400kV OHL). This work is not expected to impact significantly on air quality.

Earthworks:
Site clearance works, levelling and remediation works represent the principal activities that may generate emissions of particulate material. The sites of the tower construction are individually less than 2,500m^2, and are therefore considered as a small dust emission class site (IAQM, 2014). The area of the site of a substation in north Mayo will also likely be less than 2,500m^2.

The potential for stockpiles of materials to generate dust depends on the nature of the material. Earth is soft and friable compared to hard-core. However, hard-core generally has a lower moisture content than soil, and consequently they can both be a potential source of dust.

Construction:
Dust emissions during construction can give rise to elevated dust deposition and PM_{10} concentrations. These are generally short-lived changes over a few hours or days, occurring over a limited time period of several weeks or months.

Good site practice measures during this phase of the project are similar to those described above.

The construction works are expected to be small in scale with low risk to any nearby houses, due to the nature of the structures (pre-fabricated steel frame work). With good site practice, the construction works would have an imperceptible impact on dust deposition rates and short-term PM_{10} concentrations at any nearby receptors.

Track-out of Material:
The impact from track-out material is as described in Section 5.6.8.

The OHL development sites consist of the construction of a tower base and tower structure, and are likely to have some unpaved haul roads only for a short period of time. Facilities for the washing of vehicles and vehicle wheels will 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 and regular inspection of the local roads within 200 m of the site access point(s) will be undertaken and street cleaning applied as necessary.

6.4.8.3.1.1 Construction Traffic Impacts and Effects
As described in Section 5.6.8, it is unlikely that a development of this size will lead to a significant number of vehicle movements at each construction site. The additional number of vehicle movements is not considered to be high enough to cause a significant adverse effect at any local air quality sensitive receptor.

6.4.8.3.1.2 Conclusion

The OHL will consist of a number of small scale construction sites, each in operation for a short length of time. While there is a large number of such sites, they will be spread out along the length of the OHL development, and construction will be scheduled in such a way as to reduce the duration and intensity of construction activities and vehicle movements on the road network.

Overall, the effect on local air quality and amenity of the construction works at the tower sites and substations will be negligible for the OHL option. Construction related traffic is also expected to be small in scale, less than 200 vehicles per day, at each site, and as such would not be capable of causing a significant adverse effect on local air quality at receptors located along site access roads.

Overhead Line Route Option Air Quality Impacts and Effects
Small size construction sites in operation for a short period of time
Discrete number of sites with a large distance between each site –localised impact and effect
Dust and particulate matter from construction activities but works will be primarily in rural areas, a distance from sensitive receptors
Low traffic at each site and therefore a slight potential to impact on traffic flows
Impacts from construction limited to receptors in vicinity of sites

Table 6-11 Summary of Potential Air Quality Impacts and Effects for the OHL Route Option

6.4.8.4 Mitigation Measures for Air Quality – OHL Option

Certain activities during construction are likely to generate dust and emissions, including excavations for towers and substation construction, loading and unloading activities and transportation of materials. Measures to control dust generation, such as on-site dust suppression techniques and vehicle covers, will be used as required, particularly in the vicinity of residential housing and access and egress points for haul routes of construction materials.

Mitigation measures considered good practice 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.

A wheel wash facility will be provided at the substation sites and other relevant locations along the line route.

The local external road network will be swept and washed regularly using a specialist vehicle. Site roads shall be regularly cleaned and maintained.

These measures will be outlined in further detail in a Dust Control Plan. The DCP will also address the storage of construction vehicles, plant and machinery, un-surfaced roads and speed restrictions, material handling and storage to avoid exposure to wind.

6.4.9 Climatic Factors

6.4.9.1 Introduction

Section 5.6.9.1 above, introducing the impact on climatic factors of the UGC option for Grid West, sets out the general impact of the project in terms of reducing greenhouse gas emissions.

The emissions to air from plant and equipment during the construction phase of the project create a relatively short-term impact when considered alongside the long-term impact of the development. The Grid West project will have net positive impacts in allowing the development of renewable energy sources in the west of Ireland, thereby reducing the national dependence on fossil fuels.

The study area for this assessment considers an area of approximately 2km either side of the indicative OHL route.

6.4.9.2 Review of Indicative OHL

6.4.9.2.1 Climatic Impacts and Effects

The OHL route option will comprise a major improvement in electricity transmission system infrastructure on the island of Ireland. This improvement in energy infrastructure will facilitate the expansion and incorporation of renewable energy generation into the national grid. This will have positive impacts on Ireland achieving its EU targets with respect to reducing greenhouse gas emissions and expanding energy production from renewable sources.

6.4.9.2.2 Transmission Energy Efficiency

The OHL route development will consist of an efficient, co-ordinated and economical system of electricity transmission, which has the long-term ability to meet reasonable demands for the transmission of electricity. This will facilitate the development of renewable power generation, by enabling the installation and integration of renewable energy sources. It will also reduce the overall generation capacity required on the island of Ireland therefore having a net positive benefit of reducing carbon emissions. The development will comprise a major improvement in electricity transmission system infrastructure on the island of Ireland.

6.4.9.2.3 Emissions From Construction Traffic

Construction traffic associated with the OHL will contribute to existing traffic levels on the surrounding road network. However, these will be very short-lived and are not predicted to be of sufficient numbers to adversely affect climate.

6.4.9.2.4 Sulphur Hexafluoride (SF_6) (Substations)

SF_6, which is a potential pollutant, is used as an insulating gas in substations and as an insulating and arc quenching medium in switchgear for high and medium voltage applications. These are all closed systems, which are extremely safe and unlikely to leak. SF_6 is non-flammable.

SF_6 is a powerful greenhouse gas but very little is released into the atmosphere, so the contribution to the greenhouse effect is low. Global SF_6, that is SF_6 released to the atmosphere, is a very stable gas and therefore most emissions do accumulate in the atmosphere. However calculations show that SF_6 contributes less than 0.1 per cent to the total greenhouse effect.

On site equipment which contains SF_6 will be hermetically sealed to prevent leakage. Specialised gas handling equipment will be used when recovering contaminated SF_6 gas from electrical equipment and the gas loss to atmosphere is minimal.

For each of the options considered there is no significant difference in the amount of SF_6 filled equipment required. Hence, each option can be considered equally impacted.

6.4.9.3 Mitigation Measures for Climatic Factors– OHL Option

The project in general will have a positive impact on the climate and is not in need of mitigation.

6.4.10 Material Assets

6.4.10.1 Introduction

This section of the report reviews the OHL and its potential impacts and effects on material assets and land use. Impacts and effects during both construction and operational phases are assessed. The construction phase for the OHL will last approximately 24 months. The operational phase of a major power transmission project such as Grid West is expected to be 50 to 80 years, during which there will be routine maintenance and refurbishment of the infrastructure.

6.4.10.2 Methodology

The methodology followed in assessing the impacts on material assets of the OHL option is the same as that described in Section 5.6.10 for the UGC option. The scope of the evaluation of this report has been confined to material assets and land use including agricultural land, horticultural land, forestry, bogs/peat land, houses, commercial properties and community properties (e.g. sports grounds, golf courses, churches, community centres). This evaluation identifies locations along the indicative OHL route option where potential significant impacts may occur.

6.4.10.2.1 Review of Overhead Indicative Line, including Substations

6.4.10.2.1.1 Existing Environment

The components of the indicative OHL which will impact on material assets are:

- Construction access roads and construction sites (tower construction sites, guarding locations and stringing sites);
- Towers – new towers will be constructed along the indicative line route and at the approach to Flagford substation, a number of existing towers will be replaced;
- OHL at a minimum height of 9m above ground level;
- Two substations; and
- Undergrounding the existing 220kV line for approximately 8km into Flagford.

The land use along the OHL is predominantly agricultural land (71%), bog (17.5%), forestry (11%) and other 0.5%[109].

6.4.10.2.1.2 Agricultural Land (Farms)

The townlands in Mayo and Roscommon along the indicative OHL are all categorised as "Severely Disadvantaged" according to the database on the Department of Agriculture Food and Marine Website, indicating poor and medium land quality. Within a 20m corridor of the indicative OHL approximately 50% of the land is a mineral type soil (EPA Codes 1, 2 & 3), 40% is a peaty type soil and 10% is a combination of a mineral top soil with a high peat content or wet alluvial soils[110]. Farm types in Counties Mayo and Roscommon are shown in the table below. The information is gathered from the Central Statistics Office 2010 Agricultural Census, Tables 1, 2 and 3.

	Mayo	Roscommon	State
Average Size	22.4 ha	27.1 ha	32.7 ha
Relative Economic Output[111] (compared to state average)	37%	44%	100%
Dairy[112]	2.5%	1.5%	11%
Non-dairy grazing livestock and hay & silage crops[113]	97%	98%	84.5%
Other[114]	0.5%	0.5%	4.5%
Forestry (% total land cover)[115]	8%	7.5%	9%

Table 6-12 Agricultural Statistics for County Mayo, County Roscommon, County Sligo and the State along the Indicative OHL Route

[109] Figures derived from roadside surveys in September 2014 and examination of aerial photography.

[110] Digital Soil Data from *Soils &Subsoils Class* downloaded from the EPA website in September 2013 within a 20m corridor at each side of the OHL centre line

[111] Table 3 of 2010 Agricultural Census.

[112] Column 3, table 2 of 2010 Agricultural Census.

[113] Columns 4, 5, 6, 7 & 8, table 2 of 2010 Agricultural Census.

[114] Columns 1 & 9, table 2 of 2010 Agricultural Census.

[115] Table 2.1.3 *National Forestry Inventory* (2007)(Republic of Ireland)

In summary:

- The farms along the indicative OHL are smaller and have a lower economic output than the national average;
- There is a higher proportion of beef, sheep and silage/hay enterprises (generally classified as medium sensitivity) than the national average; and
- There is a lower proportion of dairy enterprises (generally classified as high sensitivity) than the national average.

Approximately 71% of the land (i.e. agricultural land) along the indicative OHL is medium sensitivity (the sensitivity is generally low where the land quality is poor and high if there are dairy enterprises).

In addition, the roadside surveys and examination of aerial photography indicated that:

- There are 6 non-residential farm yards with entrances on the 220kV UGC section near Flagford;
- The relatively high rainfall and poor drainage combine to produce agricultural land along the indicative OHL which is generally medium or poor quality, with rushes a common feature on the grassland;
- The land west and north west of Ballina, although mixed in quality, has a higher proportion of medium to good quality land and dairy enterprises, relative to the remainder of the OHL route;
- There are no intensive livestock (pigs or poultry) enterprises along the indicative OHL. These are generally classified as high or very high sensitivity;
- There are no glasshouses, polytunnels or vegetable cropped fields which might indicate horticultural enterprises along the indicative OHL. These are generally classified as high or very high sensitivity; and,
- There were no yards, stud railing or farm layouts identified during the review which might indicate intensive equine enterprises or stud farms. However, the project team is aware of a number of small equine enterprises within the study area.

6.4.10.2.1.3 Bogs/Peatland

Approximately 17.5% (18.6km) of the indicative OHL over-sails bogs – 20% (65) of the towers are located in bogs. These areas generally have no agricultural use and are classified as low sensitivity where they are harvested for turf or very low sensitivity where there is no other use.

6.4.10.2.1.4 Forestry

Approximately 11% (12.2km) of the indicative OHL over-sails forestry plantations. While forestry tends to be located on poor quality soils (often reclaimed bogs), it is classified as very high sensitivity because when a 400kV OHL crosses a forest, the trees within 37m of the centre of the OHL are cleared - therefore forest plantations are highly sensitive to OHL developments. Approximately 7 – 8% of Co. Mayo and Co. Roscommon is covered in forest, which is average for the state. However the indicative OHL over-sails forestry for approximately 11% of its length indicating that the selected route has a proportionately higher impact on forest plantations.

6.4.10.2.1.5 Other Land Use (Quarry Sites and Landfill)

The indicative OHL over-sails land used for quarrying in the townland of Coolagagh, near Foxford, Co. Mayo and over-sails land used as a landfill site south of Ballaghaderreen. The commercial activity on these sites means that they are classified as very high sensitivity.

6.4.10.2.1.6 Private Resident Property

There are 212 houses within 200m of the indicative OHL – four of these are located within 100m of the existing 220 kV line. The distances are shown in the table below:

Distance from the 400kV HVAC OHL Centre Line	Number of Houses
0-50m	0
50-75m	6
75-100m	23
100-125m	38
125-150m	48
150-175m	48
175-200m	49

Table 6-13 Number of Houses Located Within 200m of the Indicative 400kV HVAC OHL

Along the 220kV UGC route section associated with the 400kV OHL option, there are 34 houses with entrances onto the public road.

6.4.10.2.1.7 Commercial Properties and Other Community Properties

There are five commercial properties and two community properties within 170m of the indicative OHL as shown in the table below.

Distance from OHL Centre Line	No. of Properties	Location
0-10m	1	South-west of Ballina (Townland of Tullysleva) the OHL will over-sail a materials storage yard.
10-50m	2	50m north of the OHL there is a shrine at the junction of N17 and L5919 at Lurga, Co. Mayo. The boundary of Ballaghaderreen Golf Course is 50m south of the OHL.
50-100m	2	100m south of the OHL at Ballymanagh, Co. Mayo there is a public house and diesel/petrol pump. In Coolcronaun, Co. Mayo there is a timber yard (just off N26) 100m south west of the OHL.
100-170m	2	In Blackpatch, Co. Mayo, 150m south west of the OHL there is a heritage centre. South-west of Frenchpark, Co. Roscommon, there is a warehouse/workshop and a B&B 170m south of the OHL.

Table 6-14 Number of Commercial and Community Properties Located Within 170m of the Indicative OHL

There are no commercial or community properties located on the 220kV UGC section of the OHL.

6.4.10.2.2 Potential Impacts and Effects

6.4.10.2.2.1 Agricultural Land (Farms)

The potential impacts of the construction and operational phases of the OHL on agricultural lands are listed below. Assuming industry standard mitigation measures are employed, in general, the significance of potential impacts will be in the imperceptible to slight adverse range for the majority of the agricultural land along the indicative OHL. Higher potential impacts in the permanent, slight adverse to major adverse range may occur due to close proximity of indicative OHL to farmyards and the range of impact at the substation sites may range from permanent, slightly adverse to profound.

Potential construction phase impacts and effects include:

- The construction phase will occur for approximately 1 month at each tower site. During this time there may be disturbance to livestock and farm operations due to construction activity. At the substation sites construction activity will occur over a longer period (e.g. 18 months) with the consequent potential for disturbance near the boundary of these sites;
- Damage (e.g. wheel rutting) may occur along temporary access routes to construction sites (tower construction sites, guarding locations at road, river and rail crossings and stringing sites);
- Temporary reductions in agricultural land area will occur where stone access routes are laid and at construction sites associated with towers located on agricultural land. The area of each tower construction site will be approximately 0.12ha and in general the area of soil covered by other construction sites and access routes will generally not exceed 0.4ha per tower location. A construction materials storage yard may be required for the duration of construction - up to 2 hectares of land. At each end of the OHL a substation may be located on agricultural land;
- Where the existing 220 kV line is diverted underground there will be disturbance to agricultural accesses when the UG line is constructed on the public road;
- The 220 kV UG route will cross approximately 600m of medium quality agricultural land at Flagford, County Roscommon. During the construction phase there will be significant temporary disturbance to livestock and farm operations along this section of the UG route;
- Clearing of trees and other vegetation may occur at construction sites and along access routes. Also trees within their falling distance from the OHL will be felled – with potential impact on shelter;
- Land drainage may be affected due to excavations at construction sites; and
- Other potential construction phase impacts include damage caused due to fuel and/or concrete spillages at construction sites and contamination of drinking water sources due to surface water run-off.

Operational phase impacts and effects include are:

- The OHL will be an additional safety risk on farms;

- There will be permanent disturbance due to the towers being physical obstacles to farm machinery operations such as fertilising, ploughing and reseeding, silage and hay cutting and harvesting;
- Soil damage will persist for a number of years at construction sites and along access routes. If a construction materials storage yard is required, soil damage will occur at this site;
- Tower bases may act as reservoirs for weeds;
- Permanent agricultural land area reductions will occur at the substation sites and at the bases of the towers; and
- Restriction of farmyard development may occur where the OHL is close to farm yards at ten locations:
    - Ballyderg, Co. Mayo – farmyard located approximately 40m West of indicative OHL;
    - Knockaglanna, Co. Mayo – farmyard located approximately 20m South West of indicative OHL;
    - Loobnamuck, Co. Mayo – old sheds within 20m of OHL (South);
    - Drumalooaun, Co. Mayo – farmyard located approximately 40m South of indicative OHL;
    - Tumgesh, Co. Mayo – farmyard located approximately 20m north of indicative OHL;
    - Cartron Co. Mayo – farmyard located approximately 10m East of indicative OHL;
    - Cloonierin and Carrownlacka, Co Mayo – farmyards located approximately 30m & 50m north of indicative OHL;
    - Leggatinty, Co. Roscommon – farmyard located approximately 50m south of indicative OHL;
    - Tartan, Co. Roscommon – farmyard located approximately 30m south of indicative OHL; and
    - Knockroe, Co. Roscommon (existing 220kV tower) – farmyard located at approximately 20m north east of existing OHL.

6.4.10.2.2.2 Bogs/Peatland

Potential construction phase effects include temporary reductions in the land area of the bogs at construction sites and along access routes. Excavations at construction sites may affect drainage. Allowing for approximately 65 towers located in bogs and an area of construction sites and access routes of approximately 0.4ha per tower, the total landtake in bogs will be approximately 26ha.

During the operational phase the construction sites and access routes may be left in situ. Therefore the area of the bog / peat available for harvesting will be permanently reduced by approximately 26ha.

After consideration of these potential impacts, in general, the significance of effect will be imperceptible for the majority of the bogs along the indicative OHL, assuming industry standard mitigation measures are employed. This is because the bogs are low – very low sensitivity from a material assets assessment point of view and the impacts are on relatively small areas.

6.4.10.2.2.3 Forestry

At the commencement of construction, existing trees within 37m of the 400 kV OHL centre line will be felled leaving a 74m wide cleared way-leave through the forest. This will result in significant area reductions and potential wind tunnel effects. In addition, trees may be felled along access routes and at other construction sites for guarding locations and stringing sites. Excavations at construction sites may affect drainage.

During the operational phase, forestry will not be planted within 37m of the centre of the OHL.

After consideration of these potential impacts, in general, the significance of effect will be in the slight adverse – major adverse range for the majority of the forestry plantations along the indicative OHL, assuming industry standard mitigation measures are employed. This is because the forests are very high sensitivity from a material assets assessment point of view and the area reductions will be significant. The impact on the forestry plantation along the 220kV UGC section in Finnor, Co. Roscommon is imperceptible.

6.4.10.2.2.4 Other Land Use (Quarry Sites and Landfill)

The indicative OHL will over-sail two quarry properties, one in the townland Creggagh, County Mayo and one in Coolagagh, County Mayo.

In Creggagh, the eventual specific location of towers may restrict the ability of the quarry to expand outside of its boundary. The presence of the OHL, which will cross part of the site, may permanently restrict quarrying activities within the site. The potential effect is significant due to the high – very high sensitivity of the site.

In Coolagagh, the location of the OHL which will over-sail part of the site may restrict quarrying activities within that site (although local feedback suggests that these quarries are spent). Nonetheless, the potential impact is significant due to the high – very high sensitivity of the site.

In Aughalustia, County Roscommon there is a local authority landfill site which is located in the middle of a bog. The eventual specific location of towers may have the effect of restricting future expansion of this facility and the presence of the OHL may permanently restrict activity at the landfill facility. The potential impact is significant due to the very high sensitivity of the site.

6.4.10.2.2.5 Private Residential Properties

The normal activities within the sites of the 212 houses identified in the table below will not be significantly affected by the indicative OHL. There will be no residual impact on access, water or power supplies and building of house extensions or domestic garages/workshops within these 212 site boundaries. The construction sites will not be located on private residential property. Therefore, the impacts on residential properties, viewed purely from a material assets point of view (i.e. excluding all other potential impacts), are imperceptible. There will be a high level of temporary disturbance caused to approximately 34 houses along the 220kV UGC route west of Flagford during the construction phase – however the residual impacts are imperceptible.

6.4.10.2.2.6 Commercial Properties and Other Community Properties

The indicative OHL will have a significant impact on one commercial yard. Neither the indicative 400kV OHL nor the associated 220kV UGC route section at the approach to Flagford substation will have a significant impact on community properties.

6.4.10.2.2.7 Cumulative Impacts with Existing High Voltage OHLs

The indicative OHL will cross existing high voltage OHL at:

- Carrowcrin, County Mayo – agricultural land;
- Slievenagark, County Mayo – agricultural land;
- Corraveggaun West, County Mayo – agricultural land;
- Boherallagh, County Mayo – agricultural land;
- Tomboholla, County Mayo – agricultural land; and
- Carrowmore (ED Kilummond), County Roscommon – agricultural land.

The cumulative impacts at these locations may be slightly higher due to existing power lines - in the imperceptible to moderate adverse range.

6.4.10.3 Conclusions

The assessment is summarised in the table below:

Material Asset	OHL Potential Impact/Effect
Agricultural Land	Sensitivity of agricultural land is medium – low. OHL over-sails agric. land for 72% of length. Temporary soil disturbance. Permanent land requirement. Overall impact on majority of agricultural land is in the imperceptible – slight adverse range. Impacts in the slight adverse – profound range may occur at 10 farm yard locations and at 2 substation sites. Imperceptible – slight adverse impact along the approximately 600m of 220kV UGC section which crosses agricultural land. There may be slight adverse cumulative impacts at 6 locations where the existing OHLs are crossed by the proposed OHL.
Bog	Sensitivity of bogs/peat land is low or very low. OHL over-sails bogs for 17.5% of length. Temporary and permanent land disturbance. Overall impact on majority of bogs/peat land is imperceptible.
Forestry	Sensitivity of forestry plantations is very high. OHL over-sails forestry for 11% of length with a 74m clearance along OHL. Overall impact on majority of forestry is in the slight adverse – major adverse range depending on what proportion of a plantation is removed. The western substation may be located in forestry, therefore the impact at this site would range from slight adverse – profound adverse depending on the proportion of the plantations affected.
Quarries & Landfill Site	Significant impact on two quarries and landfill site.
Private Houses	Imperceptible impact on approximately 212 houses along OHL which are within 200m. Imperceptible impact on approximately 34 houses along 220 kV UG line.
Commercial Properties	Significant Impact on one commercial yard and imperceptible impact on four other commercial properties within approximately 100 - 150m of OHL.
Community Properties	Imperceptible impact on two community properties within 100m of OHL.

Table 6-15 Summary of Potential Impacts and Effects on Material Assets from the OHL Route

The following conclusions may be reached:

- The majority of potential impacts and effects on agricultural land and bogs will be in the imperceptible to slight adverse range. Cumulative impact from existing high voltage lines at 6 locations may increase the impact range to imperceptible -moderate adverse range.
- Potential impacts and effects where farmyard development may be restricted will range from permanent, slight adverse to major adverse at ten locations.
- The potential impacts on very high sensitive targets such as quarries and landfill site may range from permanent, slight adverse to major adverse at three locations.
- The potential impacts on forestry plantations are in the permanent, slight adverse to major adverse range along approximately 11% of the OHL.
- While there may be a high level of temporary disturbance caused during the construction of 7km of UG route, overall, the impacts on houses, commercial and other community properties are imperceptible.
- The potential impacts on agricultural or forestry land at the substation sites may range from slight adverse to profound.

6.4.10.4 Mitigation Measures for Material Assets – OHL Option

The material assets impacts are closely related to the landscape and visual impacts and the construction traffic impacts and as such the mitigations relevant to these areas apply equally to impacts on material assets.

6.4.11 Recreation and Tourism

6.4.11.1 Methodology and Background

Section 5.6.11.1 above gives the estimated value of overseas tourism in Mayo and Roscommon in 2013 as €60m and €13m respectively, based on statistics published by Fáilte Ireland for the period[116]. Figures for domestic tourism for each county are not available as statistics are only collected in relation to overseas visitors. However, the importance of domestic tourism is highlighted by the fact that Fáilte Ireland estimated that domestic visitors took almost 7.1 million trips and generated expenditure of €1.4 billion in Ireland in 2013.

The methodology and criteria for the appraisal of the potential impact on recreation and tourism is as described in Section 5.6.11.

6.4.11.2 Review of Indicative OHL and Converter Stations

6.4.11.2.1 Landscape/Visual Impact

The impact on landscape, and tourism-related features, is included in the landscape section of this report, Section 6.4.5.

6.4.11.2.2 Recreation and Sports Amenities

All residential and commercial centres (towns/villages and areas of high population relative to the surrounding environment), recreational facilities, parks and sports amenities, including golf courses and sports clubs such as GAA clubs, were avoided during the route selection stage of the OHL option, i.e. no lines cross directly over any of these amenities.

6.4.11.2.3 Fishing/Angling Clubs

Both Roscommon and Mayo have areas of significant angling tourism. Inland Fisheries Ireland carried out a Socio-Economic Study of Recreational Angling in Ireland[117] recently which had the following findings:

- Up to 406,000 individuals participated in recreational angling in Ireland in 2012;
- The total direct expenditure on recreation angling in Ireland in 2012 is estimated to be of the order of €555 million of which €121 million was generated by out-of state anglers;
- When indirect and induced impacts are taken into account, the overall economic impact of recreational angling in Ireland is therefore estimated to be approximately €755 million;

[116] http://www.failteireland.ie/FailteIreland/media/WebsiteStructure/Documents/3_Research_Insights/2_Regional_SurveysReports/Regional-tourism-performance-in-2013.pdf?ext=.pdf
[117] http://www.fisheriesireland.ie/media/tdistudyonrecreationalangling.pdf

- Recreational angling can be estimated to support approximately 10,000 jobs (based on 36 jobs per €million in tourist expenditure; and
- The aggregate non-market value of the fishing resources to the Irish public is €58 million per annum. This is the value that the public place on avoiding the deterioration in the quality of Ireland's natural fish stocks and angling experience.

The River Moy in Co. Mayo and the River Lung and Lough Gara in County Roscommon have valuable fishing locations which attract annual visitors, both domestic and overseas.

The OHL route will require careful design in order to locate towers in areas that are a suitable distance from salmonid rivers and tributaries so as to minimise disruption and safety risk to anglers during both the construction and operational phases of the development and, more importantly, not to cause any reduction in water quality that could adversely impact the fishing in waterways along the route.

6.4.11.2.4 Construction Works

During the construction phase of the OHL, some potential disturbance is anticipated along local roads in the vicinity of the OHL route mainly from visibility of construction activities and traffic disruptions. However, the majority of OHL construction, including new/upgraded access roads and tower construction, will take place off-road and the disturbance to local traffic will be temporary, short-term and minimal. Impacts and effects from maintenance traffic during operation of the OHL will be negligible with regard to tourism locations.

6.4.11.2.5 Operational Phase

During the operational phase of the OHL, negative impacts and effects are predicted to be low as construction will have ceased and the towers will be established.

6.4.11.3 Mitigation Measures for Recreation and Tourism – OHL Option

Recreation and tourism impacts will arise primarily from the landscape and visual impacts of the OHL towers and the disruption during construction of the line and the substations. The two OHL crossings of the River Moy have the potential to impact on tourism; this can be mitigated to some extent by sensitive tower location. Traffic disruption will be mitigated by planning and management as described below, taking cognisance of local tourism and recreation events such as sporting occasions, fairs, and parades.

6.4.12 Traffic

6.4.12.1 Methodology

The appraisal of traffic for the OHL route option is as described in Section 5.6.12.

6.4.12.2 Review of Indicative OHL and Substations

Installation of the overhead line includes the construction of towers located at discrete intervals. Access and temporary works will be required to accommodate the construction of the towers in fields, forest and peatlands. An increase in traffic will be experienced in the local area due to construction vehicles accessing the site and rolling closures of local roads will be required to facilitate access for larger vehicles; however overall traffic impact is expected to be relatively low as construction is largely off road.

As set out in Section 6.1, the preferred OHL design incorporates the undergrounding, along a public road from Flagford substation, of c.8km of existing 220kV OHL. For this location, site access is required to accommodate works to upgrade the existing 220kV towers to carry the 400kV OHL. Road closures will also be required along the proposed route of the 220kV UGC to the existing Flagford Substation with disruption to traffic along the R386 south of Carrick-on-Shannon.

6.4.12.3 Potential Impacts and Effects

6.4.12.3.1 Route Intersections with National or Regional Roads

Access to individual sites is likely to be via local roads, where possible, to avoid impacting on traffic on busier Regional and National roads. However some access from regional and national roads will be required.

Temporary road closures may be necessary along the identified route during these operations, but it is expected that scheduling of the works may assist with minimizing disruption to traffic. National and regional roads which the proposed route intersects are listed in the table below. Local roads affected have not been listed.

Route	Approximate Location Description
R368	Near existing Flagford Substation
N61	10km south of Boyle
N5	2km south of Frenchpark
R361	2km south of Frenchpark
R293	2km south of Ballaghaderreen
N17	5km south of Charlestown
N5	4km west of Charlestown
N26	3km east of Knockmore
R310	2km west of Knockmore
N59	5km west of Ballina
R315	3km north of Moygownagh

Table 6-16 Intersection of OHL with National/Regional Routes

6.4.12.3.2 Local Roads

Whilst most of the installation works for the OHL will take place off-road, there are times when temporary closures will be required to accommodate the stringing of the cable between towers and may also be required to allow access for larger site vehicles. Local diversions may be required at these times. As traffic volumes on these roads are minimal, significant disruption is not envisaged.

6.4.12.3.3 Populated Areas

As part of the route selection process, any towns & villages were avoided where possible. At construction stage there will be a general increase in the number of construction vehicles on the main routes to the site, with some impact to traffic in nearby towns and villages expected

The following towns and villages are close to the emerging preferred OHL route:

- Towns:
    - Carrick-on-Shannon;
    - Frenchpark;
    - Ballaghaderreen;
    - Charlestown;
    - Swinford;
    - Foxford;
    - Ballina;
    - Crossmolina.
- Villages:
    - Killasser;
    - Knockmore;
    - Knockanillaun;
    - Moygownagh.

As most of the construction process for the overhead route will take place off-road and considering the location of the OHL route corridor, significant disruption to traffic is not envisaged in any particular towns.

6.4.12.3.4 Rivers

Whilst river crossings will not directly affect traffic, it is envisaged that the local area will experience a slight increase in site traffic for the duration of the works in the vicinity of larger river crossings. Major river intersections have been identified as follows:

- The Breedoge River;
- The Owennaforeesha River;
- The Lung River south of Ballaghaderreen;
- The Sonnagh River north of the N5;
- The River Moy East of Killasser, and North East of Foxford;
- The Yellow River north east of Foxford;
- The Cloonaghmore River east of Moygownagh; and
- The Dunowen River north of Moygownagh.

Minor rivers and streams have not been listed and are expected to be numerous due to the nature of the study area.

6.4.12.3.5 Railway Lines

The identified route for the OHL route crosses the Ballina – Dublin railway line north of Knockmore and the disused railway line north of Charlestown. Closure of the railway between Foxford and Ballina will be required during the stringing operation between towers, but scheduling of these works outside of peak hours should minimise disruption to rail travel.

6.4.12.4 Mitigation Measures for Traffic – OHL Option

While the OHL construction works would be temporary and are largely off road, there will be some disruption generated by construction traffic.

A detailed Traffic Management Plan (TMP) will be developed prior to construction in consultation with Mayo and Roscommon County Councils and in accordance with Department of Transport Guidelines. 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. In addition, where the 8km of 220kV cable is to be laid, open trench lengths will be kept to a minimum to minimise traffic disruption in this area. Two-way traffic will be maintained wherever possible but where this is not possible, single-file traffic will be considered. The period during which traffic is subjected to one-way flow will be minimised. Where sections of the 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. 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.

6.4.13 Noise

6.4.13.1 Methodology

The identified OHL route will result in noise (and possibly vibration) effects at nearby sensitive receptors during the construction and operational phases. The methodology for the appraisal of noise is as described in Section 5.6.13.

6.4.13.2 Review of OHL and Substations

The identified OHL option, if selected, will include the infrastructure for the proposed 400kV line, in addition to dismantling approximately the last 8km of the existing 220kV transmission line into the Flagford station and upgrading this section to a 400kV line; undergrounding the existing 220kV line into the Flagford Substation; works associated with expanding the existing substation at Flagford and provisions of a new substation at the northern extent of the line near the village of Moygownagh.

6.4.13.3 Potential Impacts and Effects

6.4.13.3.1 <u>Construction Noise and Vibration, including Substations</u>

Noise generating activities are likely to include (but are not restricted to):

- Enabling works including; vegetation removal, haul road/access road construction, construction compound site development;
- Tower site preparation;
- Tower, conductor and cable installation;
- Construction traffic;
- Extension/construction of substation infrastructure;
- Dismantling of existing 220kV line and towers and undergrounding of the existing 220kV line for approximately 8km from Flagford Substation;
- Upgrade of the existing 220kV towers to 400kV towers near Flagford; and
- Discrete or 'one-off' construction activities such as the transportation of abnormal loads e.g. transformers, to substation locations may also require consideration.

Ground preparation for each tower is assumed to include mechanical excavation, piling, and back-filling with pumped concrete and is a process of relatively short duration.

The majority of construction work would occur during the normal daytime period (0700 to 1900 hours); however there may be some activities which may extend into the evening or night time periods, where impact may be more significant.

6.4.13.3.2 <u>Operational Noise and Vibration, including Substations</u>

Operational noise sources relating to the OHL are separated into three categories; transmission line audible noise resulting from corona discharge and aeolian noise; fixed noise sources, and scheduled or emergency maintenance/repairs.

6.4.13.3.3 <u>Overhead Transmission Line Audible Noise</u>

Overhead transmission line audible noise is more commonly referred to as "Corona Discharge". Wind-induced noise is referred to as "Aeolian". A number of prediction methodologies exist for calculating the potential worst case noise impacts, usually under higher precipitation rates. The indicative route passes generally through open countryside, and the number of potentially affected sensitive receptors is relatively few. However it is generally accepted that as audible line noise occurs during inclement weather conditions, outdoor areas of sensitive premises are less likely to be in use, and therefore the significance of the impact will be reduced. It is anticipated that noise levels will be negligible at distances greater than 50m from the line.

6.4.13.3.4 Fixed Noise Sources

Fixed noise sources relevant to the overhead transmission line will include existing and proposed substation infrastructure. Early detailed assessment and the specification of any required mitigation for incorporation in the design process should eliminate / minimise any potential noise impacts and effects.

6.4.13.3.5 Scheduled And Emergency Repairs

Operational noise effects from plant and equipment will include ongoing line surveying and maintenance, although the short durations of these activities are unlikely to result in significant impact at receptors.

Summary of OHL Noise Impacts and Effects:

The OHL route passes through open space, with the potential for construction and operational noise impacts and effects on limited numbers of isolated residential receptors.

Once constructed, the overhead lines will produce audible noise from transmission line corona, which will be most noticeable when conductors are wet i.e. in foggy or wet weather conditions. As the greatest noise emission is largely limited to periods of foul weather, it is generally accepted to be of lower significance as passers-by/sensitive receptors will be less frequent during bad weather.

Phase	Overhead Line Option Summary (Including Impacts and Effects)
Construction	Discrete number of construction sites with a large distance between each site (approx. 350m). As the majority of construction sites will be in isolated rural areas, noise impacts and effects will be localised, short-term and away from the majority of receptors.
	Impacts from construction limited to effects on receptors in close vicinity to construction sites.
Operation	Audible transmission line noise from overhead cable in foul weather, and likely to increase with age of line.
	Substation noise has the potential to be audible without mitigation measures.
	Maintenance and repair over a short amount of time will have an effect on sensitive nearby receptors .However, the line will be primarily in remote areas, at a distance from sensitive receptors.

Table 6-17 Summary of Potential Noise Impacts and Effects from an OHL

6.4.13.4 Mitigation Measures for Noise – OHL Option

Noise generating activities are likely to occur predominantly during the construction of the towers and substation and along the trenching works associated with the 8km 220kV UGC section. 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 form 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 noisy / vibratory 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 proposed development is assessed against appropriate British and/or International Standards. All sound measurements will 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".

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

The substation designs will incorporate noise attenuation such that during operation, noise associated with building services and operational plant in totality will be controlled and will not exceed a contributory noise level at the boundary of the proposed development site. The OHL may generate corona noise during operation and aeolian noise, from wind blowing through lines. The line design will mitigate these potential sources of noise.

6.4.14 OHL Option Residual Effect

Detailed environmental assessment will be carried out following selection of a preferred option that will inform an EIS and AA (in accordance with the Habitats Directive). At this stage it is only possible to provide a high level appraisal of possible significant impacts and effects, mitigation measures and any associated residual effects, based on desktop studies and fieldwork completed to date.

Following the identification of possible mitigation measures, as presented in Section 6.5.11 above, the anticipated residual effect on each environmental parameter as a result of the OHL option is presented in the table below.

6.4.15 Summary of the Environmental Analysis of the HVAC OHL

Notes:
1. During construction
2. During operation

More significant
Difficult to Mitigate
More Likely

Less significant
Possible to Mitigate
Less Likely

Table 6-18 Summary of the Environmental Analysis of the HVAC OHL

The summary of the environmental analysis of the OHL option, as shown in the table above, highlights the fact that the assessment of this option is primarily influenced by the requirement for multiple permanent above-ground structures along the route, including overhead lines, towers, sealing-end compounds and substations.

Overall, the environmental impacts and effects of the OHL option are most significant for landscape & visual and settlement and communities. Careful line design will mitigate the effect on these parameters but as the OHL infrastructure will be permanent in nature, the ease of mitigation is highlighted as difficult. The permanent visual impact and effect from the OHL and towers can be mitigated by the ongoing design of the route which includes avoidance of towns and villages and a proposal to locate the line at least 50m from every house. Screening is also being considered in route design.

Although the OHL will have no direct physical impact on any designated archaeological remains, there is likely to be a permanent effect on the setting of archaeological features in the vicinity of the OHL.

The impacts and effects on biodiversity, flora and fauna, water, soils, material assets, recreation and tourism and noise will be moderate/low as the potential impacts/effects on these parameters will be primarily temporary in nature during the construction phase of the development, with localised permanent impacts and effects. During the operational phase, low noise impact and effect is anticipated from the line and substations.

The majority of the potential impacts and effects on air quality and traffic will be temporary and will principally relate to the construction phase of the development.

With the exception of landscape & visual and settlement and communities, the residual effect on the environment following implementation of mitigation measures will be moderate to low.

6.5 TECHNICAL COMMENTARY ON THE 400KV HVAC OHL OPTION

6.5.1 Compliance with Health and Safety Standards

Discussion

As stated in Section 5.7.1 above with regard to compliance with safety standards, it should be noted that most technical standards for high voltage equipment, whether for HVAC or HVDC equipment, are inherently based on safety requirements and therefore as a general rule compliance with recognised technical standards will mean that the equipment is designed and manufactured so as to be safe. The same safety standards as set out for the HVDC UGC option apply to the 400kV HVAC OHL.

All materials shall be designed, manufactured, tested and installed according to relevant International Electrotechnical Commission[118] (IEC) or European Committee for Electrotechnical Standardisation[119] (CENELEC) standards. Where no IEC or CENELEC standards are issued to cover a particular subject, another international recognised standard will be applied. The latest edition and amendments to standards and specifications shall apply in all cases.

As with any transmission infrastructure project, an HVAC 400kV OHL for Grid West will be designed, constructed and maintained in accordance with applicable Irish and EU Health and Safety Regulations and Approved Codes of Practice. In undertaking a project, EirGrid is at all times aware of and complies with the applicable Health & Safety Legislation, Approved Codes of Practise and Industry Standards and all subsequent modifications or amendments in relation to same. To achieve this EirGrid operates a formal legal compliance process as part of its health and safety management system.

All prospective technical solutions shall comply with the Safety, Health and Welfare at Work (General Application) Regulations 2007, in particular Part 3: Electricity.

All designs will meet the requirements of the EirGrid Functional or Operational Specifications which incorporate CENELEC standards and contain specific national requirements e.g. environmental conditions, procedures and system network parameters. All equipment shall be Grid Code compliant.

Designs shall also be reviewed by appointed Project Supervisors for Design Stage (PSDP) as required by the Safety, Health & Welfare at Work (Construction) Regulations 2013.

Where any commissioning may involve connections to existing transmission infrastructure, then such commissioning is conducted in accordance with ESB Networks "Electrical Safety Rules 2006".

The principal document required at Project Completion / Handover is the completed Health & Safety File, required under the Safety, Health & Welfare at Work (Construction) Regulations 2013 [S.I. No. 504 of 2006]. This document is required irrespective of the technical solution adopted.

118 http://www.iec.ch/

119 http://www.cenelec.eu/

Conclusion

	HVAC
Compliance with all relevant safety standards	

More Difficult
More Risk

Less Difficult
Less Risk

This option will be compliant with the relevant safety standards, and therefore is at the lowest level on the difficult/ risk scale.

6.5.2 Compliance with Reliability and Security Standards

Discussion

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

- The Transmission Planning Criteria (TPC)[120];
- The Operational Security Standards (OSS)[121]; and

Any 400kV OHL solution proposed will comply with both the TPC and OSS.

Conclusion

	HVAC
Compliance with system reliability and security standards	

More Difficult
More Risk

Less Difficult
Less Risk

This option will inherently be compliant with relevant reliability and security standards, and therefore rates at the lowest level on the difficult/ risk scale.

120 EirGrid, Transmission Planning Criteria, 1998 (http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf)
121 EirGrid, Operational Security Standards, 2011 (http://www.eirgrid.com/media/Operational%20Security%20Standards.pdf)

6.5.3 Average Failure Rates, Repair Times and Availabilities

Discussion

Unplanned outages:

Almost all OHL faults are of short duration as a result of transient faults such as lightning strikes, where the auto reclose function provided for the protection of the line restores the circuit shortly (0.5 – 3 seconds) after the fault. Even if the line suffers physical damage, faults can be rapidly located and identified by visual inspection from the ground or air, and repairs effected in a matter of hours.

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

Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity (approximately 2,245km) of 400kV, 275kV and 220kV OHLs under EirGrid's control. Taking the fault statistics of this existing 2,245km of OHL for the period 2004 to 2012, gives a projected fault rate for a c.100km long 400kV OHL of one permanent fault (that is a fault that requires repairs before the OHL can be returned to service) every 28 years. Given typical repair times this would equate to the circuit being out of service due to a permanent fault for less than 2 hours per annum.

The average failure rates during normal operation, average repair times and availabilities of the main elements of a typical 400kV OHL are set out in the table below.

Parameter	400kV HVAC OHL
Reliability (Unplanned outages/100km/year)	0.035
Mean time to repair (days)	Circa 2days
Unavailability (days/100km/year)	0.073 days (c.2 hours)

Table 6-19 Average Failure Statistics for a 400kV HVAC OHL

As topographic and geographic conditions impact upon the variability of OHL designs, published figures for comparable OHL are not available.

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

Planned outages:

Planned outages are normally associated with routine maintenance. For a 400kV OHL much of the required routine maintenance can be completed without an outage of the circuit, therefore the planned outage rates and the typical outage durations taken from EirGrid maintenance policies result in an annual planned outage rate of 0.65% for the 400 kV solution, or c.2.5 days per annum.

Combination of the planned and unplanned outages:
Due to the fact that the unplanned outage time is negligible the planned outage rates can be taken as the combined rate, i.e. 2.5 days per annum.

<u>Conclusion</u>

	HVAC
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option	

More Difficult
More Risk

Less Difficult
Less Risk

This section has a number of elements but the overall availability is most important factor.

Given the availability rates for this circuit are above 99.99% (four nines generally accepted by industry for power networks as a system) which are aligned with those expected for the network, this option scores at the lowest level on the difficult/ risk scale.

6.5.4 Reliability of Supply

<u>Discussion</u>

The primary driver for Grid West is to facilitate wind generation in north Mayo. Secondary benefits include improved security of supply to Mayo. Therefore impact of unavailability is primarily a wind generation constraint.

The basic configuration of the Grid West project is compliant with the TPC and therefore meets the minimum acceptable reliability criteria. This configuration is not altered for any of the three options.

The TPC provides a balance between security of supply (reliability) and development cost, and therefore plans a resilient network for a justifiable range of events. Where opportunities exist to provide a higher security of supply at minimal or zero cost then inherently these options become preferable, as this improves the quality of supply to customers and reduces financial costs to consumers or losses to the economy.

The high reliability of this option maximises security of supply and has a negligible economic or consumer cost due to unavailability.

This development will become the longest single point connection of power generation that is circa the largest generating unit on the system. The high reliability of the OHL solution minimises the risk of the loss of this significant source of generation and the associated potential impact that this could have on the system.

Conclusion

	HVAC
The expected impact on reliability of supply of unavailability of the development	

More Difficult
More Risk

Less Difficult
Less Risk

Impact on reliability has two dimensions; the role of the circuit itself, its impact on overall system design and hence reliability.

High availability reduces exposure to both additional constraint costs and security of supply issues and on its own would be considered at the lowest level on the difficult/risk scale.

As part of the wider system the OHL head line is consistent with the rest of the network and does not impose any additional reliability risk on the system; hence is also at the lowest level on the difficult/ risk scale.

6.5.5 Implementation Timelines

Discussion

As set out in the technical commentary above on an HVDC UGC, the construction of projects in the electricity transmission sector are typically implemented under an Engineer, Procure and Construct (EPC) form of contract or a Design and Build (D&B) form of contract.

The following points should be noted concerning the timelines for a 400kV HVAC OHL solution:

- The timeline for building a 400kV HVAC OHL solution is based on EirGrid experience of the construction of similar high voltage transmission lines, for example, the Flagford - Srananagh 220kV line, with some allowance for the difficult ground conditions expected;
- The long-lead items will be the two power transformers for the substations and possibly the two reactors required at either end;
- It has been assumed that a c. 3 month commissioning period will be required;
- The construction of HVAC OHL utilises well-known, long established methods, with a number of contractors having the resources, skills and experience to construct both the overhead lines and the substations. This reduces the risk of programme over-runs, providing a higher degree for certainty to the construction timeline; and

- Access to private lands will be required for the entire linear project introducing risk.

Conclusion

	HVAC
Implementation timelines	

More Difficult
More Risk

Less Difficult
Less Risk

There are two aspects to the implementation timelines; the estimated implementation timeline, and the certainty on achieving this date.

The construction of the 400kV HVAC OHL is expected to take approximately 3.5 years. This timeline is based on experience of construction of similar HVAC circuits and would have a reasonable degree of certainty.

Therefore the rating for the 400kV option is assessed to be moderate on the difficult/ risk scale.

6.5.6 Future Reinforcement of Transmission Network

Discussion

This option presents a flexible solution for the north west region. It opens up a new corridor where generation can gain access in an area which EirGrid has already received a large number of applications for connection (c.2GW), using standard equipment.

As a 400kV development, the reinforcement provides the strongest platform for future demand or generation development within the north Mayo region. In the event that another connection along the circuit is required this can be achieved for a cost of tens of millions of Euros, depending on the required connection size

Grid infrastructure is expected to have a design life of 50 years, based on the rate of return set by CER, with some of the current infrastructure having been in place for 50-60 years. Given the level of applications in the area it is reasonable to expect that over the next 50-60 years the grid will need to expand and adapt to accommodate increasing and changing demand for electrical power.

The 400kV OHL solution for Grid West has been specified so as to offer an initial capacity of 500MVA for the project and an ultimate firm capacity of 1,580MVA.

Thus the 400kV OHL option offers a high potential for future expansion, with its inherent capacity, proven flexibility in adapting to the changing load profiles and relatively simple implementation of new extensions.

If a second 400kV transmission line was built, creating a 400kV meshed network with the Irish grid, then the full 1,580MVA capacity of the line could be realised, providing the equivalent transformer capacity was also installed. This is because in the event of one line being lost, the full 1,580MVA could be transferred on the second line without any loss of supply.

Conclusion

	HVAC
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated	

More Difficult
More Risk

Less Difficult
Less Risk

There are four aspects to future reinforcement and connection to the transmission network:

- The extent to which future generation capacity is catered for without further reinforcement;
- The extent to which future generation capacity is catered for with further reinforcement;
- The ability to add additional new stations, and
- The capacity that can be provided for into or out of the north west region (Roscommon, Leitrim, Donegal, Sligo and Mayo).

However further interconnection could raise this capacity to the full 1,580MVA thus providing alternative options to holding reserve generation to make up the loss of a circuit, and reducing operating costs, providing capacity to cater for c.50% of those seeking connection in the area. This flexibility means this option is considered to be at the lowest level on the difficult/ risk scale.

A 1,580MVA rating is possible with limited additional works and associated outages to the existing circuit; therefore it is considered as the lowest level on the difficult/ risk scale.

Similarly the development of network into the area with an equivalent rated circuit will allow power to be wheeled through the area at up to 1,580MVA; hence it would similarly be considered as the lowest level on the difficult/ risk scale.

Finally, there is no technical issue in adding in another connection point at any location along the circuit and, at 500-1,000MVA typically connected on a 400kV station, there is no likely restriction due to the rating of the circuit.

Overall the 400kV OHL option would rate at the lowest level on the difficult/risk scale for future reinforcement of the transmission network.

6.5.7 Risk of Untried Technology

Discussion

The use of 400kV OHL technology proposed for the Grid West project, including the short section of 220kV cable are tried and tested in Ireland. As it is possible to accommodate the cable section on the nearby Flagford - Srananagh 220kV circuit, any reliability issues associated with undergrounding will not have an effect on the reliability of the connection of the largest generating unit on the network.

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

In the case of the 400kV OHL option there is extensive experience of the connection of new infrastructure at this voltage internationally and some experience of this in the Irish system. The interactions are well understood and can be accurately predicted using software available to network operators. For the connection of a 400kV OHL for the Grid West project, two main system interactions with potential adverse impacts need to be considered and appropriate mitigation measures put in place. These are:

- **Loss of load:** The Irish grid system is currently operated such that the loss of any connected load or generation up to 500MW can be accommodated on the system. A single loss of greater than this may cause network instability, potentially resulting in loss of major sections of the network. It will be necessary for the Grid West line to be operated so as to limit the power being transferred to less than 500MW. This is standard practice in the operation of the network and would not be specific to this project.
- **Voltage rise at low load:** At times of low load the voltage on an OHL tends to rise, requiring reactive compensation to be provided to mitigate this effect. This is included in the form of reactors being provided at the end of the Grid West line. (See Section 6.5.2.)

Conclusion

	HVAC
Risk of untried technology	

More Difficult
More Risk

Less Difficult
Less Risk

As the initial level of generation connection for this option is likely to be less than 500MW, the impact of the loss of load supplied by the Grid West project is mitigated, which, combined with the proposed reactors to limit voltage rise at times of low load, this option is to be at the lowest level on the difficult/ risk scale.

This option uses no new technology and therefore is considered lowest on the difficult/ risk scale.

Therefore, in aggregate, it is considered lowest on the difficult/ risk scale.

6.5.8 Compliance with Good Utility Practice

Discussion

Good utility practice is to develop a flexible, robust and cost-effective solution with due regard to environmental constraints.

This option uses standard network design and technology for the connection of generation and/or as a system reinforcement in Ireland. In Europe, similar projects have been developed using the same approach accounting for the changing network.

Conclusion

	HVAC
Compliance with good utility practice	

More Difficult
More Risk

Less Difficult
Less Risk

Other TSOs have similar mandates to deliver a cost effective, efficient, flexible network.

HVAC OHL used in a meshed configuration given its low cost, high adaptability and tried technological track record, meets this mandate and is the standard building block of international networks. Therefore this option is considered the best utility practice and therefore is considered to the lowest level on the difficult/ risk scale.

6.5.9 Summary of the Technical Analysis of the HVAC OHL

The table below summarises the technical assessment of the HVAC OHL.

	400 HVAC OHL
Compliance with all relevant safety standards	
Compliance with system reliability and security standards	
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option	
The expected impact on reliability of supply of unavailability of the development	
Implementation timelines	
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated	
Risk of untried technology	
Compliance with good utility practice	

More Difficult
More Risk

Less Difficult
Less Risk

Table 6-20 Summary of the Technical Commentary of the HVAC OHL

6.6 ECONOMIC ANALYSIS FOR THE 400KV OHL OPTION

An economic appraisal of the 400kV HVAC OHL option, consistent with the requirements of the IEP Terms of Reference, was completed and the results are summarised below.

6.6.1 Approach and Methodology

The approach and methodology used in conducting the economic assessment is already discussed in detail in Sections 5.8.1 to 5.8.3 above.

As stated previously, the economic assessment measures the impact of the reinforcement project on the Irish economy, rather than on the company responsible for making the capital investment. It makes use of the Discounted Cash Flow (DCF) analysis method to present costs in a consistent manner.

All financial values are represented in the current year's Euro; and are expressed in real terms (i.e. excluding projected inflation). The start date of the economic assessment is taken as the current calendar year and all future values are referred (or discounted) to the current year. The duration of the evaluation is taken as the regulatory authority-approved useful life of the new asset being considered, i.e. 50 years[122].

6.6.2 Input Costs

Each reinforcement incurs incremental costs (e.g. inception capital costs, incremental maintenance costs); and has an impact on the overall transmission system efficiency (e.g. total generation production costs; transmission system losses and system reliability costs).

The costs considered in this assessment, consistent with the Terms of Reference, are as follows:

6.6.2.1 Project Pre-Engineering Costs

The pre-engineering costs refer to the costs associated with design and specification; route evaluation; and managing the statutory planning application.

The costs are capital in nature are estimated to be €17.2 million. This amount includes a contingency provision of €0.4 million to account for the risk that the amount may vary.

The phasing of the costs is as follows:

	2015	2016	2017	2018	2019	2020
Pre-Engineering Costs	64%	26%	5%	5%	0%	0%

Table 6-21 Phasing of Pre-Engineering Costs

[122] Decision on TSO and TAO transmission revenue for 2011 to 2015, CER/10/206, 19th November 2010: "...the CER stated its intention to continue using average assets lives of 50 years for the TAO's network assets".

The present value of the project pre-engineering costs was calculated using the estimated value of €17.2 million, phased according to the table above. The capital amounts are discounted at the Test Discount Rate, resulting in a present value of €16.5 million.

6.6.2.2 Project Implementation Costs

The project implementation costs refer to the costs associated with the procurement, installation and commissioning of the reinforcement and includes all the transmission equipment that form part of the reinforcement's scope.

The capital investment required to deliver the reinforcement is estimated to be €235.1 million, using standard development costs provided by ESB Networks. This cost estimate contains a contingency provision of 10% that has been applied to all the cost components and amounts to €21.3 million.

The estimated capital cost is categorised by its general components of OHL, UGC, stations and reactive compensation costs. Also considered is a provision for flexibility payments, proximity allowance and local community fund (referred to as "Other"). The costs, by category, are summarised in the table below:

Cost Category	*Project Implementation Cost (€ M)*
Overhead Line	122.2
Substations	46.9
Underground Cable	18.9
Reactive Compensation	4.4
Other	
Flexibility Payments, Proximity and other allowances	21.4
Non-EPC Costs	0.0
SUB-TOTAL	**213.8**
Contingency	21.3
TOTAL	**235.1**

Table 6-22 Summary of Project Implementation Costs for the 400kV OHL Option

The phasing of the costs is as follows:

	2015	2016	2017	2018	2019	2020
Project Implementation Costs	0%	0%	20%	40%	40%	0%

Table 6-23 Phasing of Project Implementation Costs

The present value of the project implementation costs was calculated using the estimated value of €235.1 million, phased according to the table above. The capital amounts are discounted at the Test Discount Rate, resulting in a present value of €192.9 million.

6.6.2.3 Project Life-Cycle Costs

Life-cycle costs refer to the costs incurred over the useful life of the reinforcement and include the on-going cost of ensuring that it remains viable for the evaluation period.

Project life cycle costs, consistent with those referred to in the Terms of Reference, are taken to be:

- The cost of electrical losses;
- Operation and maintenance costs;
- Decommissioning costs; and
- The costs of retaining any necessary specialist repair teams.

The equipment associated with the 400kV HVAC OHL option is expected to be maintained in accordance with the well-established maintenance practices that already prevail and that no replacement or upgrading would be necessary over its useful life. As a result, no cost for decommissioning has been included. No necessary specialist repair teams are required for this option.

Losses and operation and maintenance costs are considered in turn below.

- Cost of 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 losses it incurs.

  The electrical losses are determined from detailed calculations. These calculations use historical hourly wind profiles and the electrical characteristics of the new reinforcement to estimate its utilisation and hence the electrical losses incurred. The cost of electrical losses is determined using the cost of producing the next unit of electrical power i.e. marginal cost of generation. For this analysis, the average System Marginal Price (SMP) is used to represent the marginal cost of generation and is calculated to be €60.66/MWh. This figure was derived from the average SMP for Ireland over the last five years and was sourced from information made available on the SEMO website[123].

The losses and the corresponding cost of losses associated with the reinforcement are summarised in the table below.

	Circuit Losses (MWh/yr)	Terminal Losses (MWh/yr)	Total Losses (MWh/yr)	Annual Cost of Losses (€ M/a)
400kV OHL system	3,986	3,100	7,086	0.4

Table 6-24 Summary of the Annual Cost of Losses

The electrical losses are estimated to be 7,086 MWh/yr which translates into an annual cost of €0.4 million per annum. Assuming the annual cost of losses is constant for the duration of the evaluation, and then discounting those annual costs at the Test Discount Rate, results in a present value of €6.1 million.

- Maintenance cost:
  The incremental maintenance costs are those costs incurred to ensure that the appropriate level of utility is maintained over the useful life of the new reinforcement.

  The approach taken is to represent the maintenance costs as an annualised costs provision that is based on standard rates per equipment type which is taken from information provided by ESB Networks[124]. The maintenance costs provided are assumed to include a contingency provision of 10%.

  The estimates include the incremental cost of maintenance of the replacement of part of the Flagford - Srananagh existing 220kV line with cable.

  The annual maintenance costs, inclusive of contingency provision, are summarised in the table below.

[123] SEMO System Marginal Price (EP2) from 11 December 2007 to 18 February 2013: http://www.sem-o.com/Publications/General/SMP2007-2014.zip.

[124] ESB Networks, Transmission Maintenance Unit Costs (Confidential), Rev. 2, 8 December 2014

Age of Asset	Station Maintenance Cost (€ M/a)	OHL Maintenance Cost (€ M/a)	UGC Maintenance Cost (€ M/a)	Annual Cost of Maintenance (€ M/a)
< 20 years	0.082	0.079	0.017	0.2
20-40 years	0.082	0.087	0.017	0.2
>40years	0.082	0.097	0.017	0.2

Table 6-25 Summary of the Annual Cost of Maintenance

The present value of the cost of maintenance, including contingency provision, associated with this option is €2.3 million.

6.6.2.4 Cost of Unreliability

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 that are incurred.

For periods when the reinforcement is unavailable, the renewable generation that the reinforcement connects to the power system would be interrupted and would be replaced with alternative generation, including more expensive conventional plant. The average daily benefit attributed to the renewable generation connected to the power system is calculated to be €0.122 million. This value is calculated as a result of detailed market simulations that considered combinations of different wind profiles for the area for five different representative years. The studies showed that without Grid West the annual production cost would increase by approximately €39.0 million using a replacement energy cost equivalent to the average SMP of €60.66/MWh. If the circuit was unavailable during a period of particularly high wind availability then the real cost of circuit unavailability would be higher and 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 the use of this average figure is considered adequate.

The 8km of cable on the Flagford - Srananagh line is ignored in this part of the calculation as its reliability will not impact on the availability of the Grid West project.

The reliability of transmission infrastructure is separated into those that are planned and those that are unplanned, both of which are discussed below:

- Unplanned outages:
  Unplanned outages are normally associated with faults that routinely occur and are specific to the equipment type, technology employed (including voltage level, OHL, UGC etc.) and environmental conditions. Associated with the occurrence of an unplanned or "forced" outage is the mean time to repair. Both the unplanned outage rates and the mean time to repair are taken from Section 6.6.2.4 above. Using the average daily benefit attributed to having the reinforcement available, the cost of the planned outage is calculated and is summarised in the table below.

Outage Type	No. Outages/ 100km/ yr	Outages/ yr	Mean Time to Recovery (Days)	Duration Out of Service (Days)	Annual Cost (€ M/a)
Unplanned Outage	0.035	0.036225	2	0.07245	0.009

Table 6-26 Summary of the expected Unplanned Outage Statistics and Resulting Annual Cost

The calculation of the present value of unplanned outages assumes that the annual cost is constant in real terms for each year of operation and is calculated to €0.1 million.

- Planned outages:

  Planned outages are normally associated with routine maintenance. For the reinforcement, the planned outage rates and the typical outage durations are consistent with the standard maintenance practices for HVAC plant and equipment and result in an annual planned outage rate of 0.66% for the 400 kV option. Using the average daily benefit attributed to having the reinforcement available, the cost of the planned outage is calculated to be €0.3 million per annum.

  The calculation of the present value of planned outages assumes that the annual cost is constant in real terms for each year of operation and is calculated to €4.2 million.

6.6.3 Estimate of Cost Uncertainty

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 cost estimates, including pre engineering costs, include a contingency. The contingency allowance for the project development costs are assumed to be 5% of the remaining projected spend and 10% for the project implementation costs.

Similarly, a contingency allowance of 10% is provided for in the average maintenance costs that have been calculated and represented above.

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

6.6.4 Present Value Summary of Costs

The abovementioned costs for the reinforcement are summarised in the table below.

	Present Value (€ M)
Pre-Engineering Costs	16.1
Project Implementation Costs	
Overhead Line	100.2
Substations	38.5
Underground Cable	15.5
Reactive Compensation	3.6
Other	17.6
Project Life-Cycle Costs	
Cost of Losses	6.1
O&M	2.1
Decommissioning & Replacement	0.0
Cost to SEM from Development Unavailability (Reliability)	
Cost of Unplanned Outages	0.1
Cost of Planned Outages	4.2
Contingency Cost Provisions	
Pre-Engineering Costs	0.4
Project Implementation Costs	17.5
O&M	0.2
Decommissioning & Replacement	0.0
TOTAL	**222.1**

Table 6-27 Summary of Present Value of Costs Associated with the Reinforcement

The total present value of this option for Grid West amount to €222.1 million. . The cost per MVA of capacity is €0.141M/MVA

7. 220KV HVAC OVERHEAD LINE AND PARTIAL UNDERGROUND CABLE OPTIONS

7.1 DESCRIPTION OF OPTION

The proposed route of the 220kV HVAC option is shown in Figure 7-3, which commences at a new substation 2.5km north west of Moygownagh in north Mayo and runs through the counties of Mayo and Roscommon, to the existing substation in Flagford. To facilitate comparative analysis, as per the Terms of Reference, on the outskirts of Flagford an existing 220kV line (Flagford - Srananagh) will be undergrounded for a distance of approximately 8km, largely along local roads, from its intersection with the Grid West line to the Flagford substation. A standard 220kV tower has formed the basis for work on line design to date. This compensatory undergrounding measure i.e. undergrounding on a different circuit, will ensure that the 220kV HVAC OHL and 400kV HVAC OHL options are as similar as practically possible to facilitate comparison.

In order to comprehensively investigate the feasibility of HVAC UGC, EirGrid commissioned engineering consulting firm, London Power Associates (LPA), to complete a review of the maximum amount of HVAC UGC that could be utilised and assess the extent to which it meets the project need.

LPA, in their report[125], examined a HVAC UGC solution at both 400kV and 220kV. It can be concluded from the report that:

- It is necessary to limit the length of UGC to ensure that the capability of the cable to withstand temporary over-voltages, which occur for certain operational situations, are not exceeded;
- The cause of these high voltages is in part due to system conditions which are more acute with a low strength network. Therefore, the limit on UGC lengths is primarily dictated by the size of the entire network. Ireland, as a small network, is more susceptible to high voltages;
- The other major contributory factor is the stored electrical charge or capacitance in the system, which is naturally much higher in cables and increases as the nominal voltage of the network increases. Hence, EHV cables with even moderate lengths possess a very high capacitance compared to other items of plant (e.g. OHL or transformers) and the acceptable lengths of UGCs are typically reduced as the nominal voltage increases (i.e. from 220kV to 400kV);
- Under these conditions simple automated operational actions, for example switching on or off items of plant, can act as a trigger for high voltages to occur which may take minutes to dissipate. These voltages may be far greater than the ability of substation equipment and the cable's insulating layer to withstand them and, in such circumstances, permanent damage will be caused. Due to the typically widespread nature of these overvoltages, damage may occur over a large part of the network, not just on the circuit in question;
- Based on the analysis conducted, for the electrical network in the north west region of Ireland, even short segments of 400kV HVAC UGC (i.e. 8km to 10km) are not feasible; and

[125] Appendix 11 – LPA Report, Cable Studies for Grid West – Partial AC Underground Solution, January 2015

- A partial undergrounded option using 220kV is possible within certain technical limitations, where the maximum total length (with mitigation) of 220kV UGC that can be used in the region is approximately 30km.

Both the existing or planned network in the area impacts on the ability to accept cable on an individual project (which is more acute at EHV voltage levels). This is because cables, being the most dominant source of capacitance on the network, combine together to create higher voltages. The level of this interaction is complex and varies with the cables' relative location to each other and the size of the network. Hence there is an on-going issue that needs to be actively managed for the development and operation of the network.

From a technical perspective, to install the total available UGC on a single project will significantly reduce the possibility of UGC on future transmission projects in the region.

On the basis of these findings, EirGrid considered a 220kV HVAC OHL option and a 220kV HVAC PUG option[126] that uses the maximum amount of HVAC UGC possible. The environmental, technical and economic effect of the end-to-end solution will vary, depending on the final amount of UGC installed.

This report does not identify a PUG section to utilise the total underground cable available but describes the environmental, technical and economic impact of using 8km UGC at the Flagford end of the route and 22km of UGC elsewhere along the entire route.

[126] Appendix 15 – Environmental Appraisal of the 220kV HVAC Partial Underground Section Option

7.1.1 220kV HVAC OHL Option

The project team identified an indicative 220kV OHL running from north Mayo to Flagford, based on environmental appraisal, technical studies and stakeholder and public consultation.

The proposed route commences at a new substation 2.5km north west of Moygownagh in north Mayo and runs through the counties of Mayo and Roscommon, see Figure 2-4. On the outskirts of Flagford an existing 220kV line will be undergrounded for a distance of approximately 8km, largely along local roads, from its intersection with the Grid West line to the Flagford substation. This undergrounding measure will reduce wirescape in the area by preserving the number of lines entering Flagford substation at the current total.

The 220kV HVAC OHL option, and is defined for the Grid West Project as follows:

- **c.8km of 220kV XLPE HVAC cable:** installed into the first section of the existing Flagford – Srananagh 220kV line;
- **c.103km of 220kV single conductor:** installed into the remaining sections of the Flagford – north Mayo line route;
- **A new 110kV GIS substation:** north west of Moygownagh in north Mayo, including two 250MVA 220kV/110kV transformers, auxiliary equipment, filters and reactive compensation and 110kV switchgear to connect the wind generation applicants in the area, and switchgear to connect to the existing 110kV network; and
- **Modification to the 220kV Flagford station:** to connect the Flagford – north Mayo 220kV circuit to the 220kV busbar including auxiliary equipment, filters and reactive compensation.

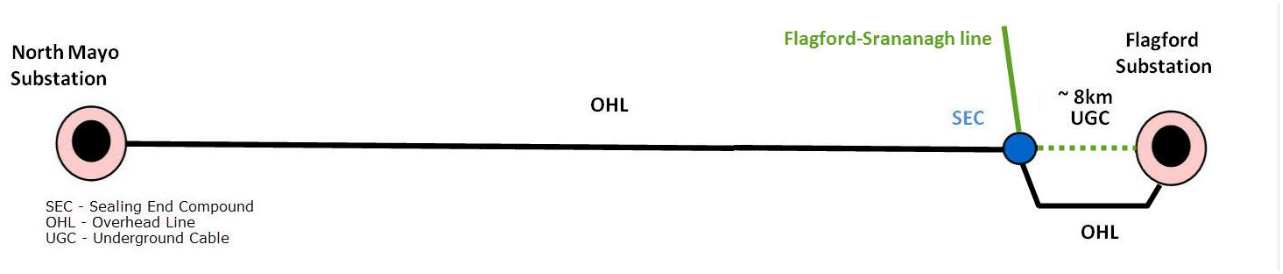

Figure 7-1 Single line Diagram of the 220kV HVAC OHL option

7.1.2 220kV HVAC PUG Option

Having regard to the findings of the LPA report which identified a maximum of 30km of UGC possible in the region, EirGrid evaluated a further option as follows:

- **c.8km of 220kV XLPE HVAC cable** installed into the first section of the existing Flagford – Srananagh 220kV line; and;
- **c.2km of 220kV XLPE HVAC cable:** installed into the last section of the Flagford – north Mayo line route at the approach to the north Mayo substation;
- **Between c.85km and c.105km of 220kV single conductor:** installed into the remaining sections of the Flagford – north Mayo line route;
- **Up to c.20km of 220kV XLPE HVAC cable:** installed into a mid-section of the Flagford – north Mayo line route with two line/cable interface compounds, i.e. one at each end of the mid-section;
- **A new 110kV GIS substation:** in north west Moygownagh in north Mayo, including two 250MVA 220kV/110kV transformers, auxiliary equipment, filters and reactive compensation, 110kV switchgear to connect the wind generation applicants in the area, and switchgear to connect to the existing 110kV network; and
- **Modification to the 220kV Flagford station:** to connect the Flagford – north Mayo 220kV circuit to the 220kV busbar including auxiliary equipment, filters and reactive compensation.

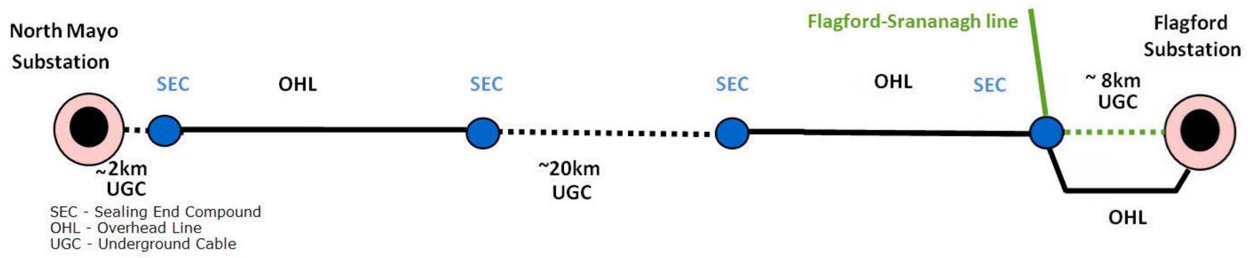

Figure 7-2 Single line Diagram of the 220kV HVAC PUG option

7.2 220KV HVAC OHL OPTION – INDICATIVE ROUTE CORRIDOR AND INDICATIVE LINE ROUTE

A fully undergrounded 220kV HVAC solution for the project is not possible and as result the 220kV HVAC OHL option will be predominantly OHL. For the purposes of this report, the project team has worked on the basis that the indicative 220kV OHL will be the same as the indicative 400kV OHL shown in Figure 7.3. This is because the same routing principles apply and the tower size differential is minimal (approximately five metres smaller and narrower compared to the standard single circuit 400kV tower).

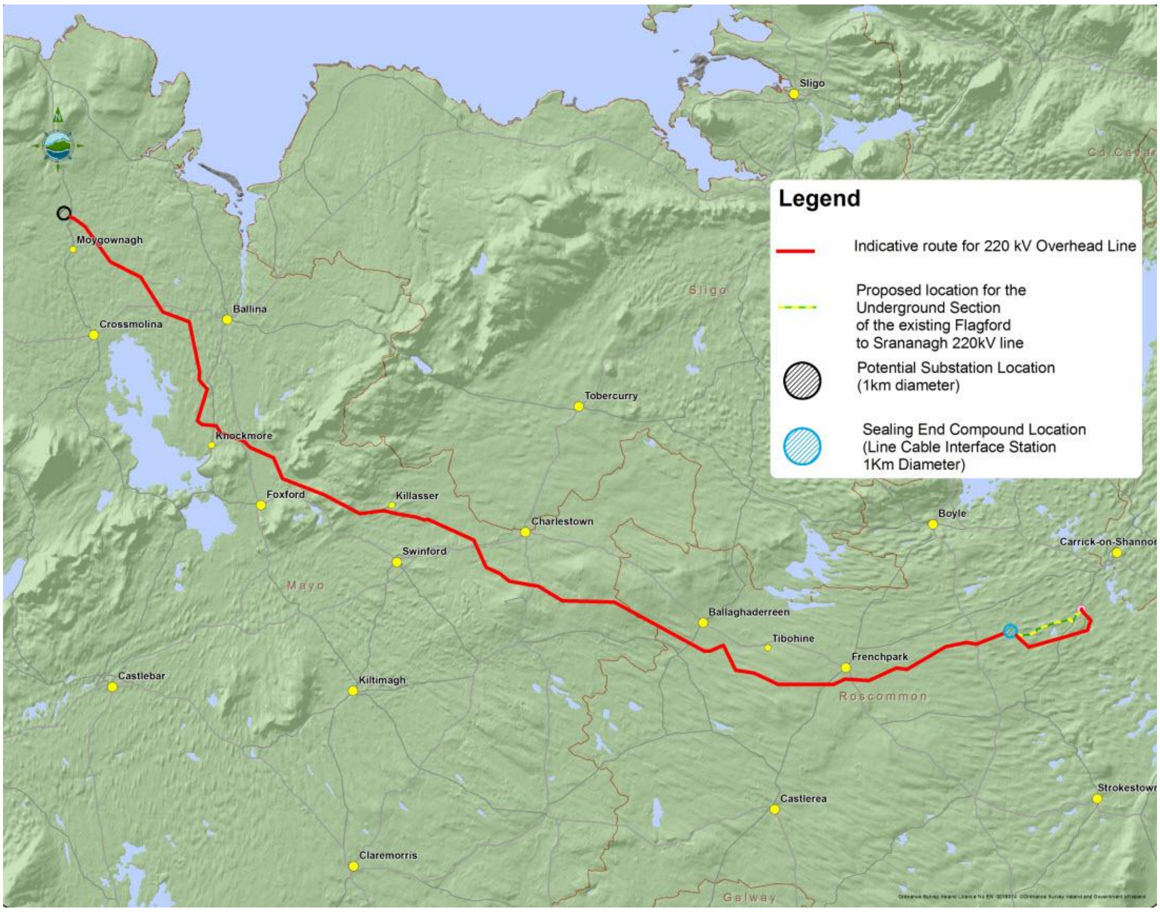

Figure 7-3 **Overview Map of the 220kV HVAC OHL Option**

7.3 220KV HVAC OHL OPTION – SUBSTATION LOCATIONS

The same indicative substation locations shown in Chapter 6 are presented for the evaluation of the 220kV HVAC OHL option. The only exception is that a sealing end compound is required at each point on the circuit where the 220kV OHL transitions to an UGC and vice versa.

7.4 220KV HVAC PUG OPTION – ANALYSIS OF POSSIBLE UGC SECTION

EirGrid undertook a preliminary appraisal of the indicative 220kV HVAC OHL for the purpose of incorporating an underground section using the maximum available 30km of UGC in the region.

Based on information collated at project open days and further studies, the project team proposes to underground the last 8km of the 220kV OHL along a local road as far as the Flagford substation.

Additionally, a 2km 220kV UGC section into the new transmission station in north Mayo is proposed to mitigate the impact of circuit congestion.

The route was divided into six sections[127] based on approximate 20km sections of the indicative OHL route option, which could potentially be undergrounded along local roads, as shown in Figure 7-4. These sections were appraised under a number of environmental and technical criteria:

- Partial Underground Section 1, PUGS1, which runs from Moygownagh, to the south of the N59 to the west of Ballina;
- Partial Underground Section 2, PUGS2, which runs between the east of Lough Conn and the west of Ballina;
- Partial Underground Section 3, PUGS3, which runs north east of Foxford to north east of Swinford;
- Partial Underground Section 4, PUGS4, which runs south west of Charlestown to south east of Charlestown;
- Partial Underground Section 5, PUGS5, which runs south west of Ballaghaderreen to south east of Ballaghaderreen; and
- Partial Underground Section 6, PUGS6, which runs from the west of Frenchpark to Flagford.

[127] Appendix 15 – Environmental Appraisal of the 220kV Partial Underground Section Option

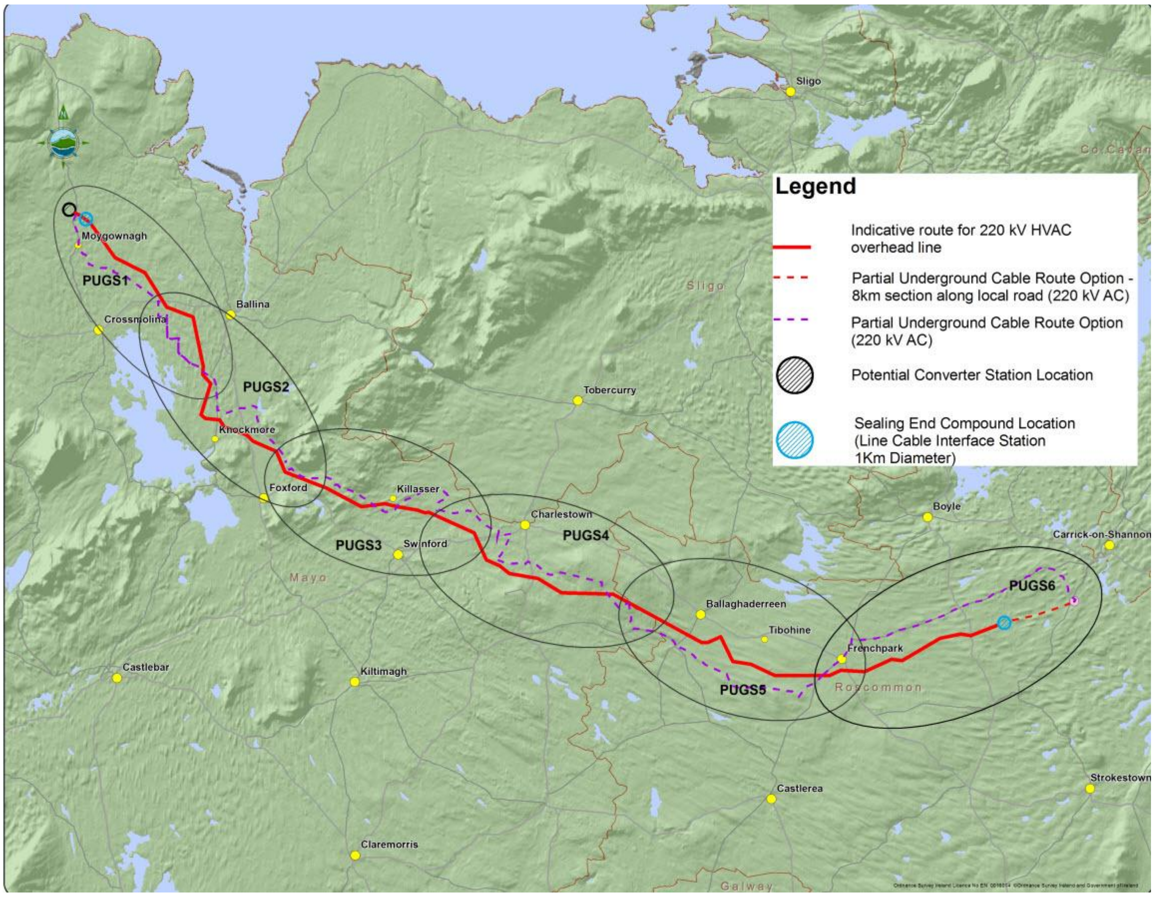

Figure 7-4 **Map of the 220kV HVAC PUGS Considered**

EirGrid selected the sections based on the feasible UGC route. This route runs along local public roads between points of intersection on the OHL route (see Appendix 15) and the roads network.

In the sections PUGS 1 to 3, the proposed UGC sections follow the same route as that proposed for the HVDC UGC option (see chapter 5). In the sections PUGS 4 to 6 however, the HVDC UGC route and the HVAC OHL route diverge. Therefore, the PUGS routes do not follow the HVDC UGC route but instead an alternative route that more closely follows the 220kV OHL route.

Detailed maps of the indicative OHL route are shown on Drawing Nos. 6424-1500 to 6424-1531[128].

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7.5 ENVIRONMENTAL ANALYSIS

7.5.1 *Environmental Assessment of the 220kV HVAC PUG Option*

The indicative 220kV HVAC OHL follows the same routing principles as the 400kV HVAC OHL option and consequently the environmental analysis, as outlined in Chapter 6, equally applies.

The 220kV HVAC PUG option incorporates an additional 2km section of UGC at north Mayo and up to an additional 20km UGC mid-section.

The key findings of the specialist environmental analysis are appraised below under the following criteria:

- Biodiversity, Flora and Fauna;
- Water;
- Soils and Geology;
- Landscape/Visual;
- Cultural Heritage;
- Settlement/Communities;
- Air Quality;
- Climatic Factors;
- Material Assets;
- Recreation and Tourism; and
- Traffic and Noise.

The impact and effect of each criterion is classified in terms of significance and ranges from "more significant" to "less significant" depending on the significance of each criterion along the route of the 220kV OHL option and the 220kV PUG option.

Ease of mitigation of the identified impacts, and effects for each is classified in a range from "difficult to mitigate" to "possible to mitigate". Possible residual effect following implementation of the mitigation measures is presented in a range from "more likely" to "less likely".

The range of impact and effect significance, ease of mitigation and the likelihood of residual effect (following mitigation) are presented as follows:

More significant **Difficult to Mitigate** **More Likely**	**Less significant** **Possible to Mitigate** **Less Likely**

An overall summary of the environmental analysis of both the 220kV HVAC OHL option and 220kV HVAC PUG option is included in Section 7.5.4. below.

In each of the criteria above, although mitigation measures will reduce the potential impacts and effects, further detailed assessments are required to quantify impacts and effects. The final amount of UGC employed on this option will also be a consideration.

7.5.1.1 Biodiversity, Flora and Fauna

The impact and effect on fauna, particularly birds, from the overhead section of the 220kV option is identified, as well as the impact and effect on receiving waters and downstream habitats from an underground section(s) of the 220kV option. This is particularly relevant where works are required in the vicinity of surface waters and where horizontal directional drilling occurs under water features, such as the River Moy or River Lung.

7.5.1.2 Water

The impact and effect on water from the construction phase of the overhead section of the 220kV option is assessed. The potential impacts and effects identified are the crossing of rivers and streams and the potential for sediment-laden runoff and potential impact on karst features from the individual tower construction sites.

The main impact from an underground section(s) of the 220kV option is the potential to directly impact on rivers and streams near the section of proposed cable. Potential disturbance of soils/geology which could cause downstream pollution of salmonid habitats and reduce water quality is also a consideration.

7.5.1.3 Soils and Geology

The impact and effect on soils and geology from the overhead section of the 220kV option will be localised (at each tower and station location). However, runoff to nearby surface water features and karst features is a potential risk during the construction phase of the development, particularly in areas of peat.

Based on the data collated along the route of the 220kV option and within the study area, an underground section(s) of the 220kV option is likely to be located in an area of underlying peat. During the construction phase, the direct disturbance of soils, including peat, may have an effect on nearby water features and underlying groundwater due to an increase in the volume of suspended solids entering these waters.

7.5.1.4 Landscape and Visual

The direct, permanent, visual impact and effect on landscape from the overhead section of the 220kV option (in areas of poor screening or elevation) is identified, including the impact and effect from tower structures, sealing-end compounds and substations.

The underground section(s) of the 220kV option will remove the direct visual impact in the area of the cable section(s) during the operational phase of the development. The Landscape Characterisation of each underground section is shown in Figures 1 and 2 of Appendix 14.

There will be some localised, temporary, extended visual impact from plant and equipment during the construction period. The additional sealing-end compounds, located at either side of the UGC section, will have a permanent, adverse effect on the landscape character and visual amenity due to their scale.

7.5.1.5 Cultural Heritage

The impact and effect on cultural heritage from the overhead section of the 220kV option is identified as an impact on the “setting” of the archaeological features, as direct effect on known archaeological features is avoided, where possible, in the route selection to date.

The underground section(s) of the 220kV option may directly affect previously unrecorded and undisturbed archaeological and architectural features along the route. However, as the underground section will primarily follow local roads, the installation of cables will, in effect, follow a route that was previously disturbed and both surface and sub-surface remains may already be removed.

7.5.1.6 Settlement/Communities

The impact and effect on settlements from the overhead section of the 220kV option is identified as a combination of visual impact during the operational phase of the development and, to a lesser extent, short-term impact arising from construction traffic and noise and visual impact from excavation and the erection of towers and the line.

Towns and villages were avoided during the route selection of the OHL. However, rural houses are more difficult to avoid by a significant distance.

The potential impact and effect on settlement from the underground section(s) of the 220kV option will include noise, disruption and disamenity, particularly from traffic diversions and road closures during the construction phase of the development. If a mid-section partial UGC is selected, two additional sealing-end compounds will have potential visual impact on rural houses.

7.5.1.7 Air Quality

The effect on local air quality from the proposed works at the OHL tower sites, substations and sealing-end compounds will be negligible. Construction related traffic will be small and will not have significant adverse effects on local air quality at houses located along site access roads.

The effect on local air quality will be negligible for the UGC section(s). However, this section(s) has the potential to affect houses on the route and also affect traffic flow which, in turn, has the potential to increase pollutant concentration at the construction sites.

The UGC section(s), therefore, has the potential to impact on dust and pollutant concentration close to houses over a wider area than the vicinity of the construction sites.

7.5.1.8 Climatic Factors

Emissions are inevitable during the construction phase. However, this relatively short-term impact should be considered alongside the long-term effect of the development. The Grid West project will have net positive residual effects by facilitating renewable energy sources in the west of Ireland, thereby reducing the national dependence on fossil fuels.

7.5.1.9 Material Assets

The impact on material assets from the overhead section of the 220kV option will include possible permanent localised effect on agricultural land, bogs, farmyard development, quarries, a landfill site and forestry plantations.

The impact on material assets from the underground section(s) of the 220kV option will most likely be temporary and during the project construction phase.

7.5.1.10 Recreation and Tourism

The impacts and effects on recreation and tourism from the overhead section of the 220kV option during construction and with the location of towers near areas of known angling tourism. Recreation and sports amenities were avoided during route selection of the OHL.

Impacts and effects from the underground section(s) of the 220kV option may result from horizontal directional drilling under major rivers, such as the River Moy or River Lung, which may have a negative effect on water quality and fish populations in the area. Traffic diversions as a result of road closures during construction of the underground section(s) may temporarily impact on tourists visiting the area and access to areas of interest.

7.5.1.11 Traffic and Noise

Access and temporary works is required to accommodate the construction of towers in fields, forest and peatlands. An increase in traffic may occur in the local area due to construction vehicles accessing the site. Rolling closures of local roads will be required to facilitate access for larger vehicles and along the proposed route of the 220kV UGC to the existing Flagford substation; however, overall traffic impact and effect will be relatively low as construction will be largely off-road.

Significant short-term disruption to traffic is expected at some locations during cable installation. 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. In addition to the traffic disruption experienced during installation of the cable, it is possible that further traffic disturbance would occur if faults were to occur along the UGC.

It is likely that the overhead and underground sections of the 220kV option will result in noise (and possibly vibration) effects at nearby houses during the construction phases. Construction noise and vibration impacts will be temporary.

For the overhead section, operational noise impacts will be long-term. Noise impacts may result from the substations and from aeolian and corona noise from the overhead lines but vibration impacts during operation will not be significant.

Noise impacts from the UGC section and the sealing-end compounds during the operational phase will not be significant.

7.5.2 220kV HVAC OHL Option and 220kV HVAC PUG Option – Possible Mitigation Measures

The indicative 220kV HVAC OHL follows the same routing principles as the 400kV HVAC OHL option and consequently the same environmental analysis and the mitigation measures apply.

With regard to the 220kV HVAC PUG option, it can be taken that the mitigation measures outlined in Section 5.6 for the UGC equally apply.

At this stage of the Grid West project, it is only possible to provide a high level identification of possible mitigation measures, based on desktop studies and fieldwork completed to date. No matter which option emerges as the preferred solution for Grid West, a Construction Management Plan (CMP) will be needed.

The principal controls for environmental management will be identified and controlled primarily through the CMP and Method Statements for the construction phase of the project.

7.5.3 Partial Underground Option Residual Effect

Detailed environmental assessment will be carried out following selection of a preferred option that will inform an EIS and AA (in accordance with the Habitats Directive). At this stage it is only possible to provide a high level assessment of possible significant impacts and effects, mitigation measures and any associated residual effects, based on desktop studies and fieldwork completed to date.

Following the identification of possible mitigation measures, as presented above, the anticipated residual effect on each environmental parameter as a result of the proposed 220kV HVAC OHL and PUG option are presented in the tables below.

7.5.4 Summary of the Environmental Analysis of the 220kV HVAC OHL & PUG Options

	220kV HVAC OHL option (8km UGC)		
	Significance of Impact/Effect	**Ease of Mitigation**	**Residual Effect (following mitigation)**
Biodiversity, flora and fauna;			
Water[1]			
Soil			
Landscape and Visual			
Cultural Heritage			
Settlements and Communities			
Air Quality[1]			
Climatic Factors			
Material Assets			
Recreation and Tourism			
Traffic and Noise[1]			
Noise[2]			

Notes:

1. During construction
2. During operation

More significant
Difficult to Mitigate
More Likely

Less significant
Possible to Mitigate
Less Likely

Table 7-1 **Summary of the Environmental Analysis of the 220kV OHL Option, with 8km UGC**

	220kV HVAC PUG option (30km UGC)		
	Significance of Impact/Effect	Ease of Mitigation	Residual Effect (following mitigation)
Biodiversity, flora and fauna;			
Water[1]			
Soil			
Landscape and Visual			
Cultural Heritage			
Settlements and Communities			
Air Quality[1]			
Climatic Factors			
Material Assets			
Recreation and Tourism			
Traffic and Noise[1]			
Noise[2]			

Notes:

1. During construction
2. During operation

More significant Difficult to Mitigate More Likely	Less significant Possible to Mitigate Less Likely

Table 7-2 **Summary of the Environmental Analysis of the 220kV HVAC PUG Option, with 30km UGC**

The summary of the environmental analysis of the 220kV option highlights the fact that the 220kV option follows the same route as the 400kV OHL option. A number of sections of UGC are proposed along this route, including:

- An UGC into Flagford substation (as per both options);

- A possible UGC into the proposed substation at north Mayo, and
- The potential for a c.20km UGC section at a location along the route of the 220kV OHL option.

Table 7.1 includes an appraisal based on the 220kV HVAC OHL option with 8km of UGC only. Table 7.2 includes an appraisal of the 220kV option including 30km of UGC. The actual location and length of UGC selected for this option will determine the final impact and effect which will reside between these two scenarios.

The environmental appraisal of each parameter identifies the impact and effect of the OHL route, as described for the 400kV OHL route option in Section 6.4, but allows for the inclusion of the potential impacts and effects from an optional partial underground section, approximately 20km in length to be located at a location along the route of the 220kV option. Overall, reflecting the OHL option and the possibility of an additional partial underground section, the environmental impacts and effects of the 220kV option are most significant for landscape and visual and settlement and communities.

The impacts and effects on biodiversity, flora and fauna, water, soil, cultural heritage, air quality, material assets, recreation & tourism, traffic and noise are classified as “mid-range/moderate” as the significant impacts on these parameters will be primarily temporary in nature, with localised permanent impacts. The link between landscape and visual and recreation and tourism is acknowledged.

The residual effect on the environment following implementation of mitigation measures is anticipated to be moderate to low.

7.6 TECHNICAL ANALYSIS

7.6.1 Compliance with Health and Safety Standards

Discussion

Technical standards for high voltage equipment, whether for HVDC or HVAC equipment are based on safety requirements and therefore as a general rule, compliance with recognised technical standards mean that the equipment is designed and manufactured so as to be safe.

For both HVAC UGC and overhead lines safety is inherent within all technical equipment standards irrespective of the final length of cable installed.

The applicable standards originate from the European Committee for Electrotechnical Standardisation[129] (CENELEC) or a similar internationally recognised standard is applied. These standards take into account the integrity of installations and systems by operating conformity assessment systems. These verify plants and systems perform to acceptable technical and safety standards.

All materials are designed, manufactured, tested and installed according to relevant International Electrotechnical Commission[130] (IEC) or CENELEC standards. Where no IEC or CENELEC standards exist, a recognised international standard will be applied. The latest edition and amendments to standards and specifications will apply in all cases.

Regardless of the technical solution chosen, the Grid West project will be designed, constructed and maintained in accordance with applicable Irish and EU health and safety regulations and approved codes of practice.

EirGrid is at all times aware of and complies with the applicable health & safety legislation, approved codes of practice and industry standards and all subsequent modifications or amendments in relation to same. EirGrid operates a formal legal compliance process as part of its health and safety management system.

All prospective technical solutions comply with the safety and health regulations, in particular the sections relating to electricity[131].

All designs shall meet the requirements of the EirGrid functional or operational specifications which incorporate CENELEC standards and contain specific national requirements e.g. environmental conditions, procedures and system network parameters. All equipment shall be Grid Code compliant.

129 http://www.cenelec.eu/
130 http://www.iec.ch/
131 http://www.hsa.ie/eng/Legislation/Acts/Safety_Health_and_Welfare_at_Work/General_Application_Regulations_2007

Designs shall also be reviewed by appointed Project Supervisors for Design Stage (PSDP)[132] as required by the Safety, Health & Welfare at Work (Construction) Regulations 2013.

Where any commissioning may involve connections to existing transmission infrastructure, then such commissioning is conducted in accordance with ESB Networks "Electrical Safety Rules 2006".

The principal document required at project completion / handover is the completed Health & Safety File, required under the Safety, Health & Welfare at Work (Construction) Regulations 2013 [S.I. No. 504 of 2006]. This document is required irrespective of the technical solution adopted.

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
Compliance with all relevant safety standards		

More Difficult
More Risk

Less Difficult
Less Risk

This option will be fully compliant with relevant safety standards, regardless of the length of cable utilised and is therefore lowest on the difficult/ risk scale.

7.6.2 Compliance with Reliability and Security Standards

Discussion

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

- The Transmission Planning Criteria (TPC)[133];
- The Operational Security Standards (OSS)[134]; and

Any 220kV OHL or UGC solution proposed will comply with both the TPC and OSS.

132 http://www.hsa.ie/eng/Legislation/New_Legislation/SI_291_2013.pdf
133 EirGrid, Transmission Planning Criteria, 1998 (http://www.eirgrid.com/media/Transmission%20Planning%20Criteria.pdf)
134 EirGrid, Operational Security Standards, 2011 (http://www.eirgrid.com/media/Operational%20Security%20Standards.pdf)

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	220kV HVAC PUG Option (30km UGC total)
Compliance with system reliability and security standards		

More Difficult
More Risk

Less Difficult
Less Risk

Notwithstanding the above, both the 220kV HVAC OHL option and the 220kV HVAC PUG will be compliant with the relevant security and reliability standards, regardless of the length of cable installed, and will therefore be rated as low on the difficulty/ risk scale.

7.6.3 Average Failure Rates, Repair Times and Availability

Discussion

Unplanned outages:

Failure Rates, Repair Times and Generic Availability Figures	220kV OHL	220-500kV Cables
Reliability(Unplanned outages/100km/year)	0.035	0.277
Mean time to repair (days)	Circa 2 days	25 – 45 days[135]
Unavailability (days/100km/year)	c.2 hours/annum	c.7 – 12 days/annum

Grid West Option Specific Availability Rates	220kV HVAC OHL Option (8km UGC at Flagford)	220kV HVAC PUG Option (30km UGC total)
220kVoption section lengths	105 km	85km (OHL) /30 km (UGC)
Unavailability (days/220kV OPTION/year)	c.2 hours/annum	c.2 – 4 days/annum

Table 7-3 Average Failure Rates, Repair Times and Availability

Almost all OHL faults are of short duration as a result of transient faults such as lightning strikes, where the auto reclose function provided for the protection of the line restores the circuit shortly (0.5 – 3 seconds) after the fault.

Even if the line suffers physical damage, faults can be rapidly located and identified by visual inspection from the ground or air, and repairs effected in a matter of hours.

135 Dependant on method of cable installation: direct lay or in ducts respectively.

An UGC is not subject to the transient faults that occur on an OHL. However when a cable fault does occur, fault localisation can result in prolonged circuit outages. As such, cable circuits have a lower availability than OHLs because of the prolonged outage times in the event of a fault.

An OHL will be subject to transient faults that will generally be cleared by auto reclosing schemes e.g. lightning strikes. Any faults on the remaining underground cabled sections will not be cleared by auto reclosing.

Analysing the fault statistics of the combined quantity (approximately 2,245km) of 400kV, 275kV and 220kV OHLs in Ireland for the period 2004 to 2012, gives a projected fault rate for a c.100 km long 400kV OHL of one permanent fault (that is a fault that requires repairs before the OHL can be returned to service) every 28 years. Transient faults are not considered, as any interruptions to supply that they may cause would be of such short duration that their effect is considered to be negligible, despite being an inconvenience for electricity users.

Given typical repair times this equates to the circuit being out of service due to a permanent fault for less than two hours per annum. The average failure rates during normal operation, average repair times and availabilities of the main elements of a typical 220kV or 400kV OHL are set out in the table above.

The above table also shows that the statistics for reliability based on international failure statistics of cables[136], the mean time to repair such outages and the availability in days per 100km per year for HV cables.

Consequently the unplanned outages for the 220kV option will vary from c.2 hours – 4 days per annum, dependant on the increasing use of the cable in the circuit towards the technical limit.

Planned outages:

Planned outages are normally associated with routine maintenance. For the OHL sections of this option much of this work can be completed without an outage. However the planned outage rates and the typical outage durations taken from EirGrid maintenance policies[137] result in an annual planned outage rate of 0.65% for the 220kV OHL solution, or c.2.5 days per annum. The HVAC 220kV cable sections require more planned outages. The typical outage duration taken from EirGrid maintenance policies is 4-6 days per annum (dependant on the number of joint bays and cable sections).

Common to all of the options is the need to perform planned maintenance for the associated substation switchgear and equipment. Each year an operational test is performed, and periodically an ordinary service. This equates to a further maintenance outage of an average of two days per annum.

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[136] Cigre, TB379 Update of service experience of HV underground and submarine cable systems, 2009

[137] EirGrid Maintenance Policies CM3, CM6, CAB D13, 2014

Whilst operational tests, ordinary services and condition assessment on bays along with OHL maintenance can be carried out simultaneously, cable maintenance must be carried out separately. EirGrid's cable maintenance policy requires that sheath tests are carried out annually to determine the integrity of the cable sheath. This is carried out by applying a voltage to the cable and checking for leakage current. This is why Station and OHL maintenance cannot be carried out concurrently with UGC maintenance.

The planned outages for the station and circuit for this option would equate to a total of c.6 days per annum on average, but much of this work would be scheduled to be completed simultaneously (resource dependant).

The planned outages for the station and circuit for the 220kV HVAC PUG option would equate to a total of c.6 days per annum on average, but much of this work would be scheduled to be completed simultaneously, depending upon resource availability, and thus the overall planned outage duration is determined by the greater of the two requirements.

Combination of the planned and unplanned outages:
The combination of the planned and unplanned outages gives a total of c.2.5 days – 10 days per annum, which is dependent on the increasing use of the cable in the circuit towards the technical limit.

<u>Conclusion</u>

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option		

More Difficult
More Risk

Less Difficult
Less Risk

The overall availability of the entire circuit is the most important factor. For an entirely OHL circuit, the availability rates are above 99.99% and it scores at the lowest level on the difficult/ risk scale.

With the maximum length of cable installed, the availability rate will be lower than 99.99%, at approximately 97.5% (9 days per annum) for the partially undergrounded circuit. As this circuit will provide access for future connection into the integrated transmission network, this reduced reliability has limited network effect and is between the mid-level and lowest level on the difficult / risk scale.

7.6.4 Reliability of Supply

<u>Discussion</u>

As described in chapter 3, the primary driver for Grid West is to facilitate the wind generation that forms the Bellacorick Subgroup. Secondary benefits include an opportunity to improve security of supply to Mayo. Therefore impact of unavailability is primarily wind generation constraint, due to the reliability of their network connection.

The basic configuration of the Grid West project is compliant with the Transmission Planning Criteria and therefore meets the minimum acceptable reliability criteria.

However the Transmission Planning Criteria provides a balance between security of supply (reliability) and development cost, and therefore only requires EirGrid to plan a resilient network for a justifiable range of events. Where opportunities exist to provide a higher security of supply at minimal or zero cost then these options are preferable.

The overall reliability of the circuit changes depending on the changing mix of technology (i.e. ratio of UGC to OHL) used and their individual reliability rates.

This development will be the longest single point connection of power generation that is circa the largest generating unit on the system. The HVAC UGC system elements and stations interfacing the overhead and underground elements present a high reliability risk, but within the acceptable standards.

<u>Conclusion</u>

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
The expected impact on reliability of supply of unavailability of the development		

More Difficult
More Risk

Less Difficult
Less Risk

Impact on reliability has two dimensions, namely the role of the circuit itself; and its impact on overall system design and reliability.

High availability reduces exposure to both additional constraint costs and security of supply issues and on its own is considered to be at the lowest level on the difficult/ risk scale. Low availability exposes the network to additional constraint costs and security of supply issues.

The use of OHL is consistent with the rest of the network and does not impede future network development options and is the lowest level on the difficult/ risk scale.

As the maximum length of cable accounts for c.30% of the total length of the circuit, the reduction in reliability from this technology is capped. Therefore, this option would be considered between mid-level and the lowest level on the difficult/ risk scale.

Based on the studies[138] carried out there is a technical limit to the amount of cable that can be accommodated on the regional network. It is unlikely that any further HVAC cable, in addition to the 30km already specified as part of the project will be acceptable. The use of the available budget of HVAC cable in this area means that for this element the score should reflect the greater system impact and is rated between the mid-level and highest level on the difficult/ risk scale.

In aggregate, an entirely 220kV OHL option is at the lowest level of the difficult/ risk scale, with the maximum use of cable the option would rate at the mid-level on the difficult/ risk scale.

7.6.5 Implementation Timelines

Discussion

The construction of the 220 kV HVAC OHL and PUG options are both expected to take approximately 3.5 years. These timelines are based on experience of construction of similar HVAC circuits, please see Section 6.5.5 above. The cable installation required with the partial undergrounding option will be sequenced so as to occur in parallel with the main OHL build.

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
Implementation timelines		

More Difficult
More Risk

Less Difficult
Less Risk

Therefore the rating for the 220kV options is assessed to both be moderate on the difficult/ risk scale.

138 Appendix 11 – LPA Report, Cable Studies for Grid West – Partial AC Underground Solution, January 2015

7.6.6 Future Reinforcement of the Transmission System

Discussion

This option, regardless of the quantity of UGC installed, meets the immediate need for the north west region. It permits an increase in generation capacity sufficient to meet the needs of the contracted generation awaiting a connection to the network. It also allows further development of a transmission corridor along the west coast, supporting the north west region with some additional works. However, the rated capacity of the circuit will be heavily utilised from the outset.

If UGC is utilised, to increase capacity above its limited remaining capacity (50-100MVA), additional reinforcement will be required. Given the current state of technology development, this could require the UGC to either be duplicated (if technically possible), or replaced ultimately with an OHL.

In order to utilise this circuit to reinforce the transmission system in the north west area, a second circuit, with a similarly rated physical capacity, is required between the new transmission station north west of Moygownagh in north Mayo and another EHV substation. This second circuit would provide N-1 redundancy, and therefore the full capacity of the Grid West circuit could be realised.

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated		

More Difficult
More Risk

Less Difficult
Less Risk

There are four aspects to future reinforcement and connection to the transmission network:

- The extent to which future generation capacity is catered for without further reinforcement;
- The extent to which future generation capacity is catered for with further reinforcement;
- The ability to add additional new stations, and
- The capacity that can be provided for into or out of the north west region (Roscommon, Leitrim, Donegal, Sligo and Mayo).

The 220kV OHL option proposed will have a 600MVA rating. The initial requirement is for 410MVA and the LSI is currently 500MVA, which is likely to increase over time as the system develops. Therefore this option provides 190MVA of surplus capacity, subject to an increase of the LSI. This would cater for only c.10% of those further generators seeking connection in Co. Mayo at this time, and it is therefore considered to be between the mid-level and lowest level on the difficult/ risk scale.

Although a later conversion of the 220kV circuit to 400kV with a 1,580MVA rating would be possible this would require substantial additional works and associated outages and therefore would be considered as mid-level on the difficult/ risk scale.

To allow for generation levels in excess of the existing LSI of 500MVA (and assuming the LSI was to stay unchanged), a second EHV circuit could be developed into the north Mayo area, essentially meshing the north Mayo substation into the EHV network, Given the 600MVA rating of the initial circuit, the maximum generation in total that could be facilitated with this solution would be 600MW. This is significantly lower than the generation potential in the area and hence it would similarly be considered as the mid-level on the difficult/ risk scale.

Finally, as a HVAC solution, a further connection point into this circuit for the area could be readily facilitated, but this would be restricted by the rating of the circuit. Therefore, for this aspect this option would be rated at the mid-level on the difficult/ risk scale.

The application of UGC up to maximum amount that is technically feasible impacts on the ability of future projects in the area to mitigate any constraints using UGC. The management of the available UGC therefore needs to be seen at a system level rather than a project level, directly impacting the development of future reinforcement options in the region. The operational complexity associated with dynamically managing a cable system, including any likely impact on system reliability and the ability to re-energise cables following a black start , is also a consideration. This risk is considered to be between the mid-level to highest level on the difficult/ risk scale.

From an operational complexity perspective, an entirely OHL option would be consistent with the existing network and is considered at the lowest point in the difficult/ risk scale.

Therefore, in aggregate, the rating for an entirely OHL solution would be between the mid and lowest point on the difficult/ risk scale and at the mid-level point if UGC was utilised up to the technical limit.

7.6.7 Risk of Untried Technology

Discussion

Overhead lines at 220kV are already widely in use in the Irish transmission system and are seen as a tried and tested technology. The use of partial UGC at various points along the route of a predominately OHL circuit, particularly mid-span, is an untried technology on the Irish system. The application of 220kV UGC, either fully undergrounded for short lengths or for the short sections at the end of an OHL into stations, has been used in Ireland in mainly urbanised locations.

It is expected that the partial underground 220kV circuit will have a significant impact on system operation. There are presently no predominately OHL circuits on the Irish transmission system with combined lengths of 220kV cable similar to the 30km proposed for the Grid West partial underground solution. In addition, and as described in previous sections, there are no circuits with partial underground sections located mid-way along the circuit.

The large capacitance of a HVAC UGC results in a different system performance in both steady state and dynamic situations, and provides a technical challenge for the operation of the transmission network as a result. Reactive compensation and harmonic filtering will be required at the substation in order to prevent voltage rise as a result of the reactive power produced by the HVAC UGC, and also to reduce the reactive current in the cable to facilitate the required power transfer capacity[139]. Shunt reactors are proposed to mitigate the negative impacts of reactive power production of the combined sections of UGC.

Consequently, the on-going operation of the network must be carefully managed to ensure that the network security is not placed at risk during periods of maintenance or system disturbance, e.g. storms.

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
Risk of untried technology		

More Difficult
More Risk

Less Difficult
Less Risk

An entirely 220kV OHL option is consistent with the existing network, and is considered a proven technology. Hence is at the lowest point in the difficult/ risk scale.

The deployment of new technology or the deployment of existing technology in untried configurations directly impacts the options and decisions available for future projects. Therefore the risk and likely impact need to be accounted for when considering new technologies.

The use of HVAC UGC technology at 220kV is not new to Ireland as it is used extensively in urban areas such as Dublin. The configuration of this technology as multiple UGC sections within an OHL circuit has not been done previously.

[139] Appendix 10 - LPA Report

This configuration often requires the use of the ancillary equipment (i.e. filters) to mitigate the issues that arise with the introduction of long lengths of cables. Once this device is added to the network it will increase the complexity of operation and will need to be modified (i.e. tuned) as the network changes to ensure it remains effective.

As the option impacts a number of areas, and affects the wider system, the rating is mid-level on the difficult/ risk scale.

Therefore, in aggregate, the OHL option is at the lowest point on the difficult/ risk scale and the PUG option is rated at the mid-level if UGC is utilised up to the technical limit.

7.6.8 Compliance with Good Utility Practice

Discussion

Good utility practice is to develop a flexible, robust and cost-effective solution with due regard to environmental constraints.

220kV OHL is a standard network design and technology that is used to reinforce the transmission system or connect generation in Ireland. This is consistent with the rest of Europe[140], where many projects have been developed using the same approach.

The use of 220kV for this option would be consistent with good utility practice as it is an existing voltage level on the network and therefore inherently offers some future flexibility.

However, it does not make maximum use of the reinforcement corridor which may be relevant given the environmental constraints in the area. The duration of the construction works, and the need to maintain an export path for power generated during subsequent works limits the opportunity of phased development with a 220kV OHL design and subsequently replacing it with a 400kV OHL design. Rebuilding a 220kV line to 400kV standard would require further planning consent, including Appropriate Assessment and Environmental Impact Assessment. Any such new future planning consent may require changes to line alignment, which could result in effectively, a stranded asset, if it was not possible to construct a future 400kV line entirely in accordance with the permitted/existing 220kV line alignment.

Similarly, phased development with a double circuit 220kV OHL would provide limited benefit as the transmission planning standards would still limit the total power carried on a double circuit tower to the LSI i.e. it is still counted as a single contingency. Therefore a further circuit would be required into the area to realise the full capacity of a 220kV double circuit tower configuration.

220kV UGC is a standard technology in use on the Irish transmission system. However, given its characteristics, there are limits to how much can be used in any area and use on one project reduces

[140] ENTSO-E, Statistical Factsheet 2013, Provisional Values as of 25 April 2014

the amount of underground cable that can be used on future development. A partially undergrounded 220kV solution is typically employed in limited circumstances, such as major water crossings, when traversing densely populated or congested areas.

In general, using UGC in mid sections is considered less desirable than using UGC at terminal ends, as it imposes additional complexity.

Conclusion

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
Compliance with good utility practice		

More Difficult
More Risk

Less Difficult
Less Risk

HVAC OHL used in a meshed configuration is the standard building block of international transmission networks. However, using 220kV HVAC gives reduced optimisation of the reinforcement corridor. As such, with regard to good utility practice, it is rated between the mid-point and on lowest point on the difficult/risk scale.

The 220kV PUG option, utilising the full available 220kV UGC for the region and comprising a mid-section cable, giving rise to increased complexity, is rated at the mid-point on the difficult/ risk scale with regard to good utility practice.

7.6.9 Summary of the Technical Analysis of the 220kV HVAC OHL Options

The table below summarises the technical assessment of the 220kV HVAC OHL options.

	220kV HVAC OHL Option (8km UGC at Flagford)	**220kV HVAC PUG Option (30km UGC total)**
Compliance with all relevant safety standards		
Compliance with system reliability and security standards		
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option		
The expected impact on reliability of supply of unavailability of the development		
Implementation timelines		
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated		
Risk of untried technology		
Compliance with good utility practice		

More Difficult
More Risk

Less Difficult
Less Risk

Table 7-4 **Summary of the Technical Commentary of the 220kV HVAC OHL Option**

7.7 ECONOMIC ANALYSIS

An economic appraisal, consistent with the requirements of the IEP Terms of Reference, was completed and the results are summarised below.

7.7.1 Approach and Methodology

The approach and methodology used in conducting the economic assessment is already discussed in detail in Sections 5.8.1 to 5.8.3 above.

As stated previously, the economic assessment measures the impact of the reinforcement project on the Irish economy, rather than on the company responsible for making the capital investment. It makes use of the Discounted Cash Flow (DCF) analysis method.

All financial values are represented in the current year's Euro and are expressed in real terms (i.e. excluding projected inflation). All future values are referred (or discounted) to the current year, which is taken to be the start date of the economic assessment. The duration of the evaluation is equivalent to the regulatory authority-approved useful life of the new asset being considered, i.e. 50 years[141].

7.7.2 Input Costs

Each reinforcement incurs incremental costs (e.g. inception capital costs, incremental maintenance costs); and has an impact on the overall transmission system efficiency (e.g. total generation production costs; transmission system losses and system reliability costs).

The costs considered in this assessment are as follows:

7.7.2.1 Project Pre-Engineering Costs:

The pre-engineering costs refer to the costs associated with design and specification; route evaluation; and managing the statutory planning application. The costs are capital in nature and are estimated to be €17.2 million. This amount includes a contingency provision of €0.4 million to account for the risk that the amount may vary.

The phasing of the costs is as follows:

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Pre-Engineering Costs	64%	26%	5%	5%	0%	0%

Table 7-5 Phasing of Pre-Engineering Costs

[141] Decision on TSO and TAO transmission revenue for 2011 to 2015, CER/10/206, 19th November 2010: "...the CER stated its intention to continue using average assets lives of 50 years for the TAO's network assets".

The present value of the project pre-engineering costs was calculated using the estimated value of €17.2 million, phased according to the table above. The capital amounts are discounted at the Test Discount Rate, resulting in a present value of €16.5 million.

7.7.2.2 Project Implementation Costs:

The project implementation costs refer to the costs associated with the procurement, installation and commissioning of the reinforcement and therefore includes all the transmission equipment that form part of the reinforcement's scope.

The capital investment required to deliver the reinforcement is estimated to be €205.0 million, using standard development costs provided by ESB Networks. This cost estimate contains a contingency provision of 10% that has been applied to all the cost components and amounts to €18.6 million. There is the potential for up to a further 22km of the OHL route to be implemented using UGC, given that 8kms of UGC have already been included. The estimated project implementation cost would then increase to €244.5 million (including €22.3 million in contingency provisions).

The estimated capital costs are categorised by their general components of OHL, UGC, stations and reactive compensation costs. Also considered is a provision for flexibility payments, proximity allowance and local community fund (referred to as "Other"). The costs, by category, are summarised in the table below. As an illustration, the situation where the maximum amount of UGC that is technically feasible is presented and is labelled as 220kV PUG (i.e. Partial Underground) Option:

Cost Category	*220kV OHL Option* *Project Implementation Cost* *(€ M)*	*220kV PUG Option* *Project Implementation Cost* *(€ M)*
Overhead Line	103.0	76.6
Substations	40.7	40.7
Underground Cable	18.9	71.0
Reactive Compensation	4.4	16.3
Other		
Flexibility Payments, Proximity and other allowances	19.4	17.6
Non-EPC Costs	0.0	0.0
SUB-TOTAL	**186.4**	**222.2**
Contingency	18.6	22.3
TOTAL	**205.0**[142]	**244.5**

Table 7-6 Summary of Project Implementation Costs for the 220kV OHL and 220kV PUG OHL Options

142 The working assumption is that the existing standard 220kV towers on the Flagford - Srananagh line will need to be replaced to carry the higher rating/ heavier conductor. If this is not necessary, there would be a cost reduction in PV terms of €7m on this option.

The phasing of the costs is as follows:

	2015	2016	2017	2018	2019	2020
Project Implementation Costs	0%	0%	20%	40%	40%	0%

Table 7-7 Phasing of Project Implementation Costs

The present value of the project implementation costs for the 220kV OHL and 220kV PUG OHL options are €168.2 million and €200.5 million respectively. The present values were calculated using the project implementation costs, phased according to the table above. The capital amounts were discounted at the Test Discount Rate to determine the resulting present value.

7.7.2.3 Project Life-Cycle Costs

Life-cycle costs refer to the future costs associated with the reinforcement whilst ensuring that it remains viable for the evaluation period.

The useful life of the transmission equipment (both OHL and UGC), based on the CER permitted depreciation of transmission assets, is taken to be 50 years. The useful life is the same as the evaluation period and as a result, no replacement costs are considered for the option. Similarly, no consideration is given for any residual value for the replacement of equipment.

In accordance with the Terms of Reference, the life-cycle costs include:

- Cost of 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 losses it incurs.

  The electrical losses and the estimated cost of electrical losses are determined using the same assumptions and methodology discussed in the preceding economic sections of this report (i.e. Section 5.8.4.3).

  The losses and the corresponding cost of losses associated with the 220kV OHL and 220kV PUG OHL options are summarised in the table below.

	Circuit Losses (MWh/yr)	Terminal Losses (MWh/yr)	Total Losses (MWh/yr)	Annual Cost of Losses (€ M/a)
220kV OHL Option	16,046	2,340	18,386	1.1
220kV PUG Option	14,335	2,340	16,675	1.0

Table 7-8 Summary of the Annual Cost of Losses for the 220kV OHL and 220kV PUG OHL Options

The present value of the cost of losses for the 220kV OHL and 220kV PUG OHL options are €16.0 million and €14.5 million respectively.

- Maintenance cost:
  The approach taken is to represent the maintenance costs as an annualised costs provision that is based on standard rates per equipment type which is taken from information provided by ESB Networks[143]. The maintenance costs provided include a contingency provision of 10%.

  The estimates include the incremental cost of maintenance of the replacement of part of the Flagford - Srananagh existing 220kV line with cable.

  The annual maintenance costs, inclusive of contingency provision, are summarised in the table below.

Age of Asset	Station Maintenance Cost (€ M/a)	OHL Maintenance Cost (€ M/a)	UGC Maintenance Cost (€ M/a)	Annual Cost of Maintenance (€ M/a)
<20 years				
220kV OHL Option:	0.086	0.079	0.049	0.2
220kV PUG Option:	0.158	0.062	0.049	0.3
20-40 years				
220kV OHL Option:	0.086	0.087	0.049	0.2
220kV PUG Option:	0.158	0.069	0.049	0.3
>40years				
220kV OHL Option:	0.086	0.097	0.049	0.2
220kV PUG Option:	0.158	0.077	0.049	0.3

Table 7-9 Summary of the Annual Cost of Maintenance for the 220kV OHL and 220kV PUG OHL Options

The present value of the maintenance costs for the 220kV OHL and 220kV PUG OHL options are €2.4 million and €3.2 million respectively, inclusive of contingencies.

143 ESB Networks, Transmission Maintenance Unit Costs (Confidential), Rev. 2, 8 December 2014

7.7.2.4 Cost of Unreliability:

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 that are incurred.

For periods when the reinforcement is unavailable, the renewable generation that the reinforcement connects to the power system would be interrupted and would be replaced with alternative generation, including more expensive conventional plant. The average daily benefit attributed to the renewable generation connected to the power system is calculated to be €0.122 million. This value is calculated as a result of detailed market simulations that considered combinations of different wind profiles for the area for five different representative years. The studies showed that without Grid West the annual production cost would increase by approximately €39.0 million using a replacement energy cost equivalent to the average SMP of €60.66/MWh. If the circuit was unavailable during a period of particularly high wind availability then the real cost of circuit unavailability would be higher and 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 the use of this average figure is considered adequate.

The 8km of cable on the Flagford - Srananagh line is ignored in this part of the calculation as its reliability will not impact on the availability of the Grid West circuit.

The reliability of transmission infrastructure is separated into those that are planned and those that are unplanned, both of which are discussed below.

- Unplanned outages:

  Unplanned outages are normally associated with faults that routinely occur and are specific to the equipment type, technology employed (including voltage level, OHL, UGC etc.) and environmental conditions. Associated with the occurrence of an unplanned or "forced" outage is the mean time to repair. Both the unplanned outage rates and the mean time to repair are taken from Section 7.6.3 above and are summarised in the tables below for both the 220kV OHL and the 220kV PUG options.

Outage Type	No. Outages/ 100km/ yr	Outages/ yr	Mean Time to Recovery (Days)	Duration Out of Service (Days)	Annual Cost (€ M/a)
Unplanned Outage (OHL section)	0.035	0.036225	2	0.07245	0.009

Table 7-10 Summary of the Unplanned Outage Statistics and Resulting Annual Cost of the 220kV OHL Option

Outage Type	No. Outages/ 100km/ yr	Outages/ yr	Mean Time to Recovery (Days)	Duration Out of Service (Days)	Annual Cost (€ M/a)
Unplanned Outage (OHL section)	0.035	0.02975	2	0.0595	0.007
Unplanned Outage (UGC section)	0.277	0.06094	35	2.1329	0.260

Table 7-11 Summary of the Unplanned Outage Statistics and Resulting Annual Cost of the 220kV PUG Option

The present value of the unplanned outage for the 220kV OHL and the 220kV PUG options are €0.1 million and €3.8 million respectively.

- Planned outages:
  Planned outages are normally associated with routine maintenance. For the options, the planned outage rates and the typical outage durations are consistent with the with the standard maintenance practices for HVAC plant and equipment. This results in annual planned outage rates for the 220kV OHL and the 220kV PUG options of 0.66% and 1.65% respectively. Using the average daily benefit attributed to having the reinforcement available, the annual cost of planned outages is calculated to be €0.3 million and €0.7 million respectively.

  The present value of planned outages is €4.2 million and €10.5 million for the 220kV OHL and the 220kV PUG options respectively.

7.7.3 Estimate of Cost Uncertainty:

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 cost estimates, including pre engineering costs, include a contingency. The contingency allowance for the project reinforcement costs are 5% of the remaining projected spend and 10% for the project implementation costs. Similarly, a contingency allowance of 10% is provided for in the average maintenance costs that are calculated above.

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

7.7.4 Present Value Summary of Costs:

The abovementioned costs for the reinforcement are summarised in the table below.

	220kV OHL Option Present Value (€ M)	220kV PUG Option Present Value (€ M)
Pre-Engineering Costs	16.1	16.1
Project Implementation Costs		
Overhead Line	84.5	62.8
Substations	33.4	33.4
Underground Cable	15.5	58.3
Reactive Compensation	3.6	13.4
Other	15.9	14.4
Project Life-Cycle Costs		
Cost of Losses	16.0	14.5
O&M	2.2	2.9
Decommissioning & Replacement	0.0	0.0
Cost to SEM from Development Unavailability (Reliability)		
Cost of Unplanned Outages	0.1	3.8
Cost of Planned Outages	4.2	10.5
Contingency Cost Provisions		
Pre-Engineering Costs	0.4	0.4
Project Implementation Costs	15.3	18.2
O&M	0.2	0.3
Decommissioning & Replacement	0.0	0.0
TOTAL	**207.4**	**249.0**

Table 7-12 Summary of Present Value of Costs Associated with the 220kV OHL and 220kV PUG OHL Options

The total present value for the 220kV HVAC OHL option is €207.4 million. The total present value for the 220kV HVAC PUG option is €249.0 million. . The cost per MVA of capacity for these options is €0.346M/MVA and €0.415M/MVA respectively.

8. SUMMARY OF OPTIONS

The following chapter provides a summary of the analysis conducted and described in detail in chapters 5, 6 and 7 for the HVDC UGC, 400kV HVAC OHL and 220kV OHL options respectively. The tables for each option summarise the outcome of the environmental, technical and economic assessments.

A detailed route was developed for each option and the analysis and studies were undertaken on these identified routes. At design stage, the route selection process will eliminate or minimise impacts and effects, primarily by avoidance. Further environmental appraisal of route options seeks to identify local impact and effect, and the mitigation measures that will reduce these.

Each environmental impact from cultural heritage to air quality was assessed individually under three different headings:

- The significance of the impact / effect in terms of the overall project;
- The ease by which mitigation measures are applied and the possibility of applying mitigation measures to this impact, and
- The likelihood of residual effect after mitigation is applied.

Each of the environmental headings is given a colour rating; the darker the colour representing a heading the more significant, more difficult to mitigate or more likely to occur. The lighter the colour representing a heading; the less significant, less difficult to mitigate or less likely to occur.

Likewise, each of the technical headings is given a colour rating with the darker the colour representing a heading that is more difficult technically to implement or carries higher risk. The lighter the colour representing a heading; the less difficult technically to implement or less risk.

The third table gives a summary of the economic assessment, highlighting the present value of the costs associated with each solution and identified route.

8.1 SUMMARY OF HVDC UGC OPTION

A HVDC option has been confirmed as the only feasible fully underground solution for the Grid West project. The identified cable route is approximately 113km in length. The trench required to accommodate the cable is approximately 1.35m deep, and will be mainly along local roads from north Mayo to Flagford.

As HVDC is a different technology from what is used on the rest of the transmission system, different types of equipment are required. The main difference is at the start and end points of the UGC where converter stations are required.

The main environmental impact along the cable route will be during construction. Separate consideration is also given to the construction of the converter stations in north Mayo and Flagford. The landscape and visual impacts and effects of this option will in the majority be from the converter stations.

The report found that these buildings, in rural settings, can be located in areas that reduce this impact by making use of natural screening and designed landscaping. It also found that there will be temporary disruption associated with the trench and converter station construction, but that these effects will be mitigated with an appropriate construction management plan.

From a technical perspective, the solution has limited flexibility in terms of providing future reinforcement and connection to the HVAC transmission network. Due to the inflexibility in modification of HVDC equipment, to deliver a higher capacity solution such as equivalent to the 400kV HVAC OHL option would add very significantly to the works and cost.

The specific technology proposed for the converter stations is currently in use on the Irish transmission system in the EirGrid East West Interconnector project, operational since 2012. The technology is proven and in line with good utility practice.

On the basis of the economic analysis presented, the total present value of the HVDC UGC option amounts to €476.8 million.

8.2 SUMMARY OF THE 400KV HVAC OHL OPTION

The 400kV HVAC OHL option is a fully OHL high voltage transmission line from north Mayo to Flagford. This line will run mainly through agricultural land on a series of steel towers. A new substation will be required in north Mayo in addition to the upgrading the existing substation in Flagford.

As part of the 400kV HVAC OHL option, approximately 8km of undergrounding on the approach to Flagford is proposed. This mitigation measure addresses environmental concerns and ensures no addition to the current wirescape in the area.

The main environmental impact that was appraised is the landscape/ visual impacts and effects that will be generated by the OHL and substations. At design stage, the route selection process will eliminate or minimise the impact and effect of the proposed OHL on settlements, primarily by avoidance. However, given the dispersed nature of the rural population, further mitigation will be challenging and there is a significant localised residual effect.

There will be temporary disruption associated with construction but, as most of the construction work will be off road and remote from dwellings, it is expected that the impact will be low and can be mitigated with the appropriate construction management plan.

From a technical perspective, HVAC OHL is flexible and offers a potential for future expansion. The technology is tried and complies with good utility practice.

On the basis of the economic analysis presented, the total present value of the HVAC OHL option amounts to €222.1 million.

8.3 SUMMARY OF 220KV HVAC OHL OPTION

In addition to a fully HVDC UGC and fully 400kV HVAC OHL solution, EirGrid also considered a 220kV HVAC OHL option. The development of this option meets the needs of the project and facilitates some partial undergrounding along the route. This option was developed and considered to the same level of detail as the other two options.

To facilitate the consideration of this option, two scenarios were developed and appraised:

- A 220kV HVAC OHL option; and
- A 220kV HVAC partially underground (PUG) option.

8.3.1 220kV HVAC OHL Option

As the 220kV HVAC OHL option follows the same route as the 400kV OHL, it is considered to have the same environmental impacts and the same table is presented for both options. To achieve a fully OHL solution at 220kV, this option also includes approximately 8km of undergrounding on the approach to Flagford. This mitigation measure ensures there is no addition to the current wirescape in the area.

8.3.2 220kV HVAC PUG Option

Studies have confirmed that the total amount of HVAC UGC that can be accommodated in the region is approximately 30km. With 8km required for the approach into Flagford, there remains a further 22km of UGC for use.

The 220kV PUG option has been appraised, taking account of the fact that any additional UGC up to the maximum will have a different environmental impact. The actual location and length of a proposed mid-section UGC will determine the final impacts and likelihood of residual effects.

The main environmental impact appraised is the landscape/visual impacts and effects that will be generated by the predominantly OHL route and substations. At design stage, the route selection process will eliminate or minimise the impact and effect of the proposed OHL on settlements, primarily by avoidance. However, given the dispersed nature of the rural population, further mitigation will be challenging and there is a significant localised residual effect in these areas.

There will be temporary disruption associated with construction but, as most of the construction work will be off road and remote from dwellings, it is expected that the impact will be low and will be mitigated with the appropriate construction management plan.

From a technical perspective a 220kV HVAC OHL with partial undergrounding has added complexity as a result of the increased component parts. The report also notes that the use of an UGC at various points along the route of a predominantly OHL, particularly mid-span, is an untried technology on the Irish system, although it has been used in other European networks.

On the basis of the economic analysis presented, the total present value of the 220kV HVDC OHL option amounts to €207.4 million. The total present value of the 220kV HVDC PUG option amounts to €249.0 million.

8.4 SUMMARY OF OPTION CAPACITY

As the Irish economy grows and the transmission system develops to meet growing demand, the LSI may increase. Further interconnections with greater capacity than the current interconnections, typically expected to be rated at 700-750MVA, would also increase the LSI in the future. Therefore, there is a reasonable probability in the short to medium term of the LSI increasing to c.700-750MVA. This would enable flows exceeding 500MVA on the Grid West circuit.

A summary of the capacity of the network for each of the options is given in the table below. Depending on the LSI applicable, the amount of surplus capacity available to accommodate any future generation seeking to connect in the region would vary for each option.

	Do Nothing Option Capacity (MVA)	HVDC UGC Option Capacity (MVA)	400kV OHL Option Capacity (MVA)	220kV OHL Option Capacity (MVA)	220kV PUG Option Capacity (MVA)
Capacity (Upgraded 110kV Network)	190	190	190	190	190
Capacity (Grid West Project)	0	500	1,580	600	600
Total Capacity	**190**	**690**	**1,770**	**790**	**790**
Total Available Capacity (LSI of 500MVA)	190	690	690	690	690
Total Available Capacity (LSI of 750MVA)	190	690	940	790	790
Bellacorick Subgroup	**-600**	**-600**	**-600**	**-600**	**-600**
Surplus Capacity (LSI of 500MVA)	-410	90	90	90	90
Surplus Capacity (LSI of 750MVA)	-410	90	340	190	190
% of Future Generation (2,000MW) Accommodated by Surplus	**0%**	**5%**	**5-17%**	**5-10%**	**5-10%**

Table 8-1 Summary of the Option Capacity (MVA) Assuming No Additional Infrastructure being Built.

At present, there is approximately 2,000MW of generation awaiting processing in Co. Mayo. The development of even part of this could drive the requirement for a second circuit from the north Mayo area back to the EHV network (most likely Cashla 220kV substation). If this was to occur, the full capacity of any of the options above could then be realised, as the second circuit would ensure no loss of generation in the case that there was a temporary loss of one of the circuits.

	HVDC UGC Option Capacity (MVA)	400kV OHL Option Capacity (MVA)	220kV OHL Option Capacity (MVA)	220kV PUG Option Capacity (MVA)
Capacity (Upgraded 110kV Network)	190	190	190	190
Capacity (Grid West Project)	500	1,580	600	600
Total Available Secure Capacity (with 2nd Circuit)	**690**	**1,770**	**790**	**790**
Bellacorick Subgroup	**-600**	**-600**	**-600**	**-600**
Surplus Secure Capacity	90	1,170	190	190
% of Future Generation (2,000MW) Accommodated by Surplus	**5%**	**59%**	**10%**	**10%**

Table 8-2 Summary of the Option Capacity (MVA) Assuming Further Infrastructure is Built.

The transfer capability of each option has to be viewed in terms of the current need, its available rating and surplus capacity available to accommodate future needs.

SUMMARY OF ENVIRONMENTAL ASSESSMENTS

CRITERIA	HVDC UGC OPTION			400kV HVAC OHL OPTION			220kV HVAC OHL OPTION			220kV HVAC PUG OPTION		
	Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)	Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)	Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)	Significance of Impact/Effect	Ease of Mitigation	Likelihood of Residual Effect (following mitigation)
Biodiversity, flora and fauna;												
Soil												
Landscape and Visual												
Cultural Heritage												
Settlements and Communities												
Climatic Factors												
Material Assets												
Recreation and Tourism												
Noise [1]												
Water[2]												
Air Quality[2]												
Traffic and Noise [2]												

Notes:
1. During operation
2. During construction

More significant
Difficult to Mitigate
More Likely

Less significant
Possible to Mitigate
Less Likely

Table 8-3 Environmental Analysis of Options

SUMMARY OF TECHNICAL ASSESSMENTS

	HVDC UGC OPTION (500MVA)	400kV HVAC OHL OPTION (1,580MVA)	220kV HVAC OHL OPTION (600MVA)	220kV HVAC PUG OPTION (600MVA)
Compliance with all relevant safety standards				
Compliance with system reliability and security standards				
The average failure rates during normal operation, average repair times and availabilities of the main elements of each option				
The expected impact on reliability of supply of unavailability of the development				
Implementation timelines				
The extent to which future reinforcement of, and/or connection to, the transmission network is facilitated				
Risk of untried technology				
Compliance with good utility practice				

More difficult
High Risk

Less difficult
Low Risk

Table 8-4 Technical Analysis of Options

* Note: The rating of HVDC circuits is generally quoted in MW, however for ease of comparison we have assumed unity power factor and displayed the rating in MVA, to enable a better comparison with the HVAC options

SUMMARY OF COST ASSESSMENTS

ITEM	HVDC UGC OPTION (500MVA) Present Value (€ M)	400kV HVAC OHL OPTION (1,580MVA) Present Value (€ M)	220kV HVAC OHL OPTION (600MVA) Present Value (€ M)	220kV HVAC PUG OPTION (600MVA) Present Value (€ M)
Pre-Engineering Costs	16.1	16.1	16.1	16.1
Project Implementation Costs				
Overhead Line	7.5	100.2	84.5	62.8
Stations	120.9	38.5	33.4	33.4
Underground Cable	145.6	15.5	15.5	58.3
Reactive Compensation	0.0	3.6	3.6	13.4
Other	47.0	17.6	15.9	14.4
Project Life-Cycle Costs				
Cost of Losses	9.0	6.1	16.0	14.5
O&M	65.2	2.1	2.2	2.9
Decommissioning & Replacement	3.9	0.0	0.0	0.0
Cost to SEM from Development Unavailability (Reliability)				
Cost of Unplanned Outages	11.0	0.1	0.1	3.8
Cost of Planned Outages	11.6	4.2	4.2	10.5
Contingency Cost Provisions				
Pre-Engineering Costs	0.4	0.4	0.4	0.4
Project Implementation Costs	32.1	17.5	15.3	18.2
O&M	6.5	0.2	0.2	0.3
Decommissioning & Replacement	0.0	0.0	0.0	0.0
TOTAL	**476.8**	**222.1**	**207.4**	**249.0**
Cost per MVA of Capacity	**0.954**	**0.141**	**0.346**	**0.415**

Table 8-5 Present Value of Costs

9. NEXT STEPS

In addition to providing an opinion to the Minister for Communications Energy and Natural Resources on the completeness, objectivity and comparability (underground with overhead) of the studies/reports undertaken, the IEP has also been tasked with overseeing the publication by EirGrid of these studies/reports prior to EirGrid proceeding to public consultation on the project.

Following submission of this report to the IEP, EirGrid will be available to engage with the Panel to provide any further information, clarification or additional studies requested.

Subject to EirGrid satisfactorily addressing any issues raised by the IEP, and on the provision of a positive opinion to the Minister, EirGrid propose to submit this report for public consultation.

In line with the outcome of EirGrid's Review of its Consultation Process published in December 2014, further material will be provided to ensure the information contained in this report is presented to the public in an accessible manner. This round of public consultation will also incorporate other improvements in EirGrid's public consultation process as set out in the Review document.

Subject to the provision of a positive opinion by the IEP, the following indicative plan is expected:

- Q2/3 Public consultation on the options; and
- Decision on preferred option and public consultation on a specific route.