North-South 400 kV Interconnection Development

An Bord Pleanála Reference: PCI001

Environmental Impact Statement

Volume 3B (DRAFT)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

The following appendices are contained in separate Volume titled ‗**Volume 3B – Appendices'**

FIGURES

The following figures are contained in separate Volume titled **‗Volume 3B – Figures’**

EXPLANATION OF TECHNICAL TERMS AND ABBREVIATIONS

Term	Explanation
AA	An appropriate assessment (AA) is an obligation under Article 6(3) of the EU Habitats Directive 92/43/EEC: –*Any plan or project not directly connected with or necessary to the management of the site [a Natura 2000 site] but likely to have a significant effect thereon, either individually or in combination with other plans or projects shall be subject to appropriate assessment of its implications for the site in view of the site‟s conservation objectives".*
AADT	Annual Average Daily Traffic
ABP (The Board)	An Bord Pleanála
AC	Alternating Current
ACA	Architectural Conservation Area: A place, area, group of structures or townscape that is of special architectural, historical, archaeological, technical, social, cultural, or scientific, interest, or that contributes to the appreciation of a Protected Structure.
ACGIH	American Conference of Governmental Industrial Hygienists
ACSR	Actual Cross Section of a Typical Conductor
AEOS	Agricultural Environmental Options Scheme
AHO	Archaeological Heritage Objectives
AIMD	Active Implantable Medical Device
AIS	Air Insulated Switchgear
ALS	Amyotrophic Lateral Sclerosis ALS
An Foras Taluntais	The Agricultural Institute
AOD	Above Ordnance Datum
AOD	Angle of Deviation
APG	Austrian Power Grid Company
AR5	The Inter Governmental Panel on Climate Change (IPCC) *Climate Change 2013 - Physical Science Basis,* referred to as the *Fifth Assessment Report (AR5)*.
ASI	Archaeological Survey of Ireland
ASSI	Areas of Special Scientific Interest
Bay	A bay is a connection point to a busbar, and comprises switchgear and measurement equipment.
BAP	Biodiversity Action Plan
BGL	Below Ground Level
Biodiversity	Word commonly used for biological diversity and defined as assemblage of

Term	Explanation
	living organisms from all habitats including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part.
Birds Directive	Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.
The Board	An Bord Pleanála (unless otherwise clarified)
BOD	Biological Oxygen Demand
BPA	Bonneville Power Administration
BS	British Standard
CA	Competent Authority
CAFE	Clean Air for Europe
CBSA	Cross Border Study Area
CDHS	California Department of Health Services
CDP	County Development Plan
CEMP	Construction and Environmental Management Plan
CENELEC	European Committee for Electrotechnical Standardization
CER	Commission for Energy Regulation
CEU	Council of Europe
CGS	County Geological Sites
CH4	Methane
CHS	Cultural Heritage Sites
Circuit	A line or cable, including associated switchgear, which carries electrical power.
CMSA	Cavan-Monaghan Study Area
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Conductors	High capacity, high strength standard cable / wire
CIRIA	*Construction Industry Research and Information Association*
Constraint	A constraint can be described as any physical, environmental, topographical, socio-economic or other feature or condition that may affect the location, development or other aspect of a proposal.
Corine	Coordination of Information on the Environment: Dataset created from satellite imagery that represents different cover / land use classifications throughout Europe.
cSAC	candidate Special Area of Conservation
CRED	Carrickmacross Rural Electoral Division
CRED	Castleblayney Rural Electoral Division
CRFRAM	Catchment Flood Risk Assessment and Management Studies
CRTN	Calculation of Road Traffic Noise

Term	Explanation
CSO	Central Statistics Office
DAFM	Department of Agriculture, Food & the Marine
DAHG	Department of Arts Heritage and the Gaeltacht
DAS	Disadvantaged Areas Payment Scheme
dB	Decibel
DC	Direct Current
DCENR	Department of Communications, Energy and Natural Resources
DCMNR	Department of Communications, Marine and Natural Resources
DECC	UK Department of Energy and Climate Change
DED	District Electoral Division
Demand	Peak demand figures refer to the power that must be transported from grid connections generation substations to meet all customers' electricity requirements. These figures include transmission losses.
DETI	Northern Ireland Department of Enterprise, Trade and Investment
DMRB	Design Manual for Roads and Bridges
DoEHLG	Department of Environment, Heritage, & Local Government
DSO	Distribution System Operator
Earth / ground wire	Wire installed above the live conductors at the top of a tower to minimise the likelihood of direct lightning strikes to conductors.
EC	European Commission
EC	European Community
ECoW	Ecological Clerk of Works
EEC	European Economic Community
EFHRAN	European Health Risk Assessment Network on Electromagnetic Fields Exposure.
EHC	Environmental Health Criteria
EHS	Electromagnetic Hypersensitivity
EHV	Extra High Voltage, in this EIS means greater than 330 kV
EIA	Environmental Impact Assessment: An examination, analysis and evaluation carried out by the Board that shall identify, describe and assess in an appropriate manner, in accordance with Articles 4 to 11 of the Environmental Impact Assessment Directive, the direct and indirect effects of a proposed development. EIA is the process by which the anticipated effects on the environment of a proposed development or project are measured as required under Directive (85/337/EEC) as amended.

Term	Explanation
EIA Directive	Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (codification).
EirGrid	The statutory electricity Transmission System Operator (TSO)
EirGrid Roadmap	EirGrid's development framework for projects under the Grid25 strategy
EIS	Environmental Impact Statement: A statement of the effects, if any, which the proposed development, if carried out, would have on the environment and shall include the information specified in Annex IV of the EIA Directive.
ELF	Extremely Low Frequency
EMF	Electric & Magnetic Fields
EMI	Electromagnetic Interference
ENTSO-E	European Network of Transmission System Operators for Electricity
EP	European Parliament
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPUK	Environment Protection UK
ES	Environmental Statement (required pursuant to the laws of Northern Ireland)
ESB	Electricity Supply Board
ESBI	ESB International
ESBNG	ESB National Grid
ESBNL	ESB Networks Limited
ETS	Emission Trading Scheme
EU	European Union
European Site	European site: A candidate Site of Community Importance, a Site of Community Importance, a candidate Special Area of Conservation, a Special Area of Conservation, a Candidate Special Protection Area, and a Special Protection Area.
Fauna	All animal life occurring in the area
FDI	Foreign Direct Investment
Flora	All plant life occurring in the area
Franklin tip	Lightning rod
FRR	Final Re-evaluation Report
GAA	Gaelic Athletic Association
GDA	Greater Dublin Area (including County Meath)
GDSDS	*Greater Dublin Strategic Drainage Study*

Term	Explanation
Geo-directory Data	Dataset which provides spatial and attribute information of the location of all buildings in Ireland.
GHz	Gigahertz
GIL	Gas Insulated Transmission Lines
GIS	Gas Insulated Switchgear
GIS	Geographic Information System: A geographic information system which captures, stores, analyses, manages, and presents data that is linked to location.
GPS	Global Positioning System
Grid	A meshed network of high voltage lines, cables and substation nodes (400 kV, 220 kV and 110 kV) for the transmission of bulk electricity supplies around Ireland. The grid, electricity transmission network, and transmission system are used interchangeably in application documents.
GSI	Geological Survey of Ireland
Guarding Positions	Where a conductor is to be strung over roads, and possibly river locations, protection will be erected prior to the commencement of stringing locations. These ‗guarding‘ positions and the protection will be in the form of guard poles, scaffolding or a telescopic handler.
GWDTE	Groundwater Dependent Terrestrial Ecosystem
ha	Hectares (100m x 100m)
Habitat	A habitat is an ecological or environmental area that is inhabited by a particular animal and plant species. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and it utilised by) a species.
Habitats Directive	Council Directive 92/43/EC of 21 May 1992 on the conservation of natural habitats and wild fauna and flora.
HCN	Health Council of the Netherlands
HGV	Heavy Goods Vehicle
HPA	Health Protection Agency
HSA	Health & Safety Authority
HV	High Voltage, in this EIS means greater than 110kV
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
Hz	Hertz, unit of frequency
IAA	Irish Aviation Authority
IARC	International Agency for Research on Cancer

Term	Explanation
ICD	Implantable Cardioverter Defibrillators
ICES	International Committee on Electromagnetic Safety
ICHEC	Irish Centre for High Engineering Computing
ICNIRP	International Commission on Non-Ionising Radiation Protection
IEC	International Expert Commission
IEEE	Institute of Electrical and Electronics Engineers
IEEM	Institute of Environmental & Ecological Management
IFA	Irish Farmers Association
IFC	Irish Folklore Commission
IFI	Inland Fisheries Ireland
IGH	Irish Geological Heritage
IGI	Institute of Geologists of Ireland
INP	Inertial Navigation System
IP	Implementation Programme
IPC	Infrastructure Planning Commission
IPPC	Irish Governmental Panel on Climate Change
ISLES	Irish-Scottish Links on Energy Study
ISO	International Organisation for Standardisation
I-WEBS	Irish Wetland Bird Survey
kHz	Kilohertz (one thousand hertz)
km	Kilometre (one thousand metres)
kV	Kilovolt (One thousand volts)
kV/m	Kilovolts Per Meter
LCA	Landscape Character Area
LCA	Landscape Character Assessment
LCC	Line Commutated Converters
LiDAR	Light Detection and Ranging: LiDAR is a remote sensing technology that uses laser scanning to collect height and elevation data.
Line Design	Location and design of transmission infrastructure (e.g. tower positions and types)
LV	Low Voltage, less than 1000 volts
L_{Aeq}	The A-weighted equivalent continuous steady sound level during the measurement period and effectively represents an average ambient noise value.
L_{Amax}	The maximum A-weighted sound level measured during the measurement period.

Term	Explanation
L_{Amin}	The minimum A-weighted sound level measured during the measurement period.
L_{A10}	The A-weighted sound level that is exceeded for 10% of the measurement period and is used to quantify road traffic noise.
L_{A50}	The A-weighted sound level that is exceeded for 50% of the measurement period and in this evaluation is used to quantify noise from overhead power lines.
L_{A90}	The A-weighted sound level that is exceeded for 90% of the measurement period and is used to quantify background noise level.
m	Metre
mbgl	Metres below ground level
mG	Milligauss, Gauss is the unit of measurement for magnetic field typically in use in North America. The corresponding unit of measurement used in Europe is tesla (T). One gauss is equal to 100 microtersla (µT).
MHz	Megahertz (one million hertz)
MLCA	Meath Landscape Character Assessment
MLCA	Monaghan Landscape Character Assessment
MPE	Maximum Permissible Exposures
MSA	Meath Study Area
MVA	Megavolt-Amperes
MW	Megawatt (One million Watts)
Natura 2000	Natura 2000 sites are part of a coherent European ecological network of special areas of conservation designated under Article 3 of the Habitats Directive (92/43/EEC) and includes Special Areas of Conservation (SAC) and Special Protection Areas (SPA).
NBDC	National Biodiversity Data Centre
NEEAP	National Energy Efficiency Action Plan
NGR	National Grid Reference
NH_3	Ammonia
Natural Habitat	Natural Habitats are terrestrial or aquatic areas distinguished by geographic, abiotic (i.e. inanimate) and biotic features, whether entirely natural or semi-natural.
Nature Reserves	Nature reserves are chosen from among the very best examples of our wildlife, habitats and geology. They contain a wide range of species, communities and geology their recognition by Ministerial order designation is a public recognition by the State Government of their importance.

Term	Explanation
NEPP	North East Pylon Pressure
NESA	North East Study Area
NGR	National Grid Reference
NHA	Natural Heritage Area: Natural Heritage Areas are designated by Ministerial order and include sites that may be significant in biological terms for species, communities and habitats or of interest for landforms, geological or geomorphological features or for their diversity of natural attributes. In Ireland the basic designation for wildlife is the Natural Heritage Area (NHA). This is an area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection.
NHA	Natural Heritage Area
NI	Northern Ireland
NIAH	National Inventory of Architectural Heritage
NIAUR	Northern Ireland Authority for Utility Regulation
NIE	Northern Ireland Electricity
NIEA	Northern Ireland Environment Agency
NIS	Natura Impact Statement: Natura Impact Statement means a statement, for the purposes of Article 6 of the Habitats Directive, of the implications of a proposed development, on its own or in combination with other plans or projects, for one or more than one European site, in view of the conservation objectives of the site or sites. It is the output from the Appropriate Assessment process, required under the EU Habitats Directive 92/43/EEC.
NISRA	Northern Ireland Statistics & Research Agency
NITB	Northern Ireland Tourism Board
NMI	National Museum of Ireland
NMA	National Monuments Act
NMI	National Museum of Ireland
NMS	National Monuments Service
NNA	National Normative Aspects
NOx	Nitrous Oxide
NPWS	National Parks and Wildlife Service: The NPWS is part of the Department of Arts, Heritage and Gaeltacht and is charged with the conservation of a range of habitats and species in Ireland.
NRA	National Roads Authority
NREAP	National Renewable Energy Action Plan
NRPB	National Radiological Protection Board of Great Britain

Term	Explanation
NSL	Noise Survey Level
N-S Link	North-South Link
NTC	Net Transfer Capacity
NUI	National University of Ireland
NYPSC	New York Public Service Commission
OHL	Overhead Line
OPGW	Earth / ground wire or shield wire with embedded optical fibres
OPW	Office of Public Works
OSI	Ordnance Survey of Ireland
PAC	Planning Appeals Commission
PAH	Polycyclic Aromatic Hydrocarbons
PLS-CADD	Specialised computer aided design programme used for full 3-D design of overhead lines.
PM_5	Particulate Matter 5
PM_{10}	Particulate Matter 10
pNHA	Proposed Natural Heritage Area
Power Flow	The flow of ‗active' power is measured in Megawatts (MW). When combined with the flow of ‗reactive power', which is measured in Mvar, the resultant overall power flow is measured in MegaVolt-Amperes (MVA).
PPP	Public-Private Partnership
PRR	Preliminary Re-evaluation Report
PPSR	Preferred Project Solution Report
PPV	Peak Particle Velocity
Ramsar Convention/Site	The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The list of Ramsar sites in Ireland includes wetlands that are considered to be of international importance under the Ramsar Convention.
Raster	A data structure representing a generally rectangular grid of pixels, or points of colour, viewable via a monitor, paper, or other display medium.
RBD	River Basin District - Administrative area for coordinated water management, composed of multiple river basins (or catchments), designated pursuant to the requirements of the Water Framework Directive.
Receptor	Any element of the environment which is subject to impact.
RES	Renewable Energy Sources
RFC	Ration to Flow Capacity Value
RMP	Record of Monuments and Places

Term	Explanation
RPA	Registered Protected Areas
RPS	Record of Protected Structures
RSA	Road Safety Authority
SAC	Special Areas of Conservation: SACs are sites that have been designated by the Minister as a special area of conservation pursuant to Article 4, paragraph 4 of the European Habitats Directive (92/43/EEC). They have been designated because of a possible threat to the special habitats or species which they contain.
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SEA	Strategic Environmental Assessment: Requirement for assessment of Plans the effects of certain Plans and Programmes on the environment (pursuant to the EU SEA Directive 2001/42/EC).
SEAI	Sustainable Energy Authority of Ireland
SEM	Single Electricity Market
SEMO	Single Electricity Market Operator
Sensitivity	The potential of a receptor to be significantly changed
SIA	Strategic Infrastructure Act
SID	Strategic Infrastructure Development: Section 182A of the *Planning and Development Act 2000* (as amended) defines strategic infrastructure development to include development comprising, or for the purposes of electricity transmission, including the transport of electricity by means of a high voltage line where the voltage would be 110 kilovolts or more, or an interconnector, requiring direct application for statutory approval to An Bord Pleanála.
SMR	Sites and Monuments Record (predecessor of RMP)
SO_2	Sulphur Dioxide
SONI	System Operator of Northern Ireland
SPA	Special Protection Area
SPS	Single Payment Scheme
SSM	Swedish Radiation Protection Authority
Stringing	The term used to describe the installation of electricity conductors or wires on the overhead line support structures. The conductors are ‗strung' from one structure to the next.
Substation	A substation is the location on the grid where equipment is placed in order to safely change the electricity from higher transmission voltages to lower voltages that are appropriate for use by end-customers. It does this by using equipment known as transformers. They ‗transform ‗the electricity from one

Term	Explanation
	voltage to another and they represent the means through which electricity is drawn from the transmission system. A substation also acts as a point of common connection of a ‗node' for several circuits. It is helpful to think of them like an intersection on a road network. Power comes in on one circuit (road) and can be redirected onto another circuit. This is achieved by using other equipment in the substation such as switches, circuit breakers and other apparatus.
SuDS	Sustainable Urban Drainage System
SUR	Standardised Unemployment Rate
SV	Scenic View
SVC	Static Var Compensator
Switchgear	A combination of electrical disconnects and / or circuit breakers used to isolate equipment in or near an electrical substation.
SWDTE	Surface Water Dependent Terrestrial Ecosystem
TAO	Transmission System Owner: The owner of the assets that form the transmission system.
TCD	Trinity College Dublin
TCS	Tourism Content System
TEPCO	Tokyo Electric Power Company of Japan
TOC	Table of Contents
Transformer	An item of equipment connecting other electrical equipment at two different nominal voltages.
Transposition	Describes the changing of the spatial arrangement of the conductors on a transmission line relative to each other for the purpose of improving the operating performance of the transmission line.
TRL	Transport Research Laboratory
TRM	Transmission Reliability Margin
TSO	Transmission System Operator
TTC	Total Transfer Capacity
TYNDP	Ten Year Network Development Plan
µT	Microtesla – where tesla (T) is the unit of measurement for magnetic field strength and 1T is equal to 1,000,000µT.
UAA	Utilisable Agricultural Areas
UCC	University College Cork
UCD	University College Dublin
UGC	Underground Cable
UK	United Kingdom
UNESCO	United Nations Educational Scientific and Cultural Organisation

Term	Explanation
VEM	Visual Envelope Map
VOM	Volatile Organic Map
V/m	Volt Per Meter
VSC	Voltage Sourced Converter
WFD	Water Framework Directive (2000/60/EEC): Water Framework Directive (WFD) is European legislation that promotes a new approach to water management through river basin planning. It covers inland surface waters, estuarine waters, coastal waters and groundwater.
WHO	World Health Organisation
Working Swathe	Working area required to install transmission lines particularly for underground construction methodologies.
WWTP	Waste Water Treatment Plant
XLPE	Cross Linked Polyethylene
ZTV	Zone of Theoretical Visibility
ZVI	Zone of Visual Influence

1 INTRODUCTION

1.1 CONTEXT OF THE PROPOSED DEVELOPMENT

1.1.1 Introduction

1 EirGrid plc (EirGrid) and System Operator Northern Ireland (SONI) (the respective applicants)[1] are jointly planning a major cross-border electricity transmission development between the existing high-voltage transmission networks of Ireland[2] and Northern Ireland. The overall interconnection project (which is termed the ‗proposed interconnector‘[3], for the purposes of this Environmental Impact Statement (EIS)) is a 400 kV overhead line (OHL) circuit linking the existing 400 kV substation in Woodland, County Meath with a planned substation in Turleenan, County Tyrone; it will provide a second high capacity electricity interconnector between Ireland and Northern Ireland. The existing interconnector, a 275 kV double circuit OHL, connects the existing Tandragee and Louth substations. The proposed interconnector is planned to traverse the counties of Tyrone, Armagh, Monaghan, Cavan and Meath.

2 Given its location across two jurisdictions, the proposed interconnector consists of two related and complementary developments, as follows:

1) A development being proposed by SONI for that portion of the overall interconnection project located in Northern Ireland (the SONI proposal); and

2) A development being proposed by EirGrid for that portion of the overall interconnection project located in Ireland (i.e. in counties Monaghan, Cavan and Meath), which forms the subject matter of this application for planning approval. The application is titled the ‗North-South 400 kV Interconnection Development‘ or ‗the proposed development‘ for the purposes of this Environmental Impact Statement (EIS) (the EirGrid proposal).

3 **Section 1.1.3** describes the evolution of the relevant planning applications for these two jurisdictional elements of the proposed interconnector.

---

[1] The planning of that portion of the proposed interconnector within Northern Ireland was originally undertaken by NIE. However, NIE was obligated by the European Commission to transfer its investment planning function (the ―Planning Function”) to SONI. The SONI transmission system operator licence (the ―Licence”) was amended on 28^{th} March 2014 to take account of the transfer of the Planning Function following a consultation process by the Northern Ireland Authority for Utility Regulation (NIAUR). The Licence amendments took effect on 30^{th} April 2014. Accordingly, responsibility for the pursuance of the planning application in respect of the proposed interconnector within Northern Ireland has been transferred from NIE to SONI.

[2] Often referred to as ‗Republic of Ireland‘ or ‗ROI‘.

[3] The term the ‗proposed interconnector‘ relates to the updating of the description of the interconnector in the 2009 *Tyrone-Cavan Interconnector Consolidated ES* and reflects the extension of the proposed interconnector to include the area between the location of the (previously proposed) substation in the vicinity of Kingscourt, County Cavan, and the existing substation at Woodland, County Meath, as described in this EIS. A full explanation of the historical development of the proposed interconnector is provided in **Section 1.1.3.**

4 The indicative alignment of the proposed interconnector, which will form part of the all-island transmission network, is illustrated by a dashed red line in **Figure 1.1**.

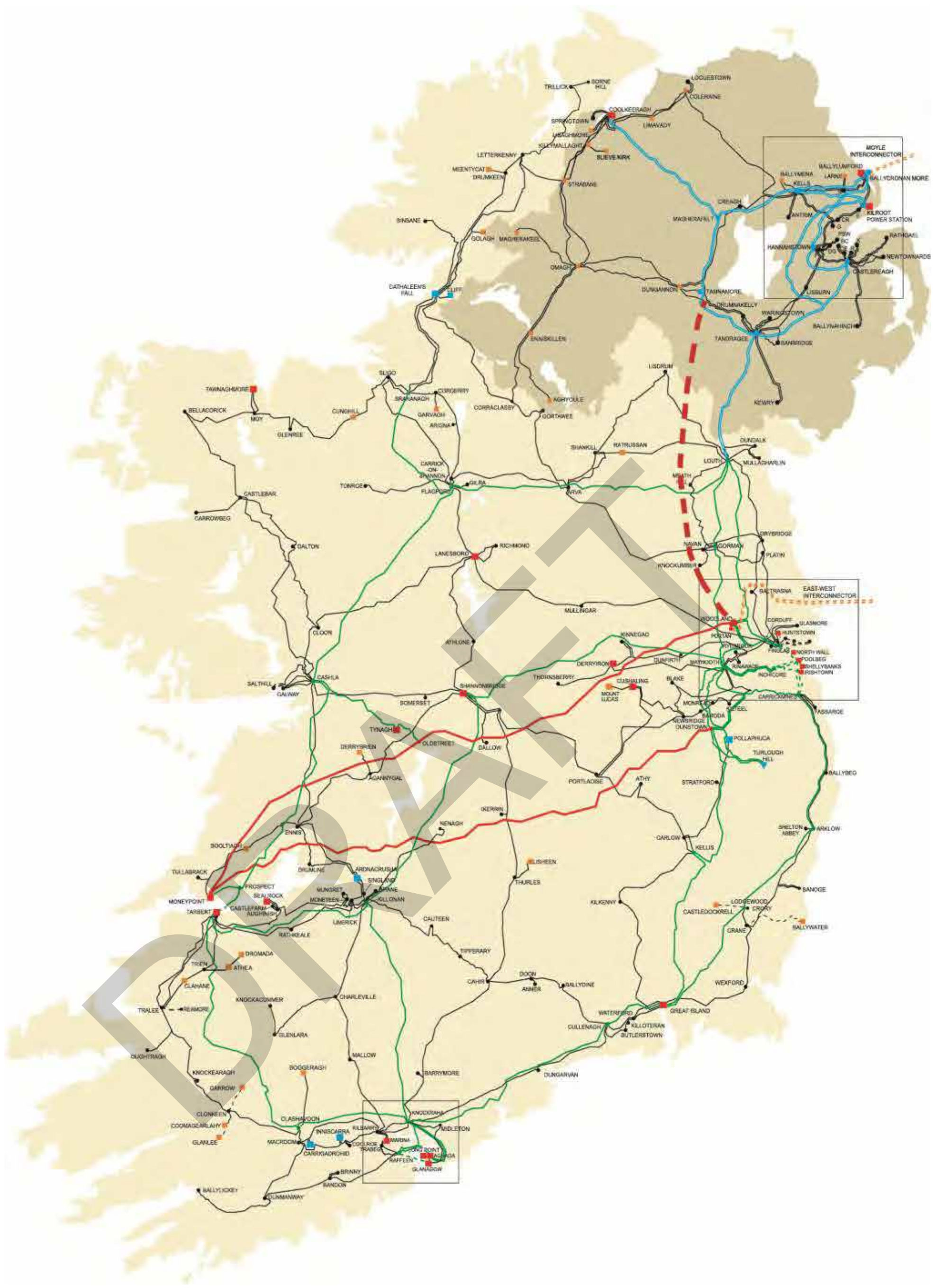


Figure 1.1: All-island Transmission Network

(The proposed interconnector is indicated in dashed red)

400 kV
275 kV
DC Interconnector
220 kV
110 kV

1.1.2 The Proponents of the Proposed Interconnector

1.1.2.1 EirGrid

5 With the enactment and coming into force[4] of the *Electricity Regulation Act, 1999* ('the 1999 Act'), the liberalisation of the electricity sector commenced. This liberalisation has been driven in large part by European directives – in particular Directives 96/92/EC,[5] 2003/54/EC[6] and 2009/72/EC. The 1999 Act established the Commission of Electricity Regulation (now the Commission for Energy Regulation (CER)) as the independent regulator of the electricity industry in Ireland. The liberalisation of the electricity industry has involved the separating of or unbundling of various functions which were once concentrated in the Electricity Supply Board (ESB). The function of Transmission System Operator (TSO) has been conveyed to EirGrid plc[7] (EirGrid), whilst the function of Distribution System Operator has been conveyed to ESB Networks Limited (ESBNL). The Transmission System Owner (TAO) is the ESB[8]. On June 29 2006, the CER issued a TSO Licence to EirGrid pursuant to Section 14(1)(e) of the 1999 Act, as inserted by Regulation 32 of the European Communities S.I. No. 445/2000 (Internal Market in Electricity) Regulations, 2000 ('the 2000 Regulations'). Thus, from July 1 2006, EirGrid has assumed the role of TSO.

6 Regulation 8(1)(a) of S.I. No. 445/2000 provides that EirGrid, as TSO, has the exclusive function to operate and ensure the maintenance of and, if necessary, develop a safe, secure, reliable, economical and efficient electricity transmission system. EirGrid also owns SONI Limited (SONI), the System Operator of Northern Ireland. The Single Electricity Market Operator (SEMO) is the market operator of the all-island wholesale electricity trading system. SEMO is a joint venture between EirGrid and SONI. EirGrid operates and develops the national electricity grid power system, providing services to all users of the electricity transmission system[9]. This includes all generators, suppliers, and high voltage customers.

---

[4] The *Electricity Regulation Act, 1999* came into force in February 2000.

[5] The 1999 Act and the *European (Internal Market in Electricity) Regulations*, 2000; The *European (Internal Market in Electricity) (Amendment) Regulations,* 2002; The *European (Internal Market in Electricity) (Amendment) Regulations*, 2003 were amongst the measures enacted / passed to give effect to this directive.

[6] The *European (Internal Market in Electricity) Regulations*, 2005, The *European (Internal Market in Electricity) Regulations*, 2006 and The *European (Internal Market in Electricity) (Electricity Supply Board) Regulations*, 2008 were amongst the measures enacted / passed to give effect to this directive.

[7] EirGrid is a public limited company established pursuant to Regulation 34 of the European Communities (Internal Market in Electricity) Regulations 2000 (S.I. No. 445/2000) and the licensed Transmission System Operator for Ireland pursuant to Section 14 of the Electricity Regulation Act, 1999.

[8] ESB is the licensed Transmission System Owner (TAO) for Ireland pursuant to Section 14 of the *Electricity Regulation Act, 1999.*

[9] The transmission network essentially refers to the higher voltage grid of 400 kV, 220 kV and 110 kV. The lower voltage distribution network is primarily developed as 38 kV, 20 kV or 10 kV infrastructure.

7 The ESB, a statutory corporation, is the licenced TAO in Ireland. The ESB owns the transmission system and is responsible for its construction and the execution of maintenance. However, EirGrid is responsible for making an application to An Bord Pleanála for planning approval.

8 The role of the TSO is as independent operator of the transmission system, thus ensuring a clear separation between the operation of the electricity transmission system from the companies that generate, distribute and sell electricity in Ireland.

1.1.2.2 System Operator Northern Ireland Ltd (SONI)

9 EirGrid plc and SONI are jointly planning a major cross-border electricity transmission development between the existing transmission networks of Ireland and Northern Ireland. The planning of that portion of the proposed interconnector within Northern Ireland was originally undertaken by NIE. However, NIE was obligated by the European Commission[10] to transfer its investment planning function (the “Planning Function”) to SONI. The SONI transmission system operator licence (the “Licence”) was amended on 28th March 2014 to take account of the transfer of the planning function following a consultation process by the Northern Ireland Authority for Utility Regulation (NIAUR). The Licence amendments took effect on 30th April 2014. Accordingly, responsibility for the pursuance of the planning application in respect of the proposed interconnector within Northern Ireland has been transferred from NIE to SONI.

10 Following the transfer of its planning function to SONI, NIE will continue to be responsible for the construction, ownership and maintenance of the transmission system in Northern Ireland. Subject to development consent being obtained for the proposed interconnector within Northern Ireland, NIE will be responsible for its construction, in accordance with said consents.

11 For the avoidance of doubt in this regard, any reference to NIE in the plans and particulars of this application for approval in relation to the proposed interconnector should now be understood as referring to SONI in the context of its newly acquired functions, which include the pursuance of the planning application in respect of the proposed interconnector within Northern Ireland. However, certain references to NIE within the application particulars refer to matters actually undertaken by NIE prior to the transfer of the planning function to SONI. These references include but are not limited to certain documents prepared by NIE in relation to the current application for development consent in respect of that portion of the proposed interconnector within Northern Ireland.

[10] In accordance with European Commission Decision of 12th April 2013 made pursuant to Article 3(1) of Regulation (EC) No. 714/2009 and Article 10(6) of Directive 2009/72/EC - United Kingdom (Northern Ireland) – SONI / NIE.

12 The NIAUR is responsible for regulating the ongoing operation of SONI and for protecting the long term interests of customers. NIAUR is, amongst other things, specifically required to promote effective competition between persons engaged in the sale or purchase of electricity through the Single Electricity Market (SEM) (see *Planning Report*, **Volume 2A** of the application documentation).

1.1.3 Overall Interconnection Project - Outline

13 As the proposed interconnector traverses a jurisdictional boundary, the project is required to be separated into its jurisdictional elements for the purposes of seeking statutory approval. In this respect, separate applications for development consent of those elements of the interconnection project within Ireland, and within Northern Ireland, have been submitted by the respective applicants to the relevant competent authorities in Ireland and Northern Ireland. The application in each jurisdiction is accompanied by an EIS and Environmental Statement (ES) respectively[11], prepared in accordance with the requirements of the EIA Directive and the respective applicable national legislation and guidelines.

14 This unavoidable separation of the proposed interconnector into its two jurisdictional elements does not diminish the extent of coordination and cooperation that has occurred, over many years, by the respective applicants in the progression of the overall interconnection project, and which, subject to development consent, will continue during the eventual construction and operation of the proposed interconnector. This issue is addressed in more detail in a *Joint Environmental Report* (**Volume 4** of the application documentation). In addition, all potential transboundary impacts of the EirGrid project have been set out in **Chapter 9** of this volume of the EIS.

15 In 2004, the Governments of Ireland and Northern Ireland, and their respective energy regulators, formally acknowledged and confirmed the need and intention to construct an additional interconnector between the two jurisdictions. This provided the regulatory context for the ESB National Grid (ESBNG) – now EirGrid - and NIE to jointly propose the construction of the major cross-border electricity interconnector linking the existing transmission networks of Ireland and Northern Ireland.

[11] The Environmental Statement that was submitted in Northern Ireland in 2013 was originally submitted by Northern Ireland Electricity (NIE). For the purposes of this EIS it will be referred to as the 'Consolidated ES'.

1.1.3.1 SONI Proposed Development

Tyrone–Cavan Interconnector Application (2009-present)

16 In December 2009, an application for the SONI proposal, defined as the ‗Tyrone-Cavan Interconnector', was submitted, to the Northern Ireland Planning Service for that portion of the proposed cross-border transmission infrastructure development located in Northern Ireland (Ref. O/2009/0792/F). This application was accompanied by an ES.

17 In August 2010, the Northern Ireland Environment minster referred the SONI proposal to the Planning Appeals Commission (PAC) for a public inquiry. Subsequently, further information was requested in respect of the application. Addenda to the ES were submitted in January 2011 and October 2011. The public inquiry commenced in March 2012 and, as at the date of this EIS, stands adjourned. At the public inquiry, the PAC made a number of requests for additional information with regard to the application. When adjourning the public inquiry, the PAC requested that a consolidated ES be prepared. In May 2013 a second application was submitted for planning permission for works associated with the construction of the main infrastructure under the 2009 application (Ref. 0/2013/0214/F). Subsequently a consolidated ES was submitted in June 2013. The 2013 ES assesses the environmental effects of both the main infrastructure works under the 2009 application and the associated works under the 2013 application.

18 The SONI proposal comprising that portion of the proposed interconnector occurring in counties Tyrone and Armagh is detailed below:

- The construction and operation of a new 275 kV / 400 kV (source) substation at Turleenan townland, north-east of Moy, County Tyrone;

- The construction and operation of two 275 kV terminal towers to enable connection of the Turleenan Substation to NIE‘s existing 275 kV OHL and the removal of one existing 275 kV tower;

- The construction and operation of a single circuit 400 kV overhead transmission line supported by 102 towers for a distance of 34.1km from the source substation (at Turleenan) to the border where it will tie into the future ESB network. The OHL will continue on into the Republic of Ireland with all further towers being promoted by EirGrid for placement within that jurisdiction. Because of the meandering nature of the border, the OHL will oversail a portion of land within the Northern Ireland townland of Crossbane for a short distance of 0.2km; and

- Associated works to include site levelling, site preparation works, modification of existing access points, construction of new access points, construction of new access lanes, construction of working areas, stringing areas, guarding, site boundary fencing and related mitigation works. Formation of access tracks and other associated works at the substation and at the tower locations.

1.1.3.2 EirGrid Proposed Development

Meath-Tyrone 400 kV Interconnection Development (2009-2010)

19 In December 2009, EirGrid submitted an application to An Bord Pleanála (the Board) for development consent for that portion of the proposed cross-border transmission infrastructure development located in counties Monaghan, Cavan and Meath (An Bord Pleanála Ref. VA0006). That application, known as the ‗Meath-Tyrone 400 kV Interconnection Development', was accompanied by an EIS. The scope of that development previously proposed by EirGrid primarily consisted of:

i. The continuation of the 400 kV single circuit OHL from the area where the circuit crosses the jurisdictional border in the townland of Lemgare, County Monaghan, to the existing 400 kV substation at Woodland, County Meath, traversing lands in counties Monaghan, Cavan and Meath;

ii. A new 400 kV substation in the townland of Moyhill, County Meath, in the vicinity of the intersection of the proposed north-south oriented transmission circuit with the existing east-west oriented 220 kV OHL between Flagford and Louth Substations;

iii. The associated diversion of the existing Flagford-Louth 220 kV OHL into the planned Moyhill Substation, thereby providing a connection between the two transmission circuits; and

iv. Associated works required in the existing Woodland Substation to accommodate the proposed 400 kV circuit.

20 During the period January-March 2010, An Bord Pleanála invited written submissions from identified prescribed bodies, other stakeholders, members of the public and all other parties. In May 2010, An Bord Pleanála commenced an Oral Hearing in respect of the proposed development. However, in June 2010, the EirGrid application was withdrawn. As such, the previous application for planning approval made by EirGrid was not determined by the Board.

The Re-evaluation Process (2010-2013)

21 During the period since the withdrawal of the previous application for planning approval, EirGrid has undertaken a comprehensive re-evaluation of that portion of the proposed interconnector located between the existing substation at Woodland, County Meath and the border with

Northern Ireland. The re-evaluation process included a review of the previous application in order to ascertain whether the scope, content, conclusions of, and rationale for that development proposal remain applicable for the purposes of informing and shaping the current application for planning approval of the proposed development.

22 As part of this review process, EirGrid published a *Preliminary Re-evaluation Report* in May 2011, which concluded with the identification of an indicative line route within an emerging Preferred Route Corridor (refer to **Appendix 1.1**, **Volume 3B Appendices,** of the EIS). The *Preliminary Re-evaluation Report* was the subject of public consultation, in order to obtain feedback from landowners, stakeholders and members of the public, primarily in relation to any new issues arising, or new insights on aspects of the proposed development, subsequent to the withdrawal of the previous application for planning approval.

23 EirGrid has also considered documents issued since the publication of the *Preliminary Re-evaluation Report*, which are relevant to the overall re-evaluation process. These documents include the *Meath-Tyrone Report Review by the International Expert Commission August – November 2011,* January 2012; *Government Policy Statement on the Strategic Importance of Transmission and Other Energy Infrastructure,* July 2012; *Grid25 Implementation Programme* (*IP) 2011-2016* and accompanying *Strategic Environmental Assessment* (SEA) both May 2012; and EirGrid's *Project Development and Consultation Roadmap,* 2012.

24 The conclusions of these documents, and of feedback received in respect of the *Preliminary Re-evaluation Report*, are addressed in a *Final Re-evaluation Report* published in April 2013 (refer to **Appendix 1.2**, **Volume 3B Appendices,** of the EIS). The *Final Re-evaluation Report* concluded with the identification of an Indicative Line Route for the transmission circuit within an identified Preferred Route Corridor linking the high voltage networks of Ireland and Northern Ireland, to be located in counties Monaghan, Cavan and Meath. However, no significant detail regarding the specific location and siting of this Indicative Line Route was provided in the report.

25 Following on from the *Final Re-evaluation Report*, the *Preferred Project Solution Report* was published in July 2013 (refer to **Appendix 1.3**, **Volume 3B Appendices,** of the EIS); which provided detail regarding the Preferred Line Design for the proposed development. The Preferred Line Design is derived from the Indicative Line Route as identified in the *Final Re-evaluation Report*, and also included the identification of feasible locations for and design of, the planned transmission line infrastructure, such as tower positions, tower types and associated construction related details (e.g. temporary access tracks). The *Preferred Project Solution Report,* including the Preferred Line Design, was subject to public consultation, with a focus on landowner engagement particularly in respect of the specific siting of structures on lands. The

ultimate output of this process is the line design of the proposed development that is the subject of this application for planning approval.

The Proposed Development

26 The proposed development comprises that portion of the proposed interconnector occurring within Ireland in counties Monaghan, Cavan and Meath. The proposed development consists of the following elements:

i. A new single circuit 400 kV overhead transmission line (covering a distance of approximately 100.5km in the counties of Monaghan, Cavan and Meath) extending in a generally southerly alignment from a point at the jurisdictional border with Northern Ireland (in the townlands of Doohat or Crossreagh, County Armagh, and Lemgare, County Monaghan) to the townland of Bogganstown (Electoral District (ED) Culmullin), County Meath. In addition the proposed transmission line crosses the jurisdictional border with Northern Ireland at two points - from the townland of Lemgare, County Monaghan into the townland of Crossbane, County Armagh and back into the townland of Lemgare, County Monaghan. This transmission line comprises 299 No. new lattice steel support structures (ranging in height from approximately 26m to 43m over ground level), with associated conductors, insulators, and other apparatus.

ii. The addition of a new 400 kV circuit for approximately 2.85km along the currently unused northern side of the existing Oldstreet to Woodland 400 kV transmission line, extending eastwards from the townland of Bogganstown (ED Culmullin) to the existing ESB Woodland Substation, in the townland of Woodland, County Meath. The existing double circuit lattice steel support structures along this existing line range in height from approximately 52m to 61m over ground level.

iii. Associated works on a site of approximately 0.544ha within and immediately adjacent to the existing ESB Woodland Substation, in the townland of Woodland, County Meath to include: a western extension of the existing compound (of approximately 0.231ha) including associated modifications to the existing 2.6m high palisade boundary fence; the addition of electrical equipment and apparatus including circuit breaker, current transformers, inductive voltage transformers, pole disconnectors, pantograph disconnecting switches, surge arresters, support insulators and support insulator bars (all ranging in height from approximately 7.4m to 13.7m); gantry structures (approximately 28m); and a lightning monopole (approximately 28m); and all associated ancillary construction and site development works.

iv. An associated temporary construction material storage yard to be located in the townlands of Monaltyduff and Monaltybane, Carrickmacross, County Monaghan, on a site of approximately 1.42ha, including associated site works, new site entrance onto the L4700 Local Road, and associated 2.6m high boundary palisade fencing.

v. All associated and ancillary development (including permanent and temporary construction and excavation works).

27 It is necessary to evaluate the proposed development within a single EIS but, given the overall geographical extent of this linear development, it is considered appropriate to present that evaluation in two sections. This approach will facilitate review by the public concerned and other parties of that section of the project which is of most importance to them, rather than having to seek this information as part of a much larger study area. The two study areas are:

- **Cavan-Monaghan Study Area (CMSA):** previously termed Cross Border Study Area (CBSA) in the application for planning approval of the Meath-Tyrone 400 kV Interconnection Development. The CMSA is primarily situated between the jurisdictional border with Northern Ireland to the north and the area of the existing Flagford-Louth 220 kV overhead transmission line (west of Kingscourt, County Cavan) to the south.

- **Meath Study Area (MSA):** previously termed North East Study Area (NESA) in the application for approval of the Meath-Tyrone 400 kV Interconnection Development. The MSA is situated on a generally north-south axis between the area of the Flagford-Louth 220 kV overhead transmission line (west of Kingscourt, County Cavan) in the north and the existing Woodland 400 kV Substation in County Meath in the south.

28 The proposed development located within these two study areas comprises the following:

- **CMSA – New 400 kV Line:** The proposed development in the CMSA comprises a single circuit 400 kV overhead transmission circuit supported by 134 towers (Tower 103 to Tower 236) extending generally southwards from a point at the jurisdictional border with Northern Ireland (in the townlands of Doohat or Crossreagh, County Armagh, and Lemgare, County Monaghan) to the townland of Clonturkan, County Cavan for a distance of approximately 46km. It includes lands traversed by the conductor from the jurisdictional border to Tower 103 and from Tower 103 to Tower 236 inclusive and lands traversed by the conductor strung from Tower 236 to Tower 237 (the first tower on the MSA section of the proposed development).[12]

12 Between Tower 106 and Tower 107 the proposed transmission line crosses the jurisdictional border with Northern Ireland at two points - from the townland of Lemgare, County Monaghan into the townland of Crossbane, County Armagh and back into the

It also includes an associated temporary construction material storage yard to be located on a site of approximately 1.42ha in the townlands of Monaltyduff and Monaltybane, Carrickmacross, County Monaghan.

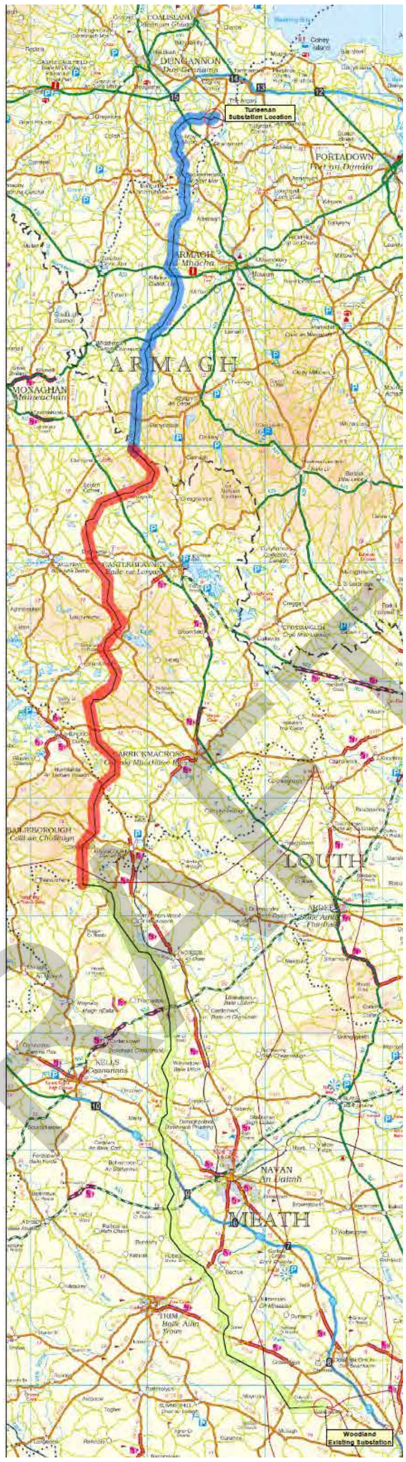
- **MSA – New and Existing 400 kV Line:** The proposed development in the MSA comprises a new single circuit 400 kV overhead transmission circuit supported by 165 new towers (Tower 237 to Tower 401) extending for a distance of approximately 54.5km from Tower 237 in the townland of Clonturkan, County Cavan to Tower 402 (an existing double circuit tower on the Oldstreet to Woodland 400 kV transmission line) in the townland of Bogganstown (ED Culmullin), County Meath.

  It includes the addition of a new 400 kV circuit for some 2.85km along the currently unused (northern) side of the existing double circuit 400 kV overhead transmission line (the Oldstreet to Woodland 400 kV transmission line) extending eastwards from Tower 402 in the townland of Bogganstown (ED Culmullin), County Meath to Tower 410 and the Woodland Substation in the townland of Woodland, County Meath.

  It also includes an extension to and works within the existing ESB Woodland Substation, in the townland of Woodland, County Meath.

29 The proposed interconnector within both jurisdictions is illustrated in **Figure 1.2**.

townland of Lemgare, County Monaghan. This results in a section of the span between Tower 106 and Tower 107 oversailing Northern Ireland. The oversail section forms part of the SONI proposal.



Preferred Route Corridor and Line Route within Northern Ireland

Preferred Route Corridor and Line Route within the CMSA

Preferred Route Corridor and Line Route within the MSA

Figure 1.2: The Proposed Interconnector

1.1.3.3 Project of Common Interest

30 Under Regulation (EU) No. 347/2013 of the European Parliament and of the Council of 17th April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No. 1364/2006/EC and amending Regulations (EC) No. 713/2009 and (EC) No. 715/2009, the European Commission has identified 12 strategic trans-European energy infrastructure priorities. The implementation of these energy infrastructure priorities by 2020 is essential for the achievement of the Union‘s energy and climate policy objectives. Significantly, one of the four ‗Priority Electricity Corridors‘ identified in Annex I to EU Regulation No. 347/2013 is:

> *―(2) North-South electricity interconnections in Western Europe („NSI West Electricity‟): interconnections between Member States of the region and with the Mediterranean area including the Iberian peninsula, notably to integrate electricity from renewable energy sources and reinforce internal grid infrastructures to foster market integration in the region.*
>
> *Member states concerned: Austria, Belgium, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Malta, Portugal, Spain, the United Kingdom."*

31 Article 7 of Regulation 347/2013 references the ‗priority status‘ of ‗Projects of Common Interest‗[13] (PCIs) in respect of ‗Permit Granting and Public Participation‘. It sets out:

> *―1. The adoption of the Union list shall establish, for the purposes of any decisions issued in the permit granting process, the necessity of these projects from an energy perspective, without prejudice to the exact location, routing or technology of the project.*
>
> *2. For the purposes of ensuring efficient administrative processing of the application files related to projects of common interest, project promoters and all authorities concerned shall ensure that the most rapid treatment legally possible is given to these files.*
>
> *3. Where such a status exists in national law, projects of common interest shall be allocated the status of the highest national significance possible and be treated as such in permit granting processes – and if national law so provides, in spatial planning – including those relating to environmental assessments, in the manner such treatment is provided for in national law applicable to the corresponding type of energy infrastructure."*

[13] ‗Project of Common Interest‘ means a project necessary to implement the energy infrastructure corridors and areas as set out in Annex 1 and which is part of the Union list of projects of common interest referred to in Article 3 of EU Regulation No. 347/2013.

32 The proposed interconnector was formally submitted by EirGrid as a PCI as part of the initial determination of projects for funding allocation through a new funding mechanism, *Connecting Europe Facility (CEF)*, which includes the provision of €5.85 billion for the period 2014-20 for improving the trans-European energy infrastructure to support the objectives of Regulation 347/2013.

33 European Commission Delegated Regulation 1391/2013, issued on 14 October 2013, identified the projects to be part of the first EU list of PCIs and described the process which led to the identification of such projects. The final list contained some 248 projects, which were listed as stand-alone PCIs or clusters of PCIs because of their interdependent or competing nature. The Annex to Delegated Regulation 1391/2013 under the heading –2. *Priority corridor North-South electricity interconnections in Western Europe ("NSI West Electricity")* lists at No. 2.13:

> *–Cluster Ireland – United Kingdom (Northern Ireland) interconnections, including one or more of the following PCIs:*
>
> *2.13.1. Ireland – United Kingdom interconnection between Woodland (IE) and Turleenan (UK – Northern Ireland)."*

1.2 REQUIREMENT FOR ENVIRONMENTAL IMPACT ASSESSMENT

1.2.1 European Legislation

34 The original Environmental Impact Assessment (EIA) Directive 85/337 and its three amending Directives[14] have been codified by the EIA Directive 2011/92/EU of December 2011. The EIA Directive aims to protect the environment, while ensuring approximation of national laws with regard to the assessment of the environmental effects of public and private projects. The means of achieving this objective are laid down in Article 2(1) of the Consolidated EIA Directive, which states that, before development consent is given, certain public and private projects likely to have significant environmental effects by virtue, *inter alia*, of their nature, size or location are subject to a requirement for development consent and an EIA. The EIA Directive harmonises the principles of EIA by introducing minimum requirements, in particular with regard to the type of projects that should be subject to assessment, the main obligations of developers, the content of the assessment and the participation of the competent authorities and the public.

[14] Directives 97/11/EC, 2003/35/EC and 2009/31/EC.

35 Thus, the EIA Directive specifies the classes of project for which an EIA will be required and the information which must be furnished in an EIS, prepared in connection with the proposed development. By virtue of the requirements of Article 4(1), all projects listed in Annex I to the EIA Directive must be made subject to an EIA in accordance with Articles 5 to 10. Accordingly, a mandatory EIA is required for, *inter alia*:

> *"20. Construction of overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15 km."*

36 In addition, pursuant to the provisions of Article 5 of the Consolidated EIA Directive, Member States are required to adopt the necessary measures to ensure that a developer supplies, in an appropriate form, the information specified in Annex IV. Thus, Annex IV to the Consolidated EIA Directive sets out the information which should be contained in an EIS.

37 Directive 2014/52/EU of 16th April 2014 amends Directive 2011/92/EU In order to strengthen the quality of the environmental impact assessment procedure, align that procedure with the principles of smart regulation and enhance coherence and synergies with other Union legislation and policies, as well as strategies and policies developed by Member States in areas of national competence. Member States have until 16 May 2017 to transpose the Directive into national legislation and apply the new rules.

38 Directive 92/43/EEC (the Habitats Directive), is a European Union legislative instrument in the field of nature conservation that establishes a common framework for the conservation of wild animal and plant species and natural habitats of Community importance and provides for the creation of a network of special areas of conservation (Natura 2000). Annex I (as amended) lists 233 European natural habitat types, including 71 priority habitats.

39 The Natura 2000 sites comprise Special Areas of Conservation (SACs) designated under the Habitats Directive (1992) and Special Protection Areas (SPAs) designated under the Birds Directive (1979). As yet, the existing candidate Special Areas of Conservation (cSACs) have not been formally designated as SACs; however, the same level of protection is afforded to cSACs as if those areas had been formally designated as SACs.

40 A key protection mechanism is the requirement to consider the possible nature conservation implications of any plan or project on the Natura 2000 site network before any decision is made to allow that plan or project to proceed. The Habitats Directive requires that any activities, plans or projects inside or outside a Natura 2000 site that are likely to have a significant effect on the conservation status of the site's features shall be the subject of an appropriate assessment on the implications for the site in view of the site's conservation objectives.

41 The Directive also requires that individual plans and projects cannot be viewed in isolation; consequently, any possible cumulative or interactive effects must be taken into account.

1.2.2 National Legislation

42 The obligations set out in the EIA Directives have been implemented into Irish law (for the purposes of an application for development consent for the proposed development) by the relevant provisions of the *Planning and Development Act 2000* (as amended) (the 2000 Act) and the *Planning and Development Regulations 2001* (as amended). The requirement in the EIA Directive, to the effect that an EIA is required for overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15km, is mirrored in Irish law pursuant to the provisions of section 176 of the *Planning and Development Act 2000* (as amended) and article 93 of, and Schedule 5 to, the *Planning and Development Regulations 2001* (as amended).

43 In addition, section 4 of the *Planning and Development (Strategic Infrastructure) Act 2006* inserted new sections into Part XI of the *Planning and Development Act 2000*, namely sections 182A to 182E, which relate to the provision of electricity transmission and gas infrastructure. Thus, section 182A of the 2000 Act, as inserted, provides that, where a person (the ‗undertaker‘) intends to carry out a development comprising or for the purposes of electricity transmission, an application shall be prepared and submitted to An Bord Pleanála for planning approval of the proposed development. Pursuant to the provisions of section 172 of the 2000 Act, as amended, An Bord Pleanála is required to carry out an EIA of any proposed development under Part XI of the Act where such proposed development is of a class specified in Schedule 5 to the *Planning and Development Regulations 2001* (as amended) which exceeds a quantity, area or other limit specified in that Schedule (which equates to Annex I to the EIA Directive). One of the classes of project listed in Schedule 5, Part 1 is:

> *"20. Construction of overhead electrical power lines with a voltage of 220 kilovolts or more and a length of more than 15 kilometres."*

44 Section 182A(9) of the 2000 Act confirms that ‗transmission‘ in relation to electricity shall be construed in accordance with Section 2(1) of the *Electricity Regulation Act 1999*. Section 182A clarifies that ‗transmission‘ shall also be construed as meaning the transport of electricity by means of (a) a high voltage line where the voltage would be 110 kV or more, or (b) an interconnector, whether ownership of the interconnector will be vested in the undertaker or not.

45 Accordingly, as the proposed development has a voltage of 400 kV and an overall length of approximately 103.5km the application for planning approval is made to An Bord Pleanála pursuant to section 182A and is accompanied by an EIS.

46 The EIS has also been undertaken having regard to *inter alia* the following documents:

- European Commission, *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (May 1999);
- European Commission, *Guidance on EIA Screening* (June 2001);
- European Commission, *Guidance on EIA Scoping* (June 2001);
- Environmental Protection Agency (EPA), *Guidelines on the information to be contained in Environmental Impact Statements* (March 2002);
- EPA, *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements)* (September 2003) and, in particular, guidelines given for Type 20 projects outlined in that document;
- European Commission, *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects* (May 2013);
- European Commission, *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* (April 2013); and
- A Scoping Opinion on the information to be contained in the EIS, prepared by An Bord Pleanála (see **Section 1.3.2** of this volume of the EIS and **Appendix 1.4**, **Volume 3B Appendices,** of the EIS).

47 Additional specialist guidance documents are referred to throughout this EIS.

48 In addition, the requirements of the Habitats Directive have, for the purposes of this application for development consent, been transposed into Irish law principally by the relevant provisions of Part XAB and section 182A(2) of the *Planning and Development Act 2000* (as inserted). In the circumstances of this application, EirGrid (as the applicant for consent for proposed development) is furnishing a Natura Impact Statement (NIS) to the competent authority in relation to the proposed development (see **Volume 5** of the application documentation).

49 The NIS will assist the Board to conduct an appropriate assessment (AA), including making a determination under Article 6(3) of the Habitats Directive, before development consent may be given, as to whether the proposed development would adversely affect the integrity of a European site.

1.2.3 Conclusion on Requirements for an Environmental Impact Assessment and Appropriate Assessment

50 Having regard to the provisions of the codified EIA Directive, the Habitats Directive and the relevant provisions of the *Planning and Development Act 2000* (as amended) and the *Planning and Development Regulations 2001* (as amended), it is considered that the proposed development requires an EIA and an AA to be conducted by the competent authority (in this case, An Bord Pleanála). In this context, both an EIS and NIS are required to be submitted with the application for planning approval to be made to the Board.

51 Whilst the terms EIA and EIS (and, to a lesser extent, AA and NIS) are often used interchangeably, it should be understood that both EIA and AA are ongoing iterative and participative processes of assessment undertaken by the competent authority, whilst an EIS and NIS are documents prepared by the developer, and submitted to the competent authority and which set a certain context for the EIA process carried out by the competent authority. Furthermore, submissions and observations made to An Bord Pleanála by all other parties in respect of the proposed development will also form part of the EIA and AA conducted respectively by the competent authority as part of the Board‘s ultimate decision-making process.

1.3 PREPARATION OF THE ENVIRONMENTAL IMPACT STATEMENT

1.3.1 Overview of Environmental Impact Assessment Process

52 There are various stages in the EIA process, which can be summarised as follows:

- The requirement for an EIS for the project is considered, having regard to the requirements of Annex I to the EIA Directive (mandatory EIA) and, in respect of Annex II projects, thresholds and other criteria (referred to as ‗screening‘);
- Once the obligation to prepare and submit an EIS is confirmed, the applicant may request an opinion (referred to as a ‗scoping opinion‘) from the competent authority as to what information should be contained in an EIS, and information may be provided by the applicant to assist the competent authority in formulating this opinion;
- Thereafter, the developer must submit an EIS which identifies and describes the direct and indirect effects on the environment of the proposed development;
- The environmental authorities, the public and, in the circumstances of this proposed development, affected Member States must be informed and consulted;

- The competent authority carries out an EIA in respect of an application for consent for proposed development, taking into consideration the: EIS, any further information furnished to the competent authority, and / or the Board, any submissions or observations made in relation to the environmental effects of the proposed development; results of consultations; and

- Once the decision of the competent authority is made, the competent authority shall inform the applicant for consent and the public of the decision (including information for the public on the procedures available to review the legality of the decision).

53 The stages of the EIA process are illustrated in **Figure 1.3**.

1.3.2 Preparation of the Environmental Impact Statement

54 The first stage in the process is to determine if an EIA is required for a particular project. This is referred to as screening. Guidance in relation to screening is provided in European Commission *Guidance on EIA Screening* (June 2001) and in the EPA G*uidelines on the information to be contained in Environmental Impact Statements (*March 2002).

55 A screening exercise was carried out for the proposed development. In this instance, an EIA is required, as the proposed development falls within the scope of Schedule 5, Part 1 of the *Planning and Development Regulations 2001* (as amended) which requires an EIA for projects involving ―*construction of overhead electrical power lines with a voltage of 220 kilovolts or more and length of more than 15 kilometres”*. This is set out in **Section 1.2.2**.

56 The second stage in the process, having considered the requirement for EIA, is to identify the information which should be included in, or the scope of, the EIS. The process of identifying issues to be included in the EIS (or ‗scoping‘) involves assessing the likely main effects of the development and, therefore, the topics on which the EIS should focus (including, considering alternatives and deciding which impacts are likely to occur and are likely to be significant, having regard to the nature, extent and location of the proposed development). Guidance in relation to scoping is provided in European Commission *Guidance on EIA Scoping* (June 2001) and in the EPA *Guidelines on the information to be contained in Environmental Impact Statements* (March 2002). An applicant can undertake an informal scoping exercise and consult with various parties in relation to this exercise, including the general public; however, scoping, as understood by section 182E of the 2000 Act (as amended), is carried out by the competent authority. The competent authority shall, on receipt of such a request from the applicant, provide such a scoping opinion in writing after consulting the prospective applicant and such bodies as may be specified by the Minister. The competent authority has the discretion to consult with any person who may, in the opinion of the competent authority, have

information which is relevant for the purposes of consultation in relation to the proposed development, before providing such a scoping opinion.

Project Preparation	The developer prepares the proposals for the report.
Notification to Competent Authority	In some MS there is a requirement for the developer to notify the CA, in advance of the application ofor the development consent. The developer may also do this voluntarily and informally.
Screening	The CA makes a decision on whether EIA is required. This may happen when the CA receives notification of the intention to make a development consent application, of the developer may make an application for a Screening Opinion. The Screening decision must be recorded and made public. **(See the guidance on Screening in EIA)** (Article 4).
Scoping	The Directive provides that developers may request a Scoping Opinion from the CA. The Scoping Opinion will identify the matters to be covered in the environmental information. It may also cover other aspects of the EIA process **(See the guidance on Scoping in EIA).** In preparing the opinion, the CA must consult the environmetal authorities (Article 5(2)). In some MS Scoping is mandatory.
Environmental Studies	The developer carries out studies to collect and prepare the environmental information required by Article 5 of the Directive **(See Appendix A)**.
Submission of Environmental Information to Competent Authority	The developer submits the environmental information to the CA together with the application for development consent. If an application for an Annex I or II project is made without environmental information the CA must screen the project to determine whether EIA is required (see above). (Articles 5(1) and 5(3)). In most MS, the environmental information is presented in the form of an Environmental Impact Statement (EIS).
Review of Adequacy of the Environmental Information	In some MS there is a formal requirement for independent review of the adequacy of the environmental information before it is considered by the CA. In other MS, the CA is responsible for determining whether the information is adequate. The guidance on **EIS Review** is designed to assist at this stage. The developer may be required to provide further information, if the submitted information is deemed to be adequate.
Consultation with Statutory Environmental Authorities, Other Interested Parties and the Public	The environmental information must be made available to authorities with environmental responsibilities and to other interested organisations and the general public for review. They must be given an opportunity to comment on the project and its environmental effects before a decision is made on development consent. If transboundary effects are likely to be significant other affected MS must be consulted (Articles 6 and 7).
Consultation of the Environmental Information by the Competent Authority before making Development Consent Decision	The environmental information and the results of consultations must be considered by the CA in reaching its decision on the application for development consent (Article 8).
Announcement of Decision	The decision must be made available to the public, including the reasons of it and a description of the measures that will be required to mitigate adverse environmental effects (Article 9).
Post-Decision Monitoring, if Project is Granted Consent	There may be a requirement to monitor the effects of the project, once it is implemented.

The highlighted steps must be followed in all Member States under Directives 85/337/EC and 97/11/EC. Scoping is not mandatory under the Directive but Member States must establish a voluntary procedure by which developers can request a Scoping Opinion from the CA, if they wish. The steps which are not highlighted form part of good practice in EIA and have parties may be required during some of these additional steps in some Member States.
Abbreviations CA = Competent Authority; MS = Member State.

Figure 1.3: Key Stages of the EIS Process

(Source: European Commission, *Guidance on EIA Scoping* (June 2001))

57 In August 2013, EirGrid requested the Board to provide a scoping opinion in respect of the proposed development. The Board consulted with various parties before providing its scoping opinion on 11th December 2013. The scoping consultation processes for the proposed development is set out in **Chapter 3**, of this volume of the EIS. The third stage in the process involves the preparation of the EIS by the developer for submission to the competent authority. This stage involves a baseline assessment to determine the status of the existing environment, impact prediction and evaluation, and determination of appropriate mitigation measures, including monitoring and reinstatement, where necessary. Article 5 of, and Annex IV to, the EIA Directive prescribe the requirements for an EIS, whilst an EIS is defined in Irish law as meaning, "*a statement of the effects, if any, which proposed development, if carried out, would have on the environment and shall include the information specified in Annex IV of Council Directive No. 2011/92/EU*".

58 The fourth stage in the process follows the application for development consent, and involves consultation with prescribed bodies, the public and ‗the public concerned‘. This stage provides for public input and participation in the EIA process.

59 The fifth stage, the actual EIA, is required to be undertaken pursuant to section 171A of the 2000 Act (as inserted) and must identify, describe and assess in an appropriate manner, in light of each individual case and in accordance with Articles 4 to 11 of the EIA Directive the direct and indirect effects of a proposed development on the following:

(a) human beings, flora and fauna;

(b) soil, water, air, climate and the landscape;

(c) material assets and the cultural heritage, and

(d) the interaction between the factors mentioned in paragraphs (a), (b) and (c).

60 The EIA process concludes when a determination is issued by the competent authority and the public is subsequently informed of the decision and the fact that a person may question the validity of a decision of the Board by way of an application for judicial review (including a statement describing where practical information on the review mechanism can be found): There may however be conditions attached to any consent, which require post-consent monitoring and reporting and additional actions on foot of monitoring. The purpose of monitoring is to compare predicted with actual impacts.

1.3.3 Consultation and EIA

61 Consultation is an essential part of the EIA process. It provides prescribed bodies, interest groups (with specific environmental responsibility) and the public (in particular those that may be directly affected by the proposed development e.g. landowners) with an opportunity to:

- Comment on the information supplied by the developer;
- To participate in the relevant environmental decision-making procedure; and
- Express comments and opinions when all options are open to the competent authority before the decision on the application for planning approval is made (pursuant to Article 6 of the EU Directive).

62 The scoping and pre-planning consultation processes for the proposed development is set out in **Chapter 3**, of this volume of the EIS.

1.3.4 Structure of the Environmental Impact Statement

63 This EIS was prepared in accordance with the ‗grouped format' structure set out in the EPA *Guidelines on the information to be contained in Environmental Impact Statements* (March 2002); where an EIS is prepared in a format which examines each environmental topic as a separate section. To facilitate this process, a schematic structure was used to provide a coherent documentation of the varied aspects of the environment considered. The schematic structure of the EIS (as set out in Chapters 1–14 of **Volumes 3C** and **3D**) is listed below with a brief outline of each specific stage:

1) Methodology:

   To facilitate evaluation of the EIS, a list of references / guidelines and descriptive standards are included where appropriate. Details as to how the chapter was prepared including the collation of any site investigation studies; how the particular environmental topic was assessed; and details of the criteria for assessing the likely significant effects of the proposed development on that aspect of the environment are provided.

2) Existing Environment (Baseline Situation):

   A description of the specific environment into which the proposed development will fit, taking account of other developments likely to occur is provided. The particular aspects of the environment are discussed in terms of their context, character, significance and sensitivity.

3) Potential Impacts:

a) The potential impact of the proposed development, including a ‗worse case' scenario, comprises a general description of the possible types of impacts the proposed development would be likely to produce during the construction, operational and decommissioning phases; before the proposed mitigation measures become fully effective.

b) This includes a consideration of the ‗Do-Nothing' impact. The ‗Do-Nothing' impact describes the environment as it would be in the future if no development of any kind is carried out.

4) Mitigation Measures:

A description of any specific remedial or reductive measures considered necessary and practicable resulting from the assessment of potential impacts of the proposed development described at (3a) above are recommended.

5) Residual Impact:

The degree of environmental change (if any) that will occur as a result of the proposed development after the proposed mitigation measures have taken effect as planned.

64 In addition, transboundary and cumulative impacts, interaction of impacts / inter-relationships are addressed in **Chapters 9** and **10** of this volume of the EIS.

65 As noted previously, this EIS has been undertaken having regard to *inter alia* the most recent EC Guidance documents, for example:

- European Commission, *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (May 1999);
- European Commission, *Guidance on EIA Screening* (June 2001);
- European Commission, *Guidance on EIA Scoping* (June 2001);
- European Commission, *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects* (May 2013); and
- European Commission, *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* (April 2013).

1.4 STRUCTURE AND CONTENT OF THIS EIS

1.4.1 Environmental Impact Statement Structure

66 The EIS comprises **Volume 3** (a single EIS in multi-volume) of the application documentation and is itself presented in 4 main volumes with associated appendices and figures as follows:

- **Volume 3A** – **Non-Technical Summary;**
- **Volume 3B** deals with strategic issues which are common to the overall proposed development;
    - Volume 3B - Common Chapters (CMSA and MSA)
    - Volume 3B - Appendices
    - Volume 3B - Figures
- **Volume 3C** provides details of the environmental appraisal of the project primarily as it passes through counties Cavan and Monaghan (The Cavan Monaghan Study Area - CMSA), and comprises:
    - Volume 3C - Cavan – Monaghan Study Area (CMSA)
    - Volume 3C - Appendices
    - Volume 3C - Figures
- **Volume 3D** provides details of the environmental appraisal of the project primarily as it passes through County Meath (The Meath Study Area - MSA), and comprises:
    - Volume 3D - Meath Study Area (MSA)
    - Volume 3D - Appendices
    - Volume 3D - Figures

67 The following documents are included in **Volume 3B Appendices** of the EIS:

- **Appendix 1.1** *Preliminary Re-evaluation Report* (May 2011);
- **Appendix 1.2** *Final Re-evaluation Report* (April 2013);
- **Appendix 1.3** *Preferred Project Solution Report* (July 2013);
- **Appendix 1.4** Scoping Opinion from An Bord Pleanála;

- **Appendix 2.1** *The Strategic Need for a Second North-South Electricity Interconnector EirGrid and SONI* (2014); and

- **Appendix 7.1** *Outline Construction and Environmental Management Plan (CEMP)* (2014)**.**

68 In addition, other background / historic reports and reference material, particularly those published by or on behalf of EirGrid, and which may be considered by the Board to be of relevance to its EIA process, are provided in soft copy on a disc at the back of this volume of the EIS. The Bibliography identifies the reports and material included on disc and where other reference material can be sourced.

69 The structure of the multi-volume EIS is set out in **Table 1.1**. As set out in paragraph 27 (**Section 1.1.3.2)** it is considered appropriate to present that evaluation in two sections. In this regard, it is noted that the same specialists have been responsible for the preparation of the environmental appraisal for both the CMSA and MSA sections of the project.

Table 1.1: Structure of the EIS

<table>
<tr><th colspan="2">**Volume 3A of the EIS** contains the Non-Technical Summary</th></tr>
<tr><td colspan="2">**Volume 3B of the EIS** (this volume) deals with strategic issues which are common to the overall proposed development, including Consideration of Alternatives, Cumulative Impacts and Impact Interactions and Transboundary Impacts.

Volume 3B Appendices contains the Appendices associated with this volume of the EIS, some of which are contained on a disc as referenced in this volume of the EIS.

Volume 3B Figures contains the 1:5,000 mapping for the project at A1 scale.</td></tr>
<tr><td>**Volume 3C of the EIS** considers the CMSA section of the project.

This volume provides an appraisal of the area of the proposed development from the area of the proposed border crossing at locations between the townlands of Doohat or Crossreagh, and Crossbane, County Armagh, and Lemgare, County Monaghan to the townland of Clonturkan, County Cavan.</td><td>**Volume 3D of the EIS** considers the MSA section of the project.

This volume provides an appraisal of the area of the proposed development, from the townland of Clonturkan, County Cavan to the existing Woodland Substation in County Meath.</td></tr>
<tr><td>**Volume 3C Appendices** contains the Appendices associated with Volume 3C.</td><td>**Volume 3D Appendices** contains the Appendices associated with Volume 3D.</td></tr>
<tr><td>**Volume 3C Figures** contains the Figures associated with Volume 3C.</td><td>**Volume 3D of the EIS** contains the Figures associated with Volume 3D.</td></tr>
</table>

70 Accordingly, **Volume 3B** of the EIS (this volume) deals with issues which are common to the project including:

Chapter 1	Introduction
Chapter 2	Strategic Need
Chapter 3	Scoping the EIS
Chapter 4	Consideration of Alternatives - Technology
Chapter 5	Consideration of Alternatives - Routing
Chapter 6	Description of Proposed Development - Transmission Circuit and Substation Works
Chapter 7	Construction
Chapter 8	Background – Human Beings - EMF
Chapter 9	Transboundary
Chapter 10	Cumulative Impact and Impact Interactions
Chapter 11	Summary of Mitigation Measures

1.4.2 Environmental Impact Statement Content

71 The content of this EIS has been completed in accordance with the relevant provisions of the Consolidated EIA Directive, *Planning and Development Act 2000* (as amended) and the *Planning and Development Regulations 2001* (as amended). In particular, as required by the EIA Directive (Article 3), the EIS must identify, describe and assess in an appropriate manner, the direct and indirect effects of a project on the following factors:

(a) *human beings, fauna and flora;*

(b) soil, water, air, climate and the landscape;

(c) material assets and the cultural heritage; and

(d) the interaction between the factors referred to in points (a), (b) and (c)."

72 **Table 1.2** summarises the information that is required and identifies where in the EIS the relevant information can be found.

Table 1.2: Information in the EIS

Requirement	Location of Information in this EIS
1. A description of the project, including in particular: (a) A description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases; (b) A description of the main characteristics of the production processes, for instance, the nature and quantity of the materials used; (c) an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the proposed project.	(a), (b): Chapter 6, Volume 3B (c): Included in each environmental chapter (Volumes 3C and 3D)
2. An outline of the main alternatives studies by the developer and an indication of the main reasons for this choice, taking into account the environmental effects.	Chapters 4 and 5, Volume 3B
3. A description of the aspects of the environment likely to be significantly affected by the proposed project, including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and, the inter-relationship between the above factors.	Volumes 3C and 3D
4. A description of the likely significant effects (including direct, indirect, secondary, cumulative, short, medium and long term, permanent and temporary, positive and negative effects) of the proposed project on the environment resulting from: (a) the existence of the project, (b) the use of natural resources, (c) the emission of pollutants, the creation of nuisances and the elimination of waste.	Volumes 3C and 3D
5. The description by the developer of the forecasting methods used to assess the effects on the environment referred to in point 4.	Volumes 3C and 3D
6. A description of measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.	Volumes 3C and 3D
7. A non-technical summary of the information provided under headings 1 to 6.	Volume 3A
8. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the developer in compiling the required information.	Chapter 1, Volume 3B (this chapter)

1.4.3 Transboundary Impacts

73 The potential transboundary effects of the project and the measures envisaged to reduce or eliminate such effects are important, as the proposed interconnector, comprising a 400 kV OHL linking the existing 400 kV substation in Woodland, County Meath with a planned substation in Turleenan, County Tyrone, is a cross-border interconnector between Ireland and Northern Ireland [in the United Kingdom (UK)].

74 Article 7 of the consolidated EIA Directive 2011/92/EU provides the basis for consultation between Member States in relation to the likely significant effects of proposed development in one state on the environment in another Member State. The principal obligation is in respect of information and consultation and is imposed by Article 7(1):

> *"Where a Member State is aware that a project is likely to have significant effects on the environment in another Member State or where a Member State likely to be significantly affected so requests, the Member State in whose territory the project is intended to be carried out shall send to the affected Member State as soon as possible and no later than when informing its own public, inter alia:*
>
> *(a) a description of the project, together with any available information on its possible transboundary impact;*
>
> *(b) information on the nature of the decision which may be taken,"*

75 Accordingly, this EIS has regard to the potential transboundary impacts associated with the proposed development (see **Chapter 9** of this volume of the EIS). Cumulative impacts and interactions are addressed in respect of each of the environmental topics in **Chapter 10** of this volume of the EIS.

76 As noted in **Section 1.1.3**, the proposed interconnector, extending across lands within Ireland and Northern Ireland, is separated into its jurisdictional elements for the purposes of applying for development consent. An EIS and ES have been submitted in respect of the separate applications for consent of those elements of the proposed interconnector within Ireland, and within Northern Ireland. Both documents (EIS / ES) address transboundary impacts associated with the respective elements within Ireland and Northern Ireland.

77 In addition, a *Joint Environmental Report* has been prepared by the respective applicants to provide an overview of the proposed development, and its predicted environmental impact, as presented in the separate EIS / ES documents. The report also provides an overview of transboundary impacts in a manner consistent with a suggested approach of recent European Commission guidance, *Guidance on the Application of the Environmental Impact Assessment*

Procedure for Large-scale Transboundary Projects (May 2013). The *Joint Environmental Report* comprises **Volume 4** of the application documentation.

1.5 DIFFICULTIES ARISING DURING PREPARATION OF THE EIS

78 The EIA Directive and Irish regulations require that difficulties such as technical deficiencies, lack of information or knowledge encountered in compiling the EIS be described. During the preparation of the EIS, restricted access to private lands was the principal difficulty encountered, as detailed below.

1.5.1 Restricted Access to Lands

79 In many instances, access was denied by landowners or occupiers to personnel attempting to conduct technical or environmental survey work associated with the proposed development, including preparation of this EIS. Land access difficulties were experienced notwithstanding a proactive landowner engagement strategy (refer to the *Public and Landowner Consultation Report* in **Volume 2B** of the application documentation). The result was that the final proposed alignment was designed, and environmental and technical appraisals had to be undertaken, without the entire line route being walked-over or physically accessed by environmental consultants.

1.5.2 Addressing Restricted Access to Lands

80 Despite the difficulties encountered in compiling certain information arising from refusal of access to lands, it is the case that EirGrid and its technical and environmental consultants were granted access to approximately 25% of identified landholdings along and adjacent to the proposed alignment which enabled both direct and vantage point environmental surveys to be undertaken. In addition to the Light Detection and Ranging Surveys (LiDAR) surveys, aerial surveys and suite of desk top appraisals that were was completed for the entire route.

81 Moreover, and as addressed in more detail in Chapter 3 (Human Beings-Land Use) of **Volumes 3C** and **3D** of the EIS, it is the case that there is considerable homogeneity of land type along the alignment of the proposed development. Reference to CORINE Land Cover mapping, which is an established authoritative data source for land type in Ireland, confirms that approximately 99% of the proposed alignment is classified as agricultural (in particular improved grassland), which is inherently robust from an environmental perspective. As addressed in the *Preferred Project Solution Report*, comprising **Appendix 1.3, Volume 3B Appendices**, of the EIS, structures have been specifically located within areas of improved grassland where land access has not been possible or sufficient to eliminate, at this stage, the potential for significant impact upon a more ecologically sensitive land type or feature. This has ensured that the

proposed alignment is set within a receiving environment of relatively low sensitivity. In addition, the attention and expertise given to the specific routing of the proposal undertaken by experienced professionals has ensured the identification and avoidance of more sensitive ecological and other environmental receptors within the receiving environment.

82 Having regard to this, and to other measures addressed below, notwithstanding land access difficulties, it was possible to carry out a robust appraisal of the likely significant environmental impacts associated with the proposed development.

83 Important considerations, and alternative means of obtaining baseline in this regard include:

a. **The nature of the proposed development.** Relative to other types of linear infrastructure, or indeed, other development in general such as dwellings, farm buildings, farmyards, industrial facilities etc., the physical footprint of an OHL development is small. As set out in more detail in **Chapter 7** of this volume of the EIS, this primarily entails the excavation (and eventual backfilling) of 4 holes at the legs of each structure. This combined with the appropriate routing of the alignment, which has sought to avoid sensitive ecological and other habitats, and to maximise distance from dwellings and public viewpoints in the first instance, ensures that the potential environmental impact of this (and any such) transmission infrastructure development is minimised.

b. **Desk-based assessments of existing published data sources.** Comprehensive and detailed published data sources are available, and in this instance (and indeed in respect of all transmission infrastructure development projects), were used to inform the baseline description and quantitative and qualitative impact assessments. This includes *inter alia* the list of National Monuments, Record of Monuments and Places (RMPs), Historic Maps, CORINE database, An Foras Taluntais (Soil Map of Ireland), Geological Survey of Ireland mapping, CSO, available data on identified wetlands, identified woodlands, identified grassland sites, general bat records, badger surveys and bird populations in the area etc. The use of such data, combined with a route identification strategy which avoided any likely significant environmental constraint to the greatest extent possible, has ensured that the proposed development now occurs within an extremely robust receiving environment.

c. **Detailed analysis of high quality OSI aerial photography and LiDAR orthography along the entire proposed line route**. Aerial photography is of an extremely high quality and definition, providing clear images of the landscape below, thereby facilitating identification of features on the ground. This is a significantly useful tool for the routing of OHL and other transmission infrastructure development, even in instances where access to land is unrestricted, as it can identify features, for example by shadows or field marks, that are not readily identifiable at ground level.

LiDAR is a remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light. Such airborne laser scanning surveys, combined with high-technology automated transmission line design software (e.g. PLS-CADD), are nowadays the standard method for full 3-D design of OHL, again also in circumstances where access to land is unrestricted.

LiDAR surveys of proposed transmission line corridors generally utilise helicopters flying at approximately 150 - 300m altitude. The laser scanner systems generally utilise pulsed laser scanners to measure the distance and direction from the sensor to ground. The sensors typically give a similar swathe width on the ground as the flying height – for example, for a 200m flying height, the width of coverage on the ground would be 200m. The position and orientation of the aircraft is determined using GPS (Global Positioning Systems) and INS (Inertial Navigation System) measurements. The measurements are combined with the LiDAR range / direction measurements to give precise 3-D coordinates for the laser footprint on the ground.

With high frequency laser scanners, point densities in excess of 25 points per square metre can pick up every feature in the corridor, including ground levels (and variations in levels), topography, vegetation, buildings, OHL etc.

1.5.3 LiDAR and the Proposed Development

84 Detailed aerial imagery available for the proposed line route, including LiDAR imagery from September 2009 and Aerial Mapping from October 2010, has been used in the process of identification of the final proposed line route, and the environmental appraisal of the proposed development. In addition, updated imagery produced from a subsequent LiDAR survey (October 2013), provides the most up-to-date details of the baseline environment along the alignment of the proposed development, and proximate lands on either side thereof. From the LiDAR it is possible to determine local changes to the baseline environment since the previous LiDAR imaging of 2009. Where possible, this is also verified by on the ground survey, even where direct access to private land has been denied (e.g. from vantage point surveys from public roads, adjoining lands etc.).

85 For example, it has been noted from field / vantage point surveys adjacent to the alignment of the proposed development that areas of locally significant habitat have been ‗reclaimed‘ or otherwise modified - these local modifications have also been confirmed by LiDAR. Similarly, new and / or widened drainage ditches can also be identified through the use of LiDAR, and where possible, confirmed by land or vantage point survey. This ensures the confidence of the

project team and environmental specialists contributing to this EIS that the LiDAR surveys, (and other detailed aerial imagery) are an appropriate substitute for direct land access where such access has not been facilitated by landowners.

86 In particular in respect of ecology, LiDAR allows for the identification of the general structure of hedgerows, confirming whether or not mature trees are present, and an accurate width and height of hedgerows to be determined in GIS. This informs a quantitative impact assessment of treelines which will be lopped / removed under the line. PLS-CADD analysis of zone of impact can also be applied to LiDAR data to further improve determination of the zone of impact and accuracy of the assessment.

87 As a practical example of the application of LiDAR to provide an understanding of the baseline ecological environment, **Figure 1.4** shows a sample of LiDAR imagery that captures a mature hedgerow. From this image the structure and likely key species (including hawthorn – red berries and gorse) can be discerned. This imagery clearly indicates land management activities and management around the hedgerow.

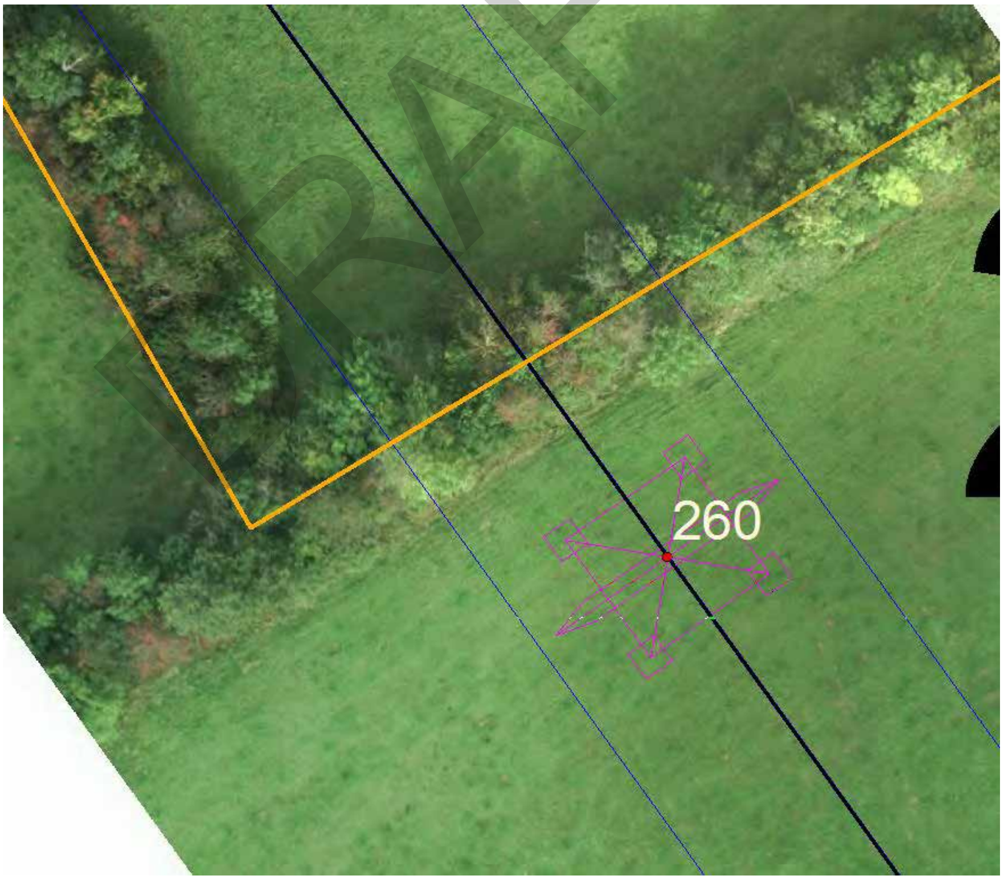


Figure 1.4: LiDAR Imagery showing Overgrown Hedgerow

88 **Figure 1.5** shows LiDAR imagery for the same hedgerow with point data attaching, from which the height above datum can be ascertained. This data can be measured against the level of the ground to give an accurate measurement of hedgerow and tree height. This assists in detailing the habitat category and is used to determine which trees will require lopping. This is reflected in the plan and profile drawings for the proposed development.

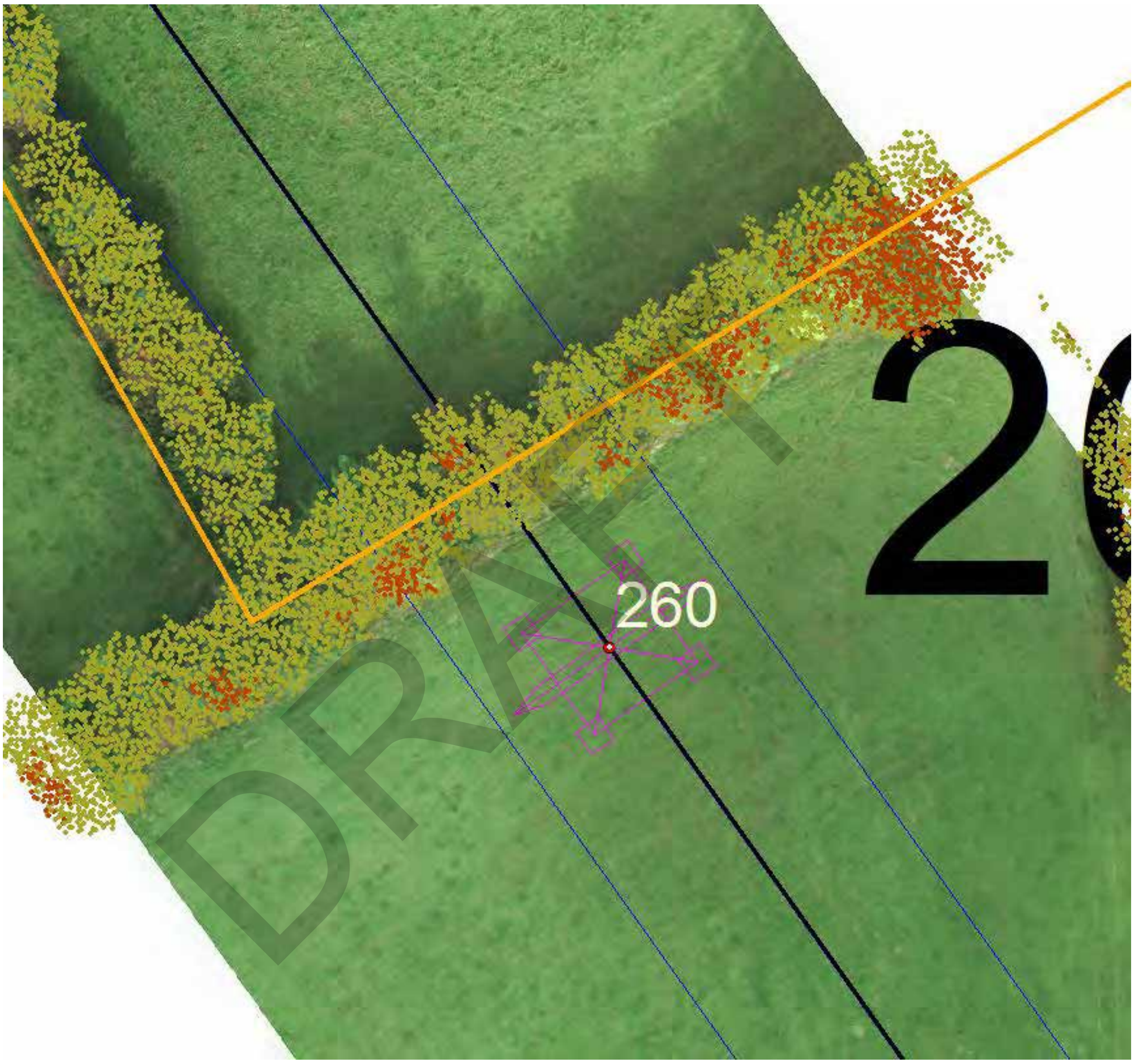


Figure 1.5: LiDAR Imagery with Point Data

89 In addition to this, the LiDAR data can be converted to an ArcGIS (a Geographical Information Systems - GIS) format can also be used to display vegetation in 3D as shown in **Figure 1.6**.

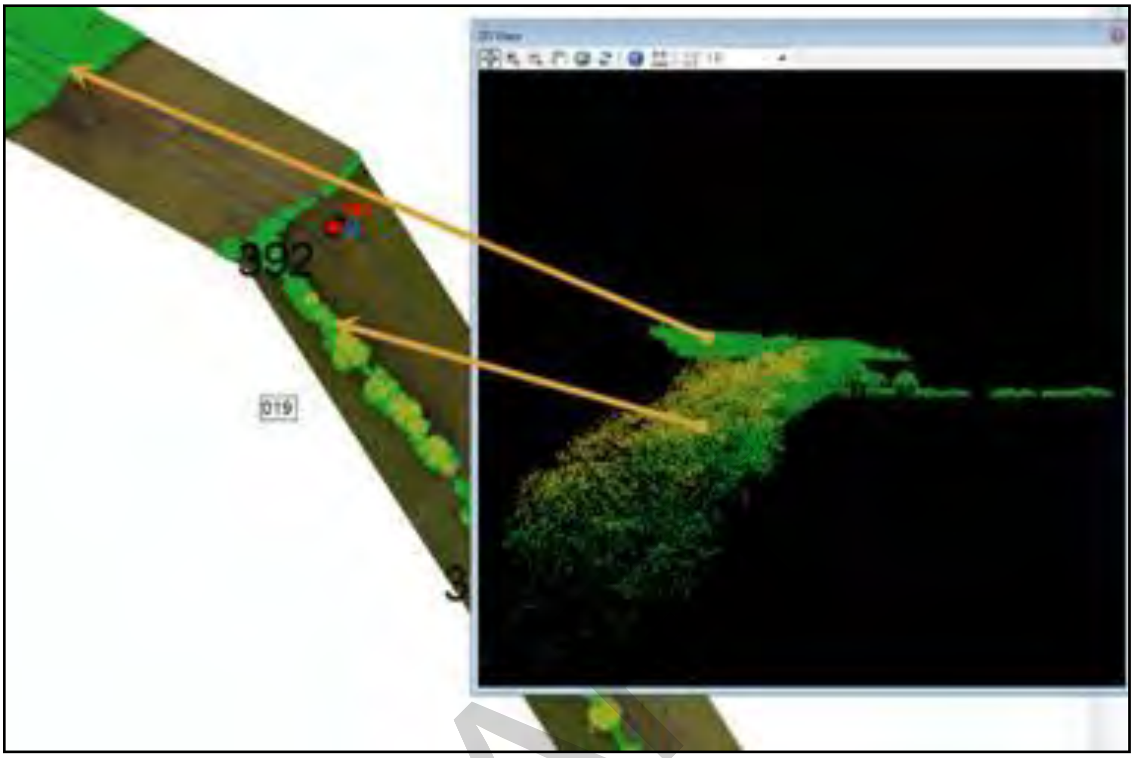


Figure 1.6: Vegetation in 3D in ArcGIS Format

90 Similarly, in terms of understanding the baseline cultural heritage environment, LiDAR data was used to assess inaccessible landholdings along the line route with greater accuracy; it was also used to verify and / or enhance survey data on lands where access had been permitted. The high resolution ortho-photography enabled the project team to cross reference cultural heritage features collected by both aerial photography and LiDAR. The usefulness of aerial photographs and LiDAR is that they allow for a different perspective, what might be termed ‗the distant view'.

91 Archaeological features may show up on the ground surface, depending on their state of preservation, by light and shadow contrasts (shadow marks), tonal differences in the soil (soil marks) or differences in height and colour of the cultivated cereal (crop marks). Such features might not always be visible on the ground, and therefore might not always be identified by land access survey.

92 Of particular note, an expanded LiDAR survey was commissioned and undertaken for the Teltown area, identified by the project team's Cultural Heritage specialist as an area of archaeological significance. The survey was specifically carried out for the purpose of determining the potential impact of the proposed development on the cultural heritage resource

in this archaeologically sensitive area. This is addressed in more detail in Chapter 14 of **Volume 3D** of this EIS.

93 Features that are difficult to distinguish on the ground or even through aerial photography can be identified by overlaying hillshades on a digital terrain model (DTM) created with artificial illumination from various angles, as with the example from past horizons, included as **Figure 1.7** – an image from the Teltown assessment.

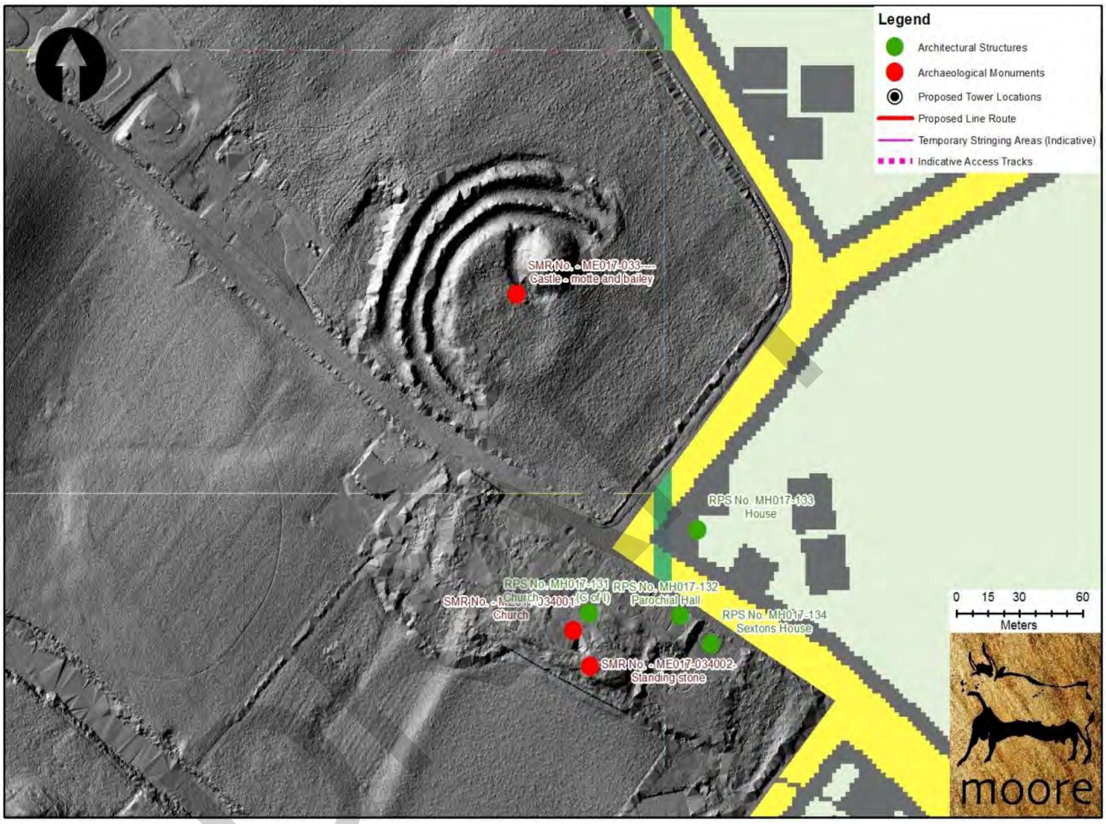


Figure 1.7: LiDAR Derived Imagery Showing Shading

1.5.4 Other Relevant Measures

94 Overall, it is considered that the use of high-quality aerial photography, and LiDAR imaging, has ensured that the baseline environment of the proposed development is fully understood, both in the scenario where direct access to land has been provided, and in the scenario where it has not. This, combined with the other matters and measures set out in this section, has ensured a comprehensive and robust evaluation of the environmental impact of the proposed development upon its receiving environment.

a. **Walkover surveys and visual surveys (from public roadways and / or adjacent lands) along the proposed line route**. There is an extensive network of public roads throughout the study area, and including in proximity to the alignment of the proposed development. Visual surveys were conducted from these public areas; of particular importance, this includes all locations where the proposed line route crosses public roads. This has ensured an appropriate understanding both of the immediate vicinity of the proposed development, as well as the wider receiving environment of the line route.

In addition, where access was granted to landholdings along the alignment, it was possible to carry out a visual survey of adjoining landholdings where such access had not been granted. Given the low value habitats (from an ecological and environmental perspective) in which the vast majority of towers are located - primarily comprising improved grassland (this is also addressed above and in Chapters 3 of **Volumes 3C** and **3D** of this EIS), this allowed confirmation that the desktop evaluation undertaken in respect of the proposed development were accurate.

b. **The findings of ongoing ecological studies, including those undertaken over an extended period of time.** Very extensive winter bird, breeding bird and bat surveys have been undertaken over a number of seasons (refer to Chapters 6, of **Volumes 3C** and **3D** of this EIS). For example, wintering bird surveys have been undertaken every season between 2007 and 2014. These have produced a very significant body of information to inform the ecological evaluations, and to ensure that appropriate mitigation measures can be applied to avoid or minimise potential environmental impact upon sensitive ecological receptors.

c. **Avoidance of areas of potential ecological significance.** As outlined above, it has been a guiding principle for the line design of the proposed development – and indeed all transmission infrastructure development, to seek to avoid any significant impact on sites of known ecological importance. In the case of sites of potential ecological importance, site surveys and assessments have been carried out where possible to determine the presence of, and nature of, ecological features and species.

Where it has not been possible to secure access to lands to undertake such surveys, or indeed where on-site survey has revealed the presence of significant ecological species and habitats, EirGrid has sited the various OHL structures away from areas of potential ecological importance. In particular this includes hedgerows and wetlands, with structures proposed in adjacent managed agricultural fields, i.e. into a modified habitat where the ecological sensitivity is clearly low. This strategy, which is based on taking an extremely cautious approach to the siting of transmission infrastructure, has been discussed with the National Parks and Wildlife Service (NPWS) of the Department of Arts, Heritage and the Gaeltacht.

Notwithstanding this approach, however, it is important to note, in reference to the National Roads Authority (NRA) 2009 *Guidelines for Assessment of Ecological Impacts of National Road Schemes*, key ecological receptors are, fundamentally, the significant ecological elements for consideration in the ecology assessment, rather than all ecological receptors. This is also the basis for ecological assessment set out in EirGrid's *Ecology Guidelines for Electricity Transmission Project – A Standard Approach to Ecological Impact Assessment of High Voltage Transmission Projects* (2012) and which, as the title suggests, is applied to all transmission infrastructure development. Key ecological receptors are features that are evaluated as being of Local Importance (Higher Value) or greater (up to International Importance). The relevant key ecological receptors have been identified based on the ecological assessment works carried out – this is addressed in more detail in Chapters 6 of **Volumes 3C** and **3D** of this EIS.

In some cases, key ecological receptors cannot be accurately identified e.g. bat roosts, which are notoriously difficult to confirm, even where access to land for ecological survey is permitted. In most cases, a precautionary assessment is undertaken, based on aerial imagery and LiDAR imagery as addressed above, to inform potential roost areas. This information is augmented with roadside bat activity surveys. Using the best practice approaches, as addressed in the NRA and EirGrid Guidelines, standard precautionary mitigation measures have been applied in respect of the proposed development – in much the same way as they would be applied to all linear transmission infrastructure development proposals.

Furthermore, in accordance with established good practice, site specific pre-construction ecological (and other environmental) verification and monitoring, the nature of which are outlined in this EIS, will be carried out by appropriately qualified consultants, prior to actual construction works being carried out.

1.5.5 Conclusions Regarding Restricted Access to Lands

95 Overall, while it would always be preferable that access to the entirety of a development site occurs for the purposes of assisting in the environmental appraisal of a proposed development, this has not been possible in the case of the proposed development. However, it is considered that the approach of EirGrid and its project team to (a) the routing of the alignment – avoiding key sensitive receptors, (b) the siting of the proposed structures – and the construction methodology that will be employed, and (c) the range of alternative and complementary tools and measures to gather the necessary information regarding the baseline receiving environment – in particular including the use of aerial photography, LiDAR imagery, vantage point survey, and extended ecological survey, has ensured that an adequate and robust EIS has been prepared in respect of the proposed development.

96 Having regard to the above, it is the case that, despite the difficulties encountered in compiling this EIS (including the inability to access the entire extent of the alignment of the proposed development), EirGrid and its project team are satisfied that a comprehensive and objective EIS has been prepared in respect of the proposed development, which is more than adequate to meet the requirement that it alerts the competent authority, the public and public concerned and prescribed authorities to the potential effects of the proposed development on the environment.

1.6 CONCLUSION

97 The proposed cross-border electricity infrastructure will provide a second high capacity electricity interconnector between Ireland and Northern Ireland. Under the provisions of the codified EIA Directive, an EIA is required for overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15km. This requirement of the EIA Directive is mirrored in Irish law pursuant to the provisions of section 176 of the *Planning and Development Act 2000* (as amended) and article 93 of, and Schedule 5 to, the *Planning and Development Regulations 2001* (as amended).

98 In addition, under the requirements of the Habitats Directive, an appropriate assessment (AA), including making a determination under Article 6(3) of the Habitats Directive, *“before development consent may be given, as to whether the proposed development would adversely affect the integrity of a European site”* must be carried out by the competent authority in respect of the proposed development.

99 Having regard to the provisions of the codified EIA Directive, the Habitats Directive and the relevant provisions of the *Planning and Development Act 2000* (as amended) and the *Planning and Development Regulations 2001* (as amended), it is considered that the proposed development requires an EIA and an AA to be conducted by the competent authority. Accordingly this application for planning approval includes both an EIS and NIS to assist the Board in its consideration of whether to grant development consent for the proposed development.

100 The EIS has been prepared in accordance with Schedule 6 of the Pl*anning and Development Regulations 2001* (as amended), and applicable guidance documents, and conforms to the relevant requirements as specified therein. Difficulties encountered in compiling this EIS, arising principally from the refusal by some landowners to permit access to land for the purposes of technical and environmental appraisal, have been overcome by the approach of EirGrid to the routing and siting of the proposed development, and the range of alternative sources of information and survey data which have been used to understand the baseline receiving environment in compiling the EIS.

2 STRATEGIC NEED

2.1 INTRODUCTION

1 This chapter sets out the need and benefits of the proposed interconnector between Ireland and Northern Ireland. The need for a second interconnector arises from the required development of the existing high voltage transmission network infrastructure on the island of Ireland. The chapter concludes by identifying some of the key benefits that the delivery of the proposed interconnector will provide to consumers across the island.

2 The underpinning European, national, regional and local policy context for the proposed development is detailed in a separate *Planning Report* (refer to **Volume 2A** of the application documentation).

3 As noted above, and addressed in more detail also in **Volume 2A** of the application documentation, the proposed interconnector is designated as a Project of Common Interest (PCI). Specifically, Article 4 of the governing Regulation 347/2013[15] - refers to Criteria for Projects of Common Interest, stating:

> *1. "Projects of common interest shall meet the following general criteria:*
>
> *(a) the project is necessary for at least one of the energy infrastructure priority corridors and areas;*
>
> *(b) the potential overall benefits of the project, assessed according to the respective specific criteria in paragraph 2, outweigh its costs, including in the longer term; and*
>
> *(c) the project meets any of the following criteria:*
>
> *(i) involves at least two Member States by directly crossing the border of two or more Member States;*
>
> *(ii) is located on the territory of one Member State and has a significant cross-border impact as set out in Annex IV.1;*
>
> *(iii) crosses the border of at least one Member State and a European Economic Area country.*

[15] Of the European Parliament and of the Council of *17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009.*

2. *The following specific criteria shall apply to projects of common interest falling within specific energy infrastructure categories:*

   (a) for electricity transmission and storage projects falling under the energy infrastructure categories set out in Annex II.1 (a) to (d), the project is to contribute significantly to at least one of the following specific criteria:

   (i) market integration, inter alia through lifting the isolation of at least one Member State and reducing energy infrastructure bottlenecks; competition and system flexibility;

   (ii) sustainability, inter alia through the integration of renewable energy into the grid and the transmission of renewable generation to major consumption centres and storage sites;

   (iii) security of supply, inter alia through interoperability, appropriate connections and secure and reliable system operation;…"

4 With endorsement from energy regulators and Governments in both jurisdictions the respective applicants have worked jointly to identify and execute proposals for appropriate interconnection between the transmission network in Ireland and Northern Ireland. The new Interconnector will largely remove existing restrictions limiting cross-border power flows between Ireland and Northern Ireland, thus enhancing security of electricity supply throughout the island of Ireland.

5 EirGrid has 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*".[16]

6 EirGrid also has a licence obligation to develop the Irish transmission system "*as part of an efficient, economical, co-ordinated, safe, secure and reliable electricity transmission system on the island of Ireland as a whole*[17]*."*

7 Relevant considerations arising from this statutory duty and the development context for the proposed interconnector are set out in the following sections.

[16]Article 8 of the *European Communities (Internal Market in Electricity) Regulations 2000 (*S.I. No. 445 of 2000).
[17]*Transmission System Operator Licence Granted to EirGrid* - Condition 3 General Functions 1 (a)

2.2 EXISTING TRANSMISSION NETWORK INFRASTRUCTURE AND DEVELOPMENT CONTEXT

2.2.1 Existing Electricity Infrastructure

8 The nature of electrical power transmission systems is such that electricity generation and demand must always be balanced, since it is impractical for electrical energy to be stored in bulk quantities. This means that a strategic electricity transmission system must be capable of providing a continuously stable and reliable supply of electricity throughout a wide geographic area, but also capable of immediately coping with significant changes in operating conditions.

9 Transmission systems were originally designed to cater for the receipt of power from a relatively small number of large reliable sources of power generation and to distribute that power to widely dispersed load centres (primarily centres of population). However, the requirements of the modern transmission system have changed. Firstly, to enable use of the cheapest energy sources transmission system capacity needs to be capable of transferring large amounts of electricity between a greater range of power generators and load centres. Secondly, more small-scale and renewable energy-sourced generation is seeking connection to, or use of, transmission systems. Much of this is wind-powered generation, which has intermittent output. Transmission System Operator‘s (TSOs) therefore need to exchange large amounts of power to efficiently manage the variability.

10 The transmission system on the island of Ireland provides a substantial, reliable and proven corridor for balancing bulk power flows and ensuring stable system performance across the entire island. It operates at high voltages, to enable power to be transferred most efficiently, and is designed and constructed to provide a high standard of reliability and dependability. **Figure 2.1** shows the existing transmission networks in both jurisdictions as well as the existing interconnection between Northern Ireland and Scotland and between Ireland and Wales.

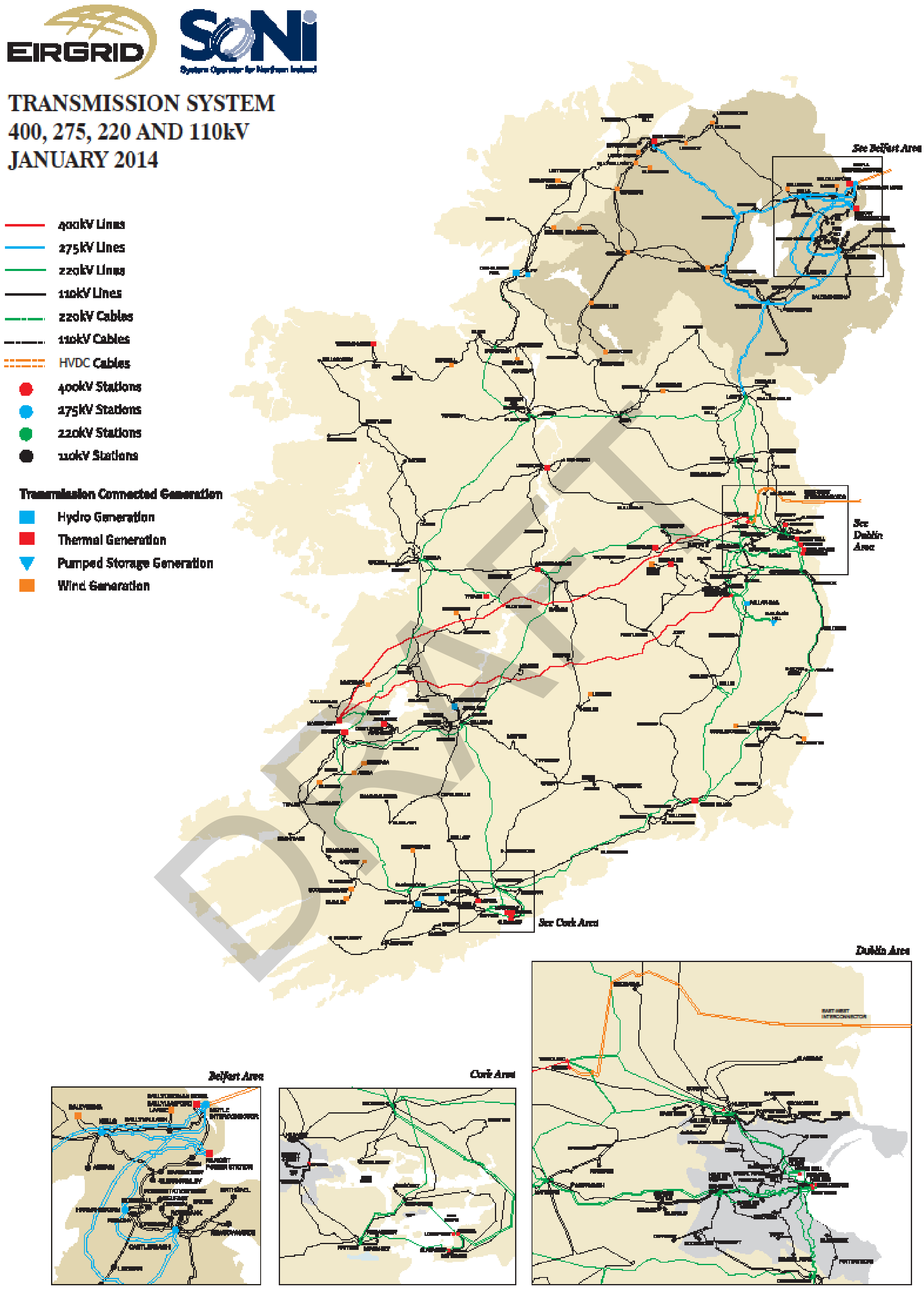


Figure 2.1: Transmission Systems in Ireland and Northern Ireland (2014)

2.2.1.1 The Transmission System in Ireland

11 In Ireland the electricity transmission system comprises the following:

- The 400 kV network;
- The 220 kV network; and
- The 110 kV network.

12 The 400 kV and 220 kV networks form the major ‗arteries‘ of transmission infrastructure across the country, facilitating transfers of large amounts of electrical power from the larger power generation sources within Ireland. Transmission of electricity at these higher voltages reduces losses and enables power to be transferred more efficiently than at lower voltages. A high voltage reliable transmission system therefore provides a conduit for bulk power flows, thereby ensuring stable performance across the entire transmission system.

13 The 400 kV network currently comprises two circuits, one connecting Moneypoint Substation on the west coast to Woodland Substation at Batterstown near Dunshaughlin, County Meath, and the other connecting Moneypoint Substation to Dunstown Substation in County Kildare. In addition, the Oldstreet 400 kV Substation, connected into the Moneypoint-Woodland circuit, provides a strong feed to Galway and the West.

14 The 500MW High Voltage Direct Current (HVDC) East-West Interconnector between Wales and Ireland connects into the 400 kV network at Woodland Substation and the proposed interconnector will also connect into the 400 kV network at this node, as it is the most robust in this part of the network in Ireland.

15 The 220 kV network forms a number of largely single circuit loops across the country. The 110 kV network is the most extensive element of the overall transmission system, extending across each county. The high voltage transmission system is almost entirely constructed as overhead line (OHL) infrastructure, with conductors supported on steel lattice towers at the 400 kV and 220 kV voltage level, and supported mostly on wooden pole structures at the 110 kV voltage level. These connect the major switching and voltage management points (substations), which interface at certain substations with the more extensive lower voltage distribution system.

2.2.1.2 The Transmission System in the North-East Area of Ireland

16 The transmission network in the area from Dublin northwards towards County Louth and the border - described as the north-east area for the purposes of the proposed development - is a key strategic corridor which supports security of supply in the region and facilitates the transfer of electricity power to other areas in the country.

17 The existing transmission system in the region comprises two 220 kV lines connecting Dublin to Louth (Louth-Gorman-Maynooth & Louth-Woodland), and a 220 kV OHL from Louth Substation to Flagford in County Roscommon, all as outlined in **Figure 2.1**. These lines have been in service for over 40 years and no new 220 kV lines have been constructed in the north-east area in that time. The underlying 110 kV network also extends from Dublin to Louth Substation. Louth Substation is the main node of electricity supply for counties Cavan, Louth, Monaghan and parts of Meath. Louth Substation also serves as the southern terminus of the existing interconnector between the two jurisdictions.

2.2.1.3 The Transmission System in Northern Ireland

18 In Northern Ireland, the strategic electricity transmission system comprises the following elements:

- 275 kV network; and
- 110 kV network.

19 The bulk transmission system is made up of double circuit OHL (two transmission circuits erected on single steel tower structures), constructed to a 400 kV standard but which is currently operated at 275 kV. The network mainly forms a double circuit loop from a number of power generation stations in the east of Northern Ireland around Lough Neagh. There is a spur from the north-western portion of that loop stretching to Coolkeeragh Substation in County Derry and a second spur running south from Tandragee to form the existing interconnector to Louth Substation. The lower voltage 110 kV network is the most extensive element of the grid; and the transmission system connects to the lower voltage distribution system at substations.

2.2.2 History and Current Operation of Existing Interconnection

2.2.2.1 Existing Interconnection between Ireland and Northern Ireland

20 Until 1970, the electricity systems in Ireland and in Northern Ireland operated separately. When commissioned in 1970, the first interconnector connected the two transmission networks at,

what was then, their strongest point - Maynooth, County Kildare and Tandragee, County Armagh. At this time, however, the Electricity Supply Board (ESB) was separately planning a major reinforcement of the transmission network in the north-east area of Ireland, including construction of a new 220 kV / 110 kV substation near the village of Louth in County Louth.

21 Thus, in 1973, after commissioning Louth Substation, the Maynooth-Tandragee Interconnector was diverted into that substation to form the Louth-Tandragee double circuit 275 kV Interconnector, with a nominal capacity of 1,500MW (750MW per circuit), and the Louth-Maynooth 220 kV transmission line. The two other 220 kV lines connecting to Louth Substation, referred to in **Section 2.2.1.2**, were commissioned in the following years to facilitate interconnection transfers and to further enhance connection with the strongest points north of Dublin.

22 In addition, two 110 kV circuits were commissioned in 1994 to provide cross-border support between local networks. One circuit links Letterkenny in County Donegal with Strabane in County Tyrone; the other links Corraclassy in County Cavan with Enniskillen in County Fermanagh. These were originally planned as standby circuits to provide emergency supply to Letterkenny and Enniskillen.

23 The existing 275 kV interconnector operates in parallel with the two 110 kV tie-lines. However, the 275 kV interconnector forms the only effective large scale interconnection pathway between the transmission systems of Northern Ireland and Ireland. The two 110 kV tie-lines do not, on their own, have sufficient power carrying capacity to securely hold the two transmission systems together. A power system protection scheme has therefore been installed to ensure that, should the existing 275 kV interconnector trip due to a fault, or is otherwise put out of service, the two 110 kV interconnectors will automatically trip, thus ensuring that they are not left on their own as the only form of interconnection between the two systems.

2.2.2.2 Existing Interconnection between Northern Ireland and Scotland

24 The existing Moyle HVDC Undersea Interconnector, operating since 2002 and running between Ballycronan More in Islandmagee, County Antrim, and Auchencrosh in Ayrshire, links the electricity systems of Northern Ireland and Scotland. The link has a capacity of 500MW[18]. The operation of the Moyle Interconnector ended the isolation of Northern Ireland – and thus the island of Ireland – from the much larger electricity systems and markets, and indeed, the more

[18] The Moyle Interconnector is currently limited to a capacity of 250MW due to a cable fault. Repairs are currently being planned to return the Interconnector to full capacity at a future date.

diverse range of power generation sources, of Scotland, England, Wales, and the European mainland.

2.2.2.3 Existing Interconnection between Ireland and Wales

25 The East-West Interconnector links the electricity systems of Ireland and Britain and has been in operation since 2012. It runs between Woodland Substation in County Meath and Deeside in North Wales. It is a 260km HVDC underground and undersea link with the capacity to transport 500MW of electricity.

2.2.3 Transmission System Needs

2.2.3.1 Limitations of Existing Interconnection between Ireland and Northern Ireland

26 Having regard to the nature and extent of the existing interconnection infrastructure between Ireland and Northern Ireland, there is a risk that a single event – such as a lightning strike, accidental or deliberate damage to a tower structure, a fire at one of the termination points, or a mal-operation of the complex power system protection schemes - could cause a trip of the existing double circuit 275 kV interconnector between Louth and Tandragee. In such a scenario, interconnection between the transmission systems of Ireland and Northern Ireland would be lost entirely. This scenario is known as ‗system separation‘; in this situation, the transmission systems in Ireland and Northern Ireland would revert to operating independently of each other. This could result in loss of load in either or both systems as power transfer and mutual support cannot occur.

27 System separation, depending on the pre-separation interconnector flows, will result in a generation surplus in one system and a deficit in the other. The system with the deficit may be required to disconnect demand customers; the system with the surplus may have difficulty stabilising the system frequency. Both systems must be capable of dealing with this contingency and this puts a limit on the power transfer which the systems can cater for with the existing interconnection.

28 The respective applicants are obliged, by licence, to design the transmission systems of the two jurisdictions to be robust against a single event that would cause the quality of the electricity supplied to customers to deviate from specified quality standards. With the current extent of interconnection infrastructure between the two networks, it is possible for a single event to result in system separation. It is necessary, therefore, that the two networks are able to withstand, at all times, the sudden and unexpected loss of interconnection. The consequence of this is that under the circumstances where the existing interconnector would be required to be utilised close to its capacity an unexpected system separation would result in an

unsustainable imbalance between the quantity of electricity generation and demand in one or both networks. If such an imbalance is not corrected quickly enough (i.e. within a matter of seconds) then one or both power systems will potentially collapse resulting in black-outs. Correction is normally achieved by automatic load shedding – i.e. automatically switching off large numbers of customers - on the network with the excess demand, and automatically reducing generation on the network with the excess generation.

29 In the context of such a risk scenario the TSOs have agreed that the quantity and direction of power flow on the interconnector – the Total Transfer Capacity (TTC) - be constrained below the level at which system stability can be ensured following an unexpected system separation. Therefore, while each of the two circuits of the existing 275 kV interconnector could in theory carry power flows up to 750MW, the actual TTC of the Interconnector is limited to approximately 450MW. This limitation creates a bottleneck in the network. The capacity available for economic power flows is less than this TTC limit as some capacity must be maintained for emergency response between the two systems. In addition, there may at times be other bottlenecks (e.g. during transmission maintenance outages) in the networks that will also limit flows in either jurisdiction. This bottleneck, seriously limits the scope for commercial exchanges of electricity between generators and suppliers in each part of the all-island electricity market, and leads to inefficiencies and costs that are passed through to final customers as part of their electricity prices. Such a limitation restricts the efficient operation of the interconnector and the attainment of the obligations of Directive 2009/72/EC or the Third Electricity Directive, which establishes *Common Rules for the Internal Market in Electricity* (refer to the *Planning Report*, **Volume 2A** of the application documentation).

30 To address the power flow limitations described above, the proposed second interconnector needs to be physically separate from the existing interconnector so that the risk of concurrent failure will be low. Operating the transmission system with both interconnectors in service will provide enhanced security of supply in the event of the failure of either interconnector because the interconnector which remains in service can instantaneously accept the additional power flow so that there is no resulting instability in system behaviour, or loss of supply to customers.

2.2.4 Electrical Power Carrying Requirements

2.2.4.1 Background to Identifying the Electrical Power Carrying Requirements for the Proposed Interconnector

31 In February 2005 ESB National Grid (ESBNG) and NIE presented a paper titled *Additional Interconnection between Northern Ireland and the Republic of Ireland - Selection of Preferred Option* to their respective Regulatory Authorities. This paper considered the transmission system limitations and needs as described under **Section 2.2.3** and recommended the

selection of a development option comprising a 400 kV OHL with an ultimate capacity of 1,500MW. The recommendation was accepted by both Regulatory Authorities and ESBNG was directed by the Commission for Energy Regulation (CER) in March 2006 to carry out the necessary studies, route investigations and other investigations required for the preparation and submission of a planning application, on that basis.

2.2.4.2 Electrical Power Carrying Requirements for the Proposed Interconnector

32 It is considered by the respective applicants that the appropriate nominal electrical carrying capacity requirement for the proposed interconnector is 1,500MW[20]. This is supported by the following:

- The proposed interconnector will form a link between the 400 kV network in Ireland and the double circuit 275 kV network in Northern Ireland. The nominal capacity of the circuits that form these 400 kV and 275 kV networks is 1,500MW.
- The nominal capacity of the existing north-south interconnector is 1,500MW[21]. The proposed interconnector will form a second north-south interconnector and operate in parallel with the existing interconnector. A nominal capacity of 1,500MW will therefore match that of the existing interconnector.

[20] MVA (megavolt-amperes) is the technically correct unit of measurement for describing the capacity of transmission circuits and power transformers, and is the product of voltage (V) and current (A for amperes / amps). It has however become customary in non-technical documents to use MW for this purpose; therefore in this context, MW shall be interchangeable with MVA for the purpose of this EIS.
[21] Although the existing 275 kV double circuit OHL has a nominal capacity of 1,500MW the transformers at the Louth Substation end have a combined capacity of 1,200MW.

2.3 BENEFITS OF THE PROPOSED INTERCONNECTOR

33 The respective applicants are satisfied that the development of an additional high-capacity electricity interconnector between the electricity networks of Ireland and Northern Ireland is required in order to comply with, and to implement, the obligations of EU and national energy policy guidelines. The proposed interconnector provides many technical and other benefits which support the delivery of the key policy objectives of competitiveness, sustainability and security of supply for both Ireland and Northern Ireland. At present, in order to ensure system stability across the island of Ireland, power flows on the existing interconnector are limited to a value well below its nominal capacity. This limit is applied due to the potential impact on security of supply if an unexpected outage of the existing interconnector arises at higher power flows leading to unacceptable voltage and frequency stability issues. The second north-south interconnector will help to resolve this risk, as it provides a separate power flow independent of the existing interconnector, which significantly reduces the risk of system separation.

34 There are a number of benefits which arise as a result of the removal of existing constraints on power flow transfers between Ireland and Northern Ireland. These benefits include:-

2.3.1 Improving Competition by Reducing the Constraints Restricting Efficient Performance of the All-Island Single Electricity Market

35 In Ireland and Northern Ireland, as in other EU countries, domestic and commercial customers were historically restricted to a monopoly supplier of electricity, with no competition in the electricity supply market place. The All-Island Project is a joint initiative run by the CER and the Northern Ireland Authority for Utility Regulation (NIAUR). The aim of the project is to create a single market for natural gas and electricity on the island of Ireland. The all-island Single Electricity Market (SEM)[22] was successfully established in November 2007, commencing the trading of wholesale electricity in Ireland and Northern Ireland on an all-island basis. The aim of the SEM is to promote cross border trading in electricity for the benefit of all consumers on the island of Ireland.

36 The absence of a second north-south interconnector at present means that a significant infrastructure bottleneck exists that restricts power flows between the two systems. The efficient operation of the electricity market on the island of Ireland requires an adequate and appropriate linkage of the separate transmission networks in such a way that they operate as a

[22] The SEM is the electricity market structure currently in place on the Island of Ireland. This market structure is due to transition into that of the I-SEm which will allow integration with the European Target model. This is scheduled to happen in 2017. The aims of both market structures are fundamentally the same.

single synchronised transmission network. To achieve this, the level and reliability of interconnection must be such that the demand for cross border power flows can be met at all times even during system disturbances. As described in **Section 2.2.3.1**, to manage the risk of system separation, power transfers on the existing interconnector are currently limited to the level where the generation / load imbalance resulting from system separation can be managed by both systems. The existing reliance on a single interconnector is considered a significant constraint to ensuring an efficient electricity market. The constraint creates inefficiency in the market, due to the operational limits on transfer capacity and therefore excess cost for customers because it prevents the most efficient generators having unconstrained access to the market at all times.

37 With the present low level of interconnection, electricity cannot be traded in an effective way to facilitate the full benefits that the all-island single electricity market should bring to customers. The construction of an additional high capacity interconnector will diminish the possibility of system instability arising from the failure of one interconnector to an acceptable level; consequently, the transfer limit across the interconnector can be increased towards its nominal capacity, thereby permitting greater trade in electrical power, and enhanced security of supply. An additional benefit of enhanced high voltage interconnection is that the existing 110 kV tie-lines could be used more fully and would not automatically have to be removed from service in the scenario of an outage of the existing 275 kV interconnector, as is currently the case.

38 By reducing the existing infrastructure constraint between both jurisdictions, the second interconnector would remove this unnecessary congestion and would allow the all-island single electricity market to operate more efficiently, in line with its design objectives[23]. Studies by EirGrid have calculated annualised benefits to the market from the delivery of the second north-south interconnector of the order of €20m per annum in 2020 rising to a range of between €40m and €60m by 2030[24].

2.3.2 Improving Security of Supply by Providing a Reliable High Capacity Link between the Two Parts of the All-Island Transmission System

39 Due to the restrictions in the available transfer capacity of the existing interconnector, the level of security of supply support that can be provided by each system to the other is significantly limited. The *All Island Generation Capacity Statement 2014-2023* published jointly by EirGrid and SONI highlights how, for Northern Ireland, with this limited support, the availability of

[23] The key SEM Objectives are set out at http://www.allislandproject.org/GetAttachment.aspx?id=5d50b98a-5aef-47e1-a3f7-904cc7aeac9e.
[24] See *The Need for a Second North South Electricity Interconnector*, **Appendix 2.1**, **Volume 3B Appendices,** of this EIS and at www.eirgrid.com. This paper describes the detailed calculation of associated benefits for the project.

generation to meet forecast demand is subject to significant risk from 2016 and will be in deficit from 2021.

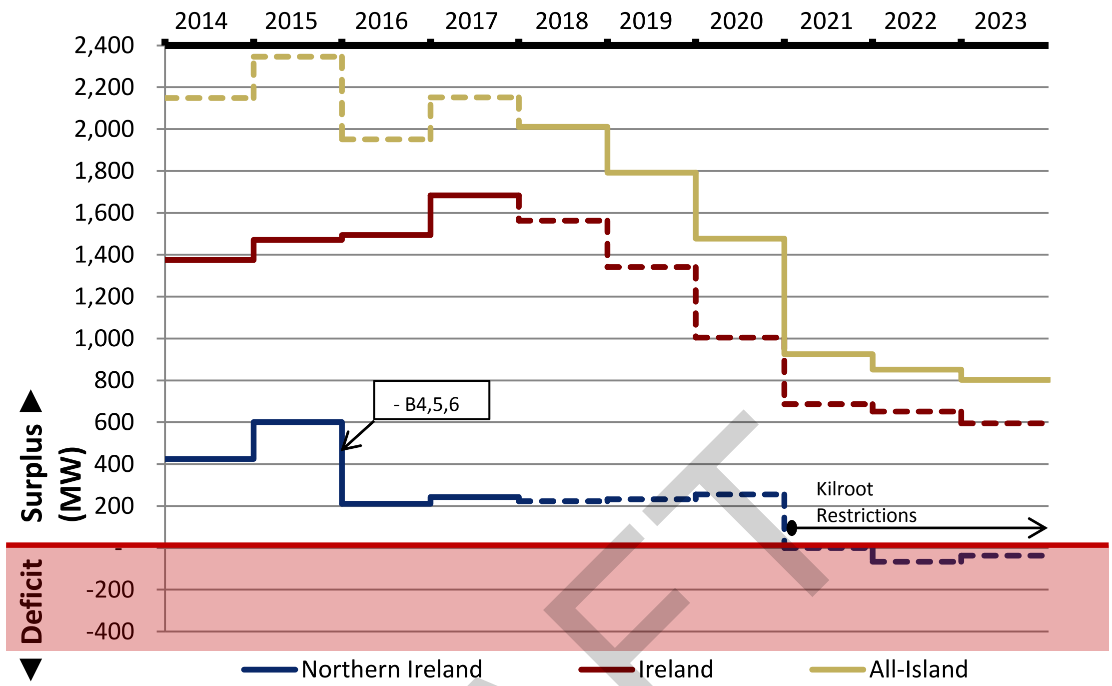


Figure 2.2: Forecasted Generation Capacity Adequacy on the Island of Ireland, 2014-2023[27]

Source: *All-Island Generation Capacity Statement 2014-2023*

40 Due to the risk to Northern Ireland security of supply identified in the Generation Capacity Statement 2014 – 2023, in the past year, action has been taken by the Utility Regulator and SONI, working with DETI, to address the risk. Following a competitive procurement process, a contract has been signed between SONI and AES Ballylumford for the provision of 250MW of Local Reserve services for a three-year time period commencing 1st January 2016, with an option to extend for a further 2 years. This contract has secured the continued operation of two of the steam units at Ballylumford at a slightly reduced capacity, to be made possible by investment in emission-abatement technology and like-extension works at this plant.

[27] The information presented here from the Generation Capacity Statement 2014 – 2023 is accurate at the time of writing. This report is updated annually. Since its publication, a short term contract for the provision of 250 MW of Local Reserve Services has been signed between SONI and AES Ballylumford to provide additional reserve in Northern Ireland prior to the commissioning of the Second North South Interconnector. In addition, the expected commissioning date of the second North South Interconnector has moved from 2017 to 2019. Neither the Local Reserve Services contract nor the revised commissioning date are reflected in figure 2.2.

41 The graph in **Figure 2.2** shows an update on the 2014-2023 generation capacity assessment and includes both the effects of retaining generation at Ballylumford through the Local reserve services contract (solid blue line 2016 – 2019) and of not retaining that generation capability (dotted blue line 2016 – 2019) It combines a number of assessments of generation adequacy between 2015 and 2024. The red line presents the results of a separate generation adequacy study for Ireland and the blue line presents the results of a separate generation adequacy study for Northern Ireland. The Ireland results are for that jurisdiction on its own, i.e. for the Ireland generation plant to meet the demand forecast in Ireland, without the additional north-south interconnector but with a 100MW reliance on Northern Ireland through the existing interconnector. Similarly the Northern Ireland study results are for that jurisdiction on its own, i.e. without the additional north-south interconnector and with a 200MW reliance on Ireland.

42 In addition to these two separate studies, an assessment has also been carried out to show the generation adequacy situation on an all-island basis, with all of the generation on the island being employed to meet the combined load forecast. This is indicated by the solid gold line. This assumes that the additional north-south interconnector is in place by the end of 2019.

43 For completeness, the single-area studies for Ireland (red) and Northern Ireland (blue) have been continued beyond 2019 (and shown as dashed lines) to illustrate the situation should the interconnector project be delayed. Similarly, as the results for the combined, all-island system (gold) are only applicable once the second interconnector is in place from 2019 onwards, all-island adequacy results are also shown before 2019 (gold dashed lines) to convey the situation should the interconnector be completed early. The benefit of this approach is that it allows a full consideration of the impact that the second north-south interconnector has on both jurisdictions over the entire period of generation adequacy assessment (2015-2024).

44 The graph illustrates how Northern Ireland is in significant surplus up to the end of 2015 (blue line). Following the closure of three generating units at Ballylumford at the end of 2015 and the introduction of emissions restrictions on the generating station at Kilroot at the start of 2016, if the second north-south interconnector is not in place the Northern Ireland adequacy position is close to deficit with surpluses reduced to modest levels of circa 200MW (Dotted blue line). The dotted blue line from 2016 to 2019 represents the situation as presented in the 2014 – 2023 Generation Capacity Statement. This means that even with a 200MW reliance on Ireland being available to Northern Ireland if the second north-south interconnector is not in place, Northern Ireland is at risk of a security of supply issue in the event of a prolonged outage of a large generation station or the Moyle Interconnector. The solid blue line between 2016 and 2019 represents the generation adequacy case with the extra generation capacity retained at Ballylumford. This extra capacity is assumed to remain in place until the commissioning of the second North South Interconnector in 2019 which provides the long term enduring solution to the security of supply problem in Northern Ireland.

45 From 2021, further emissions restrictions on the generating station at Kilroot have a large effect on system adequacy, and push Northern Ireland into significant deficit (dashed blue line). However, based on the ‗All Island' generation adequacy study (gold line), this deficit would be alleviated if the second north-south interconnector was in place. Under this scenario, Northern Ireland, as part of the combined all-island system, is found to be in surplus for the period of assessment. This highlights the importance of the proposed interconnector to maintain security of supply in Northern Ireland in the medium term and also demonstrates the enduring security of supply benefit to consumers across the island in the longer term.

2.3.3 Supporting the Development of Renewable Power Generation by Enhancing the Flexible Exchange of Power Flows over a Large Area of the Island

46 In response to Article 4 of *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources* [the Renewable Energy Directive], (refer to the *Planning Report,* **Volume 2A** of the application documentation for details), the Government of Ireland has submitted a *National Renewable Energy Action Plan (NREAP)* to the EU Commission. Northern Ireland contributes to the United Kingdom NREAP. The Government of Ireland and the Government of Northern Ireland have set clear policies for increasing the energy delivered from renewable energy sources on the island of Ireland. The geography and topography of the island of Ireland is such that both jurisdictions have substantial potential wind energy resources. The development and exploitation of these resources is expected to bring significant benefits to both economies, whilst improving the overall diversity of supply, reducing dependence on imported fossil fuels and decreasing CO_2 emissions in the power sector. In order to meet 2020 Renewable Energy Sources for Electricity (RES-E) targets in Ireland and Northern Ireland, it is projected that the amount of wind generation across the island of Ireland will reach an installed capacity of between 4,400MW and 4,900MW by 2020.[28] At these levels, Ireland and Northern Ireland will have one of the highest penetrations of renewable generation, as a percentage of system size, in the world. A key constraint to the practical development of wind powered generation is the ability of the existing transmission systems to absorb and manage this form of power generation.

47 The second north-south interconnector contributes to this objective by resolving the power transfer limitations that currently exist between both power systems. Resolving this power transfer issue will allow a re-consideration of a wide variety of operational metrics on an all-island basis. These operational metrics include synchronising torque, inertia, dynamic reactive power and reactive power. The ability to share these characteristics on an all-island basis not

[28] *All Island Generation Capacity Statement 2014-2023.*

only mitigates system separation but also enhances the capability of incorporating significantly greater volumes of RES-E than either system on its own could securely and efficiently manage.

48 The addition of the second interconnector therefore significantly contributes to power system stability on the island as the level of RES-E installed on the island increases to meet the future renewable targets in Ireland and Northern Ireland.

2.3.4 Reinforcement of the North–East Area of Ireland

49 During public consultation in respect of the previous application for approval of the Meath-Tyrone 400 kV Interconnection Development, the ‗need' for the development was, understandably, questioned in light of the decline in electricity consumption as a result of the economic downturn. The recent economic downturn commenced in the second half of 2008. It resulted in a significant and general decline in electricity consumption in Ireland. However, it is clear from the above sections, that the drivers for the establishment of a second north–south interconnector are not diminished to any material degree by the decline in national electricity consumption that has resulted from the economic downturn. The decline in electricity consumption in the north-east area of Ireland has, however, an obvious and significant effect on the need from a security of supply perspective for the reinforcement of the transmission network in that specific area.

50 As part of the re-evaluation of the proposed interconnector, which has been undertaken since the withdrawal of the previous planning application in June 2010, EirGrid has re-examined the security of supply risk in the north-east area in light of the economic downturn. Using the median demand forecasts from the *All Island Generation Capacity Statement 2014–2023,* it was found that the peak demand in the area will still be below the critical level for at least a decade. Therefore, unless there is a stronger recovery in the economy in the area and / or one or more new large industrial consumers emerge, reinforcement of the network in the area for security of supply reasons is not likely to be required within the current planning horizon, i.e. within the next ten years.

51 Although the need to reinforce the north-east area of Ireland for security of supply reasons is no longer an immediate driving factor for the delivery of the proposed interconnector (as that reinforcement is not now expected to be required for at least a decade), the presence of the interconnector will nevertheless provide reinforcement to the area by providing an additional high capacity circuit in the region, thus reducing flows on the existing circuits. Based on current predictions, such reinforcement will provide sufficient additional transmission capacity in the area to cater for growth in electricity consumption for many years and will also put the north-east area in a good position if an even stronger economic recovery should emerge in the coming years.

2.4 CONCLUSION REGARDING THE STRATEGIC NEED FOR THE PROJECT

52 It is a fact that both the CER and NIAUR have recommended that there exists a sound economic and strategic case for an additional high capacity interconnector linking the electricity transmission systems of Ireland and Northern Ireland. This recommendation has been endorsed by the two Governments of these jurisdictions[29].

53 The re-evaluation process (2010–2013) reconsidered the strategic need, rationale, justification and benefits of the interconnection development. It considered a range of benefits which underline the need for the proposed interconnector and the national and European Union (EU) policy objectives which support their effective delivery. The re-evaluation process also considered alternative options (including those raised by third parties during consultation) and explains why the second north-south interconnector is the only option that will fully address the strategic need identified.

54 The findings of the re-evaluation process concluded that:

- There remains a clear and immediate strategic need for a second north-south interconnector;
- A new and physically separate high capacity cross border interconnector circuit, connecting between appropriately robust parts of the two existing transmission networks north and south of the border, is the only option that will satisfy the identified strategic need; and
- An additional north–south interconnector ensures that the security of supply position in Northern Ireland is fully compliant with the generation adequacy standard for all study years covered in the latest *All-Island Generation Capacity Statement.*

55 The proposed interconnector will overcome the risk of system separation and, together with associated system reinforcement, will increase transfer capacity between the two systems. This will have the strategic benefits of improving market competition in the context of the SEM, of supporting the development of renewable power generation, and of improving security of supply.

---

29 CER and NIAUR assessment and evaluation - *Joint Report For the Case For a Second North-South Interconnector* Joint Government Endorsement*: All-Island Energy Market – A Development Framework*, p5, p10.

56 The resulting increase in cross-border interconnection capacity will allow consumers and producers on the island of Ireland to fully benefit from the SEM with savings of approximately €20m in 2020 rising to a range of between €40m and €60m by 2030.

3 SCOPING THE EIS

3.1 INTRODUCTION

1 Consultation is an important part of the Environmental Impact Assessment (EIA) process; in this context, consultation with statutory agencies, interested parties, the public and public concerned (including landowners) and other representative organisations provides an opportunity to *inter alia*:

- Identify matters regarding the project which inform the preparation of the Environmental Impact Statement (EIS);
- Incorporate mitigation measures where possible into the design of the project in early stages (for example, mitigation by avoidance of certain potential impacts), including those local impacts that might be identified during public and landowner consultation and engagement;
- Take into consideration the expertise and knowledge of individuals, landowners, local communities, experts, interest groups and statutory agencies and non-governmental organisations;
- Encourage participation in decisions yet to be made; and
- Ensure submissions and observations are taken into consideration by the competent authority during the decision making process.

2 The extent and nature of public consultation and participation in relation to all stages of the proposed development since 2007 is described in a separate *Public and Landowner Consultation Report* (see **Volume 2B** of the application documentation). This report sets out the objectives of the general consultation strategy, its structure, details of all consultation and engagement activities, feedback received and how such feedback was responded to.

3 This chapter separately outlines the requirements for consultation undertaken and relevant to the EIA process prior to submission of the application for planning approval to An Bord Pleanála (the Board), and specifically considers consultation as eliciting feedback in relation to:

- The matters which were considered by the various bodies, agencies groups and individuals to require evaluation in the EIS and the methods to be used for that evaluation;

- The likely effect of mitigation measures in order to determine the likely acceptability of any residual impacts; and

- The consideration of alternatives in order to ensure that options of interest to all parties are evaluated.

4 It should be noted that, as the EIA process is iterative, consultation and public participation can and will continue right through the development consent process.

5 The chapter also considers the scoping opinion received from the Board.

3.2 BACKGROUND

3.2.1 The Previous Application for Approval

6 As set out in **Chapter 1** of this volume of the EIS, a planning application was made to the Board for development consent in December 2009, which was subsequently withdrawn in June 2010.

7 A considerable body of work was undertaken in respect of the previous application, including the preparation and submission of an EIS and associated technical, environmental and planning documents. In order to ensure that the previous EIS addressed the issues that were likely to be of significance, an associated consultation and informal scoping exercise was carried out. Consultation consisted of interactions with the public concerned (including landowners), interested parties and prescribed bodies, as well as pre-planning consultations with the Board.

8 The EIS (2009) and associated technical, environmental, planning and other documents were also publically available during the period of the previous application for approval and the Board invited submissions from prescribed bodies, other stakeholders, the general public and other parties. In May 2010, the Board convened an oral hearing in respect of the proposed development. A number of prescribed bodies and a number of members of the public made further oral and written submissions at the oral hearing. This included submissions from certain statutory agencies in Northern Ireland.

9 The consultation during the previous application for approval has been inputted into the preparation of this EIS (2014). For example, in response to submissions made in respect of that previous proposal, this EIS includes consideration of agronomy as a topic.

3.2.2 The Re-evaluation Process and Report

10 Subsequent to the withdrawal of the previous application for approval, EirGrid undertook a comprehensive re-evaluation of the proposed development. The purpose of the re-evaluation process was to ascertain whether the scope, content, conclusions, and proposal of the previous application remain relevant for the purposes of informing and shaping the new application for approval.

11 The re-evaluation process was an important initial step in the public consultation process for the now proposed development as it revisited consideration of technical and route corridor / line route alternatives and involved a high level re-assessment of environmental considerations including likely impacts and mitigation measures.

12 The initial findings of the re-evaluation process were published for public consultation in a *Preliminary Re-evaluation Report* in May 2011. A *Final Re-evaluation Report* was subsequently published in April 2013 and it addressed a number of issues raised during, and subsequent to, the consultation process on the *Preliminary Re-evaluation Report*.

13 Appendix A of the *Final Re-evaluation Report* provided a review of the issues raised in written submissions to the Board and a review of presentations at the oral hearing in respect of the previous application for approval. Appendix B provided a response to submissions and other engagement arising during the re-evaluation process. Relevant key issues raised therein have informed the scoping and content of this EIS and are included in **Table 3.4.**

3.2.3 The Preferred Project Solution Report

14 Following on from the *Final Re-evaluation Report*, the *Preferred Project Solution Report* published in July 2013, provided detail as to the preferred line design for the proposed development. This preferred line design included identification of feasible locations for, and design of, the infrastructure, such as tower positions, tower types and associated construction related details (e.g. temporary access tracks).

15 Chapter 2 (and Appendix C) of the *Preferred Project Solution Report* outlined how submissions on the *Final Re-evaluation Report* were reviewed and considered by the project team. This included *inter alia*:

- Submissions received from prescribed bodies and other stakeholders on issues of relevance, or in response, to the *Final Re-evaluation Report*; and
- Submissions relevant to the prospective EIS.

16 The preferred line design as published in the *Preferred Project Solution Report* provided the focus for on-going landowner engagement, particularly in respect of the specific siting of structures on lands, as well as further environmental survey, design and evaluation, in consultation with prescribed authorities, other stakeholders and members of the public. The *Preferred Project Solution Report* also provided an opportunity to provide feedback on the issues to be addressed in the EIS. In this regard, Chapter 6 of the *Preferred Project Solution Report* provided a general summary of the EIA process and outlined the matters proposed to be addressed in the EIS for the proposed development. The majority of issues raised in subsequent written submissions and during discussions with stakeholders at the consultation events related to the potential impact of the proposed development on the environment which were broadly categorised under the following headings:-

- Agronomy;
- Community and Population & Economic Impact (including proximity to residential receptors);
- Property Devaluation and Loss of Development;
- Cultural Heritage & Archaeology;
- Ecology;
- Health and EMF;
- Landscape & Visual Impact;
- Noise; and
- Cumulative Impacts.

17 Section 4.5.2 of the *Public and Landowner Consultation Report* (see **Volume 2B** of the application documentation) sets out further detail in relation to the feedback received. For convenience, the key issues arising from engagement on the *Final Re-evaluation Report* and *Preferred Project Solution Report* which have informed the content of the EIS are included in **Table 3.4**.

3.3 EIS SCOPING AND ASSOCIATED CONSULTATION

3.3.1 Scoping

18 Scoping is an integral part of the preparation of an EIS. The process of identifying issues to be included in the EIS (or ‗scoping‘) involves appraising the project‘s possible impacts, considering available alternatives and deciding which impacts are likely to occur and likely to be significant based on the proposed development.

19 A developer can undertake an informal scoping exercise and consult with various parties in relation to this exercise. As noted above, all preceding consultation, including the previous application for approval, the re-evaluation process and the *Preferred Project Solution Report,* sought to inform and elicit opinion from stakeholders on all matters relating to the proposed interconnector. It also sought to ensure that the concerns of stakeholders were considered and addressed during the design process and inputted into the EIA process. Specific consultation was also undertaken with prescribed bodies (see **Section 3.3.3**) and others in respect of matters to be addressed in the EIS. This has informed the scoping and content of this EIS.

3.3.2 Pre-application Consultation with An Bord Pleanála in respect of the Content of the EIS

20 In accordance with section 182(E) of the *Planning and Development Act 2000* (as amended) (the 2000 Act), a series of pre-application consultations was held with the Board in respect of the proposed development which forms the subject matter of this application. Information provided by the Board during the course of these discussions and feedback received from the Board also in respect of the pre-application consultations held in respect of the previous application has also informed the EIS.

21 The key issues arising from these meetings relevant to the EIS are summarised in **Table 3.1** and are also included in **Table 3.4**.

Table 3.1: Pre-application Consultation with An Bord Pleanála

Date of Meeting	Key Issues
Previous Application for Statutory Approval	Relevant issues raised during the course of pre-application meetings in respect of the previous application included *inter alia*: • Alternatives (including underground (UGC) versus overhead line (OHL); route corridor options – including to the east of Navan); • Transboundary impacts; and • Route selection process in relation to houses, archaeology and cultural heritage.
2nd December 2010	The purpose of this meeting was to outline activities post withdrawal of the previous application (i.e. the Meath-Tyrone 400 kV Interconnection Development).
31st July 2013	The focus of this meeting was to update the Board on activities since the previous meeting including *inter alia* the findings of the Independent Expert Commission Review (on the case for, and cost of, undergrounding all or part of the Meath-Tyrone 400 kV Interconnection Development), the *Government Policy Statement on Strategic Importance of Transmission and Other Energy Infrastructure, The Final Re-evaluation Report,* and current activities following publication of the *Preferred Project Solution Report on 16th July 2013*. Issues arising of relevance to the EIS included: the implications (if any) of no longer seeking approval for the substation at Moyhill and whether the line could be located further to the east; the route selection process in relation to houses, ecology and historic landscapes; and tower alternatives.
20th August 2013	EirGrid requested a scoping opinion from the Board.
15th October 2013	The focus of this meeting was to update ABP on activities since the publication of the *Preferred Project Solution Report*, including landowner engagement, modifications to the indicative line design and issues arising. Discussions were also focused on procedures in relation to the potential transboundary environmental impacts of the proposed development on the environment of an area of a Member State.
11th December 2013	The Board issued its scoping opinion on the information to

Date of Meeting	Key Issues
	be contained in the EIS.
18th December 2013	The focus of this meeting was to update the Board on the drafting of the EIS and application particulars and to discuss the Board's scoping opinion. Other relevant matters included transboundary issues and procedures, the *Joint Environmental Report* and difficulties encountered.
23rd December 2013	This was a follow up meeting to clarify particular issues arising from the meeting of 18th December including the level of detail to be included in an outline *Construction and Environmental Management Plan* to be included as an Appendix to the EIS.

3.3.3 Consultation with Prescribed Bodies and Other Interested Parties in respect of the Content of the EIS

22 Section 182A(4)(b) of the 2000 Act (as amended) requires that on making an application for strategic transmission infrastructure development, the applicant must also submit the application documentation to the relevant local authorities and certain prescribed authorities. These authorities and other interested parties were issued project material and were specifically invited to make a submission in respect of matters / issues they considered relevant to the project. In addition, meetings (both formal and informal) were held with many parties, including the relevant local authorities.

23 As part of the informal scoping process undertaken by EirGrid, local and prescribed authorities and other interested parties have been circulated with project information since the withdrawal of the previous application for approval. Some of these parties are identified in **Table 3.2**. As set out in **Section 3.2.1**, all consultation during the previous application for approval (including submissions made by prescribed authorities and other interested parties at the oral hearing) has inputted into the process which culminated in the production of this EIS.

Table 3.2: Local and Prescribed Authorities and Interested Bodies Provided with Project Information prior to and since the Withdrawal of the Previous Application

Authority / Body	
Department of Arts, Heritage and the Gaeltacht	Irish Wildlife Trust
Department of Environment, Community and Local Government (including NPWS)	Railway Safety Commission
Department of Communications, Energy and Natural Resources	Iarnród Éireann
Department of Environment, Heritage and Local Government (National Monuments Service)	An Taisce
Meath County Council	Geological Survey of Ireland
Border Region Authority	Health Services Executive
Greater Dublin Area Regional Authority	Health and Safety Authority
Cavan County Council	Teagasc
Monaghan County Council	Irish Farmers Association
The National Roads Authority	Commission for Energy Regulation
Fáilte Ireland	Inland and Regional Fisheries Board
The Heritage Council	BirdWatch Ireland
Irish Aviation Authority	Environmental Protection Agency
Údarás na Gaeltachta	

24 Many of the prescribed authorities and interested bodies identified were also contacted by members of the project team with specific focus on informing the content of the EIS and a number of follow up meetings were held; the dates of such meetings are identified in **Table 3.3**.

Table 3.3: Meetings with Prescribed Authorities and Interested Bodies

Local & Prescribed Authorities	Meeting Dates
Department of Environment, Community and Local Government (including NPWS)	26th November 2011 13th November 2012 18th December 2012
Meath County Council	3rd September 2013 23rd October 2013 5th November 2013
Cavan County Council	23rd September 2013 17th October 2013
Monaghan County Council	5th June 2013 9th September 2013 22nd October 2013
Fáilte Ireland	18th September 2013
Inland Fisheries Ireland	1st October 2013

25 Key issues arising from consultation with prescribed authorities and other agencies which informed the content of the subject EIS are included in **Table 3.4**

26 It should be noted that the elected representatives of the relevant local authorities were also consulted during various phases of the project development process. This is detailed in the separate *Public and Landowner Consultation Report* (see **Volume 2B** of the application documentation).

3.3.4 Transboundary Consultation

27 It is also noted that EirGrid consulted with the Department of Environment Northern Ireland with regard to the information to be contained in the EIS. Issues raised were consistent with those identified in its response to the Board's scoping request.

3.3.5 Public Consultation in respect of the Content of the EIS

28 The EIA Directive has been amended, in line with the Aarhus Convention[30], to ensure that not only the authorities likely to be concerned by the project are given an opportunity to express their opinion on the information supplied by the developer but that the public (including the public concerned) is given early and effective opportunities to participate in the environmental decision-making procedures.

29 Specific details in relation to the public and landowner consultation process are detailed in the separate *Public and Landowner Consultation Report* (see **Volume 2B** of the application documentation). Issues arising from consultation with the public relevant to informing the content of the subject EIS are included in **Table 3.4.**

3.3.6 Landowner Consultation in respect of the Content of the EIS

30 This section relates to consultation that was carried out with individual landowners along the line route. The purpose of landowner consultation was *inter alia* to ensure that their views could be considered during the design process.

31 Specific details in relation to the landowner consultation strategy and process are detailed in the separate *Public and Landowner Consultation Report* (see **Volume 2B** of the application documentation). Issues arising from consultation with the landowners relevant to informing the content of the subject EIS are included in **Table 3.4.**

3.4 FINDINGS OF THE INFORMAL SCOPING AND CONSULTATION PROCESS

32 As noted, the process of scoping involves an appraisal of the project‘s possible impacts and the alternatives that should be considered, and deciding which impacts are likely to occur and to be significant.

33 A summary of the key concerns raised to date during all stakeholder consultation and relevant to the informal scoping the EIS is provided in **Table 3.4**.

[30] The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters.

Table 3.4: Issues Identified in the Scoping and Consultation Exercises

Topic	Main Issues Raised	Relevant Chapter
Need for the Proposed Development	The all island, national, regional and local purpose of / need for the proposed development should be clearly set out.	Volume 3B, Chpt 2
Description of Development	The full description of the nature, scale and extent of all aspects of the development including *inter alia* a description of the development within Northern Ireland, works to the existing Oldstreet to Woodland transmission line, substation works, temporary construction access routes, construction methodology etc.	Volume 3B, Chpt 6 and Chpt 7
Alternative Technologies	The potential to underground the proposed development (including partial undergrounding) was one of the main and recurring issues raised during consultations. Other alternatives raised included interconnection / network reinforcement options, the requirement for the inclusion of a substation(s) along the route, AC versus DC technology, subsea cable option and alternative tower designs.	Volume 3B, Chpt 4,
Alternative Routes	Route corridor section and route alignment considerations during and prior to the selection of the preferred development option were recurring issues raised during consultations. This included the balance and weighting given to sensitive receptors such as residential property and landscape in determining route choice. Other issues included proximity to dwellings.	Volume 3B, Chpt 5
Health	The main issues raised in relation to this topic included potential for adverse impacts on human health arising from EMF during the operational phase and public health and safety during the construction phase of the proposed development.	Volume 3B, Chpt 8 and Volumes 3C and 3D, Chpt 5
Community and Population & Economic	The effect that the project is having on the people of the local communities and its proximity to community facilities, including children's recreational areas and schools were raised. The potential impact on the business of the local air ballooning company, bed and breakfast tourist	Volumes 3C and 3D, Chpt 3

Topic	Main Issues Raised	Relevant Chapter
	accommodation and a helipad operations business was also raised.	
Flora & Fauna	The main issues of concern raised during consultations include potential impacts on designated sites (cSACs, SPAs and NHAs), species of conservation status, including Whooper Swans - listed under Annex 1 of the EU Birds Directive (EU79/409/EEC), fisheries and habitats of high local value within and in the vicinity of the proposed development (including within the aquatic environment). Potential impacts need to consider excavation and construction activities and the long term operational impacts of the development.	Volumes 3C and 3D, Chpt 6
Soils & Geology	The main issues raised under this environmental topic which merited detailed examination included areas of sensitivity such as County Geological Site (CGS) – including Altmush Stream and Galtrim Moraine, outcrops of bedrock, areas of karst or other types of highly permeable geology and ground potentially contaminated (physically or chemically) by historical or current activities.	Volumes 3C and 3D, Chpt 7
Water	The main issues raised under this topic relate to the potential for water pollution (both surface and groundwater) particularly during the construction stage (including excavation).	Volumes 3C and 3D, Chpt 8
Air Quality and Climate	This was not raised as a significant issue.	Volumes 3C and 3D, Chpt 10
Noise & Vibration	The main issues raised during consultation relate to the potential for noise from the OHL and vibration during the construction phase.	Volumes 3C and 3D, Chpt 9
Landscape & Visual	Given that the project consists of overhead lines supported by steel lattice towers, the main concerns raised in relation to this topic was its visibility and potential to impact the visual amenity of designated landscapes, protected views and other views of significant amenity along its length including for example Bective	Volumes 3C and 3D, Chpt 11

Topic	Main Issues Raised	Relevant Chapter
	Abbey, Donaghpatrick and Teltown. Specific issues raised included the Drumlin landscape of Monaghan and views from individual dwellings.	
Traffic	The main issues raised in relation to traffic relate to the construction phase of the project and the potential for increased construction traffic on roads; the relationship of the proposed development with planned roads (including the Leinster Orbital Route); and construction implications when building across roadways.	Volumes 3C and 3D, Chpt 13
Material Assets	The main issues raised were in relation to the potential impact of the proposed development on Trim airfield, existing and proposed windfarms and public utilities. Telecommunications was not raised during consultation and was not considered by the project team to be a significant issue.	Volumes 3C and 3D, Chpt 12
Land Use	The main issue raised in relation to this topic was agronomy including potential restrictions on farming, sterilisation of farmland beneath the line and construction access and methods.	Volumes 3C and 3D, Chpt 3
Tourism	The main issue raised in relation to this topic was the potential effects on the amenity / tourism value of the area, including designated tourist routes and related business. Examples of such locations included the Boyne Valley, Teltown, Monaghan Way and Trim Castle.	Volumes 3C and 3D, Chpt 4
Property	The main issues raised were in relation to the impact on residential properties in the vicinity of the proposed development (visual amenity, noise etc.) and potential property de-evaluation / sterilisation of lands from future development. Issues relating to amenity are addressed by specific environmental topics. Property de-valuation is not considered in this EIS; but is considered elsewhere in the application documentation.	Volumes 3C and 3D – various chapters
Cultural Heritage	The main issues raised in relation to this topic include potential impacts on archaeological,	Volumes 3C and 3D, Chpt 14

Topic	Main Issues Raised	Relevant Chapter
	architectural and other features of cultural heritage importance, arising from the proposed development. This includes the potential visual impact on listed sites and construction related impacts.	
Transboundary	Having regard to the linear nature of the project across two jurisdictions the potential for transboundary issues must be considered.	Volumes 3B, Chpt 9
Cumulative impact	The main issues raised in relation to the potential cumulative impacts of the proposal when considered with other existing, proposed developments related to new or proposed development in proximity to the line including wind turbines, other transmission projects and the SONI section of the proposed interconnector.	Volumes 3B, Chpt 10
Interrelationships between Environmental Factors	While almost all environmental aspects are interrelated to some degree, potentially significant interactions have been considered in this EIS.	Volume 3B, Chpt 10

3.5 AN BORD PLEANÁLA - SCOPING OPINION

34 Scoping, as contemplated by section 182A of the *Planning and Development Act 2000* (as amended), is carried out by the Board (as competent authority) on receipt of a request from a developer to provide a scoping opinion in writing. In August 2013, EirGrid requested the Board to provide a scoping opinion in respect of the proposed development. The Board consulted with various parties (including local and prescribed authorities and certain statutory agencies in Northern Ireland) before providing its scoping opinion on 11th December 2013 (refer to **Appendix 1.4, Volume 3B Appendices**, of the EIS).

35 The scoping opinion confirmed the issues identified during the informal scoping process undertaken by EirGrid as identified in **Table 3.4**. A summary of the Board's scoping opinion is presented in **Table 3.5**.

Table 3.5: Issues Identified in the Board's Scoping Opinion

Topic	Specific Issue Raised	Relevant Chapter
Alternatives – considered (national, regional and local)	The need to provide an outline of the following alternatives / options considered prior to the selection of the development option: interconnection / network reinforcement options, technologies, corridor options, design & scale of development / structures, inclusion of substation(s) along route and construction methodologies.	Volume 3B, Chpts 4, 5 and 7
Human Beings	• Identification of potential impacts on settlement patterns along the route. The Board specifically requested that existing dwellings, community facilities and public facilities be identified (such as schools and healthcare facilities) including any extant planning permissions. • An assessment of impacts on residential amenities from construction and siting of support structures and OHL. • Identification and assessment of operation impacts and human health including noise and EMF, based on recognised international standards. • Assessment and comparison of the effects of above and below ground development alternatives. • An assessment of the likely impacts on the linguistic or cultural heritage of the Gaeltacht area, or on the promotion of Irish as the community language. • Implications / impacts on the local, regional or national economy.	Volume 3B, 3C and 3D and other elements of the application documentation
Flora and Fauna	• Baseline data should include an ecological survey of all works sites at an appropriate time of the year. Survey work may also be required outside of the development sites. • Assessment of the impacts of flora, fauna and habitats to have regard to Natura 2000 sites, other (proposed) designated sites, Habitats Directive, Birds Directive, Wildlife Acts, Red Data Book species and biodiversity in general. • The assessment should include indirect effects of	Volumes 3C and 3D, Chpt 6

Topic	Specific Issue Raised	Relevant Chapter
	construction activities and access, as well as long term impacts of fragmentation and severance. • Assessment of potential impacts on the aquatic environment during construction and operation. • EIS should address invasive alien plant and animal species and methods to ensure they are not introduced or spread. • Assessment of the extent and impact of hedgerow removal or linear woodland loss along the route. • Identification of any requirement for licenses or derogations.	
Soils and Geology	The main items raised were: the inclusion of an assessment of potential soil erosion, the submission of a construction method statement (to include peat mitigation) and identification and assessment of potential impacts on sites of geological heritage interest (including Altmush Stream and Galtrim Moraine).	Volumes 3C and 3D, Chpt 7
Water	The main items raised were: the identification and assessment of the potential water quality impacts of excavation / construction activities proximate to water courses, assessment of potential hydrogeological impacts and submission of a construction method statement and management plan (including measures to protect water quality when diverting field drains / pumping groundwater).	Volumes 3C and 3D, Chpt 8
Air and Climate / Noise	Air and Climate were identified as minor issues not requiring significant studies. In terms of noise the Board requested a description and assessment of the noise environment at construction and operational phases (clearly measurable against the existing ambient noise environment).	Volumes 3C and 3D, Chpt 10

Topic	Specific Issue Raised	Relevant Chapter
Landscape	The Board requested the following: an overview of defined landscape character areas affected, identification of the area of visual influence of the development; an assessment of the impacts on landscape character and visual amenity including designated landscapes and views of amenity value; consideration of the impacts of the development on the character and setting of sites of cultural and historical interest and on historic landscapes, and identification of historic demesne landscapes along the route. Visual impacts of the development should be demonstrated by a series of scaled / accurate photomontages to include impacts on protected views / scenic routes. In addition the Board require consideration of the potential for alternative routing or partial undergrounding in sensitive landscape areas, or where separation between towers is reduced below average with resulting visual impacts. The rationale for the route / design approach adopted should be identified and the cumulative visual and landscape impacts of the development with the existing and proposed 110 kV and 220 kV network should be considered.	Volumes 3C and 3D, Chpt 11
Material Assets	In terms of material assets the Board require: the identification of the enhancement of existing electrical network infrastructure, the identification and assessment of public road crossings (including construction methodology); information on the likely effects on public utilities and services; submission of a construction management plan (addressing stringing options, road closures, detours, and impacts on railway infrastructure, access for construction, on-going maintenance and treatment of new / widened construction entrances). In addition the likely impact / restrictions for agriculture or commercial forestry and the assessment of the effects on the amenity / tourism value of the area including designated tourism routes (the Monaghan way) and impacts on fishing and fisheries tourism, the potential future use of disused railways and impacts on aviation transport (including Trim airfield).	Volumes 3C and 3D, Chpts 4, 12 and 13

Topic	Specific Issue Raised	Relevant Chapter
Cultural Heritage	The Board has requested the following information in relation to cultural heritage - identification and assessment of: archaeological heritage (including impacts on the character and setting of features of interest) as well as relationships between sites; and areas of social, cultural and historic interest (including Bective Abbey, Donaghpatrick, Teltown Zone of Archaeological Amenity and Muff Crossroads). The Board also requested the identification of any pre-application archaeological excavation or site investigation undertaken; any heritage in the vicinity of the route corridor; indirect effects of construction activity including access / routes on structures and buildings; and the impact on longer views from sites of national importance and significance.	Volumes 3C and 3D, Chpt 14
Transboundary Effects	The Board requested that a *Joint Environmental Report* be prepared. The joint report should ensure the implementation of a common approach and methodology for the identification and assessment of impacts arising across the overall project. The prospective applicants are advised to consult with the relevant authorities in Northern Ireland with regard to the information to be contained in the EIS.	Volume 4 of the application documentation

36 The scoping opinion also referred to the inclusion of a schedule of mitigation measures and a *Construction and Environmental Management Plan (CEMP)* in the EIS. The scope of these particulars was discussed in subsequent pre-application consultation with the Board. Following clarification of this matter, a schedule of mitigation measures is included as **Chapter 11** of this volume of the EIS and an outline CEMP is provided in **Appendix 7.1, Volume 3B Appendices**, of the EIS.

3.6 CONCLUSION

37 Having ascertained which environmental topics are of most significance and in particular the content of the Board's scoping opinion in relation to the proposed development, this EIS was prepared in accordance with the relevant legislation and having regard to *inter alia* the following documents:

- European Commission, *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (May 1999);

- European Commission, *Guidance on EIA Screening* (June 2001);
- European Commission, *Guidance on EIA Scoping* (June 2001);
- Environmental Protection Agency (EPA), *Guidelines on the information to be contained in Environmental Impact Statements* (March 2002);
- EPA, *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements)* (September 2003) and, in particular, guidelines given for Type 20 projects outlined in that document;
- European Commission, *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects* (May 2013); and
- European Commission, *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* (April 2013).

4 TRANSMISSION AND TECHNOLOGY ALTERNATIVES

4.1 INTRODUCTION

1 EirGrid is obliged, pursuant to the terms of its licence as Transmission System Operator (TSO), to develop the electricity transmission system using cost effective, technically and environmentally acceptable solutions. This chapter sets out the context in which the main alternatives were considered by EirGrid for the proposed development and an indication of the main reasons for the final project chosen, taking into account the effects on the environment. It outlines the main transmission and technology alternatives considered by the respective applicants to meet the identified need set out in **Chapter 2** of this volume of the Environmental Impact Statement (EIS). It addresses the alternative technologies and methods for delivery considered appropriate for transmission interconnection design, capacity and circuit operation. The alternative route options for the proposed development are outlined in **Chapter 5** of this volume of the EIS.

2 This chapter also identifies the project objectives / design criteria required of the proposed development and considers and assesses the technology options including the form of electrical current (Alternating Current (AC) or Direct Current (DC)) and design (overhead line (OHL), underground cable (UGC) and off-shore submarine cable). It also considers the option of partial undergrounding - that is a combination of 400 kV AC UGC and 400 kV AC OHL (for this project) and alternative OHL support structures.

3 The consideration of transmission and technology alternatives as set out in this chapter has occurred over a considerable period of time dating back to 2001. Of importance, it should be noted that the consideration of the alternative transmission and technology alternatives as set out in this chapter did not occur in a chronological format. For clarity, however, the various issues are set out under clear subject headings.

4 Where appropriate, reference is made to studies and reports which have informed EirGrid and NIE in their consideration of transmission alternatives for the proposed project. In this context five studies were commissioned jointly by EirGrid and NIE or by Government to evaluate potential transmission alternatives specifically for the proposed project. A summary of these studies and their findings is included in this chapter. The overall process has also included reviews and updates to ensure that the conclusions drawn by EirGrid (in association with NIE) have been fully informed by the latest developments in worldwide power transmission technology and practice. A summary of these updates and reviews is also included in this chapter.

5 This chapter of the EIS also relies on the considerable body of work undertaken during the previous evaluation of the transmission and technology alternatives for the Meath-Tyrone 400 kV Interconnection Development application to An Bord Pleanála for planning approval in 2009 (which was subsequently withdrawn) and the comprehensive re-evaluation of that portion of the proposed interconnector occurring within Ireland since the withdrawal of that previous application. This re-evaluation process (which is described in **Chapter 1** of this volume of the EIS) had regard *inter alia* to the findings of the International Expert Commission (IEC) who were appointed by the Minister for Communications, Energy and Natural Resources to:-

- Examine the case for, and cost of, undergrounding all or part of the Meath–Tyrone 400 kV line (now known as the North-South 400 kV Interconnection Development – the subject of this application); and

- Review expert literature already available both in Ireland and internationally in relation to undergrounding high voltage (HV) power lines.

6 The re-evaluation process included *inter alia* a review of the transmission and technology alternatives considered for the previous Meath-Tyrone Interconnection Development to ascertain whether they remain applicable for the proposed development and accordingly, it is relevant as background to this chapter. This work is detailed in the following publications:

- *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report* (May, 2011);

- *North-South 400 kV Interconnection Development Final Re-evaluation Report* (April, 2013); and

- *North-South 400 kV Interconnection Development Preferred Project Solution Report* (July 2013).

7 A summary of these can be found in **Table 4.4.**

4.1.1 Legislative Context

8 Annex IV to the Environmental Impact Assessment (EIA) Directive and Schedule 6 of the *Planning and Development Regulations 2001* (as amended), both require that information to be contained in an EIS includes –*An outline of the main alternatives studied by the developer and an indication of the main reasons for his or her choice, taking into account the effects of the environment.”*

9 In preparing this chapter of the EIS we have referred to the *Guidelines on the information to be contained in Environmental Impact Statements* (March 2002), *Advice Notes on Current Practice* (in the preparation of Environmental Impact Statements) (September 2003), published by the Environmental Protection Agency (EPA) and the *Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment* (2013). (Additional specialist EIA guidance documents are referenced throughout this EIS).

10 Paragraph 2.4.3 of the *Guidelines on the information to be contained in Environmental Impact Statements*, notes that it is important to acknowledge the existence of difficulties and limitations when considering alternatives. These include:

> *"Hierarchy*
> *EIA is only concerned with projects. Many projects, especially in the area of public infrastructure, arise on account of plans, strategies and policies which have previously been decided upon. It is important to acknowledge that in some instances neither the applicant nor the competent authority can be realistically expected to examine options which have already been previously determined by a higher authority (such as a national plan or regional programme for infrastructure or a spatial plan)*
>
> *Non Environmental Factors*
> *EIA is confined to the environmental effects which influence the consideration of alternatives. It is important to acknowledge that other non-environmental factors may have equal or overriding importance to the developer, e.g. project economics, land availability, engineering feasibility, planning considerations."*
>
> *Site-Specific Issues*:
> *The consideration of alternatives also needs to be set within the parameters of the availability of land (it may be the only suitable land available to the developer) or the need for the project to accommodate demands or opportunities which are site specific. Such considerations should be on the basis of alternatives within a site e.g. design and layout."*

11 These matters are of relevance to the proposed development. In relation to the strategic matter of determined policy, reference is made to EirGrid plans and strategies including *Grid25 – A Strategy for the Development of Ireland‟s Electricity Grid for a Sustainable and Competitive Future (2008)*, *Grid25 Implementation Programme 2011-2016* (which was the subject of a Strategic Environmental Assessment (SEA)) and the *Transmission Development Plan 2013-2023* (and environmental appraisal report which assesses the draft plan against the provisions of the Grid25 Implementation Programme 2011 – 2016 SEA). In addition, the *National Spatial Strategy 2002-2020*, the *National Development Plan 2007-2013*, the *Border Regional Authority Planning Guidelines 2010-2020*, the *Regional Planning Guidelines for the Greater Dublin Area*

2010-2022, and the Monaghan, Cavan and Meath County Development Plans have recorded strong energy policies in support of projects to generally deliver high voltage electrical infrastructure and future corridors for energy transmission. Strategic and Statutory policy also records strong energy policies in support of projects linking the electricity transmission systems of Ireland and Northern Ireland. Other policies such as reducing dependence on fossil fuels, accelerating the growth of electricity by renewable sources and achieving EU-wide targets for renewable energy by 2020, all point to a determined policy context within which the consideration of this Interconnector project is merited. (Refer to the *Planning Report*, **Volume 2A** of the application documentation for details of this policy context).

12 With regard to non-environmental factors, as described by the EPA, a central aspect of material relevance to the proposed project is the EU led requirement to establish a Single Electricity Market (SEM) (refer to **Chapter 2** of this volume of the EIS). Interconnector projects are considered crucial to secure both the commercial capacity and the security of the transmission network. The proposed second interconnector will have the strategic benefits of improving market competition in the context of the SEM, of supporting the development of renewable power generation, and of improving security of supply.

13 On the matter of site specific issues, and as per the guidance of the EPA, varying configurations of feasible route corridor options for the proposed second interconnector were mapped and assessed (refer to **Chapter 5** of this volume of the EIS).

14 The EPA report, *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements)* (2003), elaborate on the manner of presentation as to ‗Alternatives Considered' in an EIS. Specifically the report states that:

> *"Alternatives, where relevant, may be described at three levels indicating the main reasons for choosing the proposed development. These consider alternative locations, designs and processes."*

4.1.2 Outline of Main Alternatives Considered

15 The consideration of the main alternatives in respect of the proposed development was undertaken jointly by the respective applicants and has occurred throughout an extensive and coordinated decision-making process, over a considerable period of time. The main alternatives considered relate to transmission, technological and route alternatives.

16 The main alternatives considered for the proposed development, and where they are addressed in the EIS, are identified in **Table 4.1**.

Table 4.1: Consideration of the Main Alternatives

Alternative	Context	EIS Chapter
Designs	A number of different solutions are available for most design issues such as varying the site layout, building massing or location of facilities. Where designers are briefed at an early stage about environmental factors, these can usually be incorporated along with other design parameters. For the proposed development, the consideration of alternative designs focuses on Transmission and Technology Alternatives relating to the character and physical form of the planned transmission infrastructure, including alternative tower design.	Chapter 4 of Volume 3B
Locations	Some locations have more inherent environmental problems than others. Such sites can usually be avoided in favour of sites which have few constraints and the maximum capacity to sustainably assimilate the development. For the proposed development, the consideration of alternative locations focuses on Route Alternatives relating to the identification of the route alignment.	Chapter 5 of Volume 3B
Processes	Within each design solution there can be a number of different options as to how the process or activities of the development can be carried out. These can include management of emissions, residues, traffic and the use of natural resources. Consideration of environmental factors can influence the selection of processes which avoid adverse impacts. For the proposed development, the consideration of alternative processes will focus on the environmental topics considered and will comprise the description and analysis of impacts on specific environmental topics and suggested mitigations measures.	Chapters 2-14 of Volumes 3C and 3D

4.2 DO NOTHING ALTERNATIVE

17 It is best practice in Environmental Impact Assessments (EIA) to consider the ‗Do Nothing‘ alternative – i.e. where no development occurs. Under a ‗Do Nothing‘ alternative, the strategic transmission infrastructure and its associated development would not be constructed. The land upon which such development is proposed to occur – primarily comprising agricultural land - would remain unchanged (unless developed for some separate purpose). As a consequence, the environmental impacts, identified in this EIS, positive and negative, would not occur.

18 Furthermore, under a ‗Do Nothing‘ scenario, there would remain a single interconnector between the transmission systems of Ireland and Northern Ireland, with consequent limitations, as set out at **Chapter 2** of this volume the EIS. Of particular note, there would remain an inherent risk of system separation, requiring a constraint on the total transfer capacity available on the existing interconnector. This would serve to frustrate the operation of the SEM, as per the Single Electricity Market Directive (2003/54/EC); it would also significantly frustrate current Government targets for 40% of National electricity consumption from renewable sources by 2020. The ‗Do Nothing‘ scenario would also fail to offset the likely environmental impact of any alternative options to secure the future reinforcement of the transmission infrastructure in the north-east area of Ireland.

19 Having regard to all of the above, the ‗Do Nothing‘ alternative is not considered to be appropriate.

4.3 STRATEGIC NEED

20 **Chapter 2** of this volume of the EIS sets out the ‗case for need‘ for the proposed interconnector and shows that there are three key drivers for the proposed interconnector:

i. Improving all-island electricity market competition;

ii. Improving the security of supply; and

iii. Supporting the development of renewable generation.

21 The proposed interconnector is being developed jointly by the respective applicants in response to all three of these fundamental and inter-related strategic needs.

4.4 ALTERNATIVES TO TRANSMISSION NETWORK SOLUTIONS

4.4.1 Context

22 The ‗all-island‘ Single Electricity Market (SEM) structure has been designed to separate the electricity supply chain into three fundamental parts:

- Power generation (production);
- Electricity transmission and distribution (delivery); and
- Electricity supply (retail sales).

23 This market structure relies fundamentally upon the transmission and distribution network infrastructure to link the sources of electricity production to the points of electricity demand. The owners and operators of the networks on the island of Ireland are required, under their respective Licences, to provide generators and suppliers with effective and efficient pathways for the delivery and sale of electricity to electricity users, if the cross-border transmission network is not developed, the following considerations become relevant.

4.4.2 Transmission System Limitations and Consequences

24 The existing Louth-Tandragee 275 kV double circuit OHL forms the primary existing interconnection pathway between Northern Ireland and Ireland, but further and more effective interconnection arrangements are required to meet the three strategic objectives listed in **Section 4.3**.

25 Due to the fact that both of the existing 275 kV interconnection circuits are supported on the same set of structures, there is a real risk that they could both be forced out of service simultaneously by a single event. Such a loss of interconnection would bring about an electrical separation of the transmission networks in Northern Ireland and Ireland and depending upon the operating conditions at the time, could lead to widespread outages of electricity supply and the potential collapse of the importing transmission network. The risk of such an event is unacceptable, and for this reason the TSO currently impose a transfer capacity restriction on the existing Interconnector. This ensures that if there is a sudden loss of the interconnector, the shock to the network is limited to a level that can be managed without widespread black-outs.

26 However, the restriction described creates a ‗bottleneck‘ in the network, seriously limiting the scope for commercial exchanges of electricity between generators and suppliers in each part of the all-island electricity market, and leading to inefficiencies and costs that are passed through to final customers as part of their electricity prices.

27 Another issue of increasing concern, as more fully explained in **Chapter 2** of this volume of the EIS, is that future reductions in generation capacity within Northern Ireland could lead to a shortfall in available electricity supply north of the border in the years beyond 2016. In these circumstances, the ‗bottleneck‘ described, which limits the ability of the network to transfer electricity from available spare power generation capacity in the south, could seriously threaten electricity supply security in Northern Ireland.

4.4.3 Potential Alternatives for Addressing the Emerging Shortfall in Generation Capacity in Northern Ireland

4.4.3.1 Potential Alternative: New Conventional Generation in Northern Ireland

28 One measure to reduce the impact of the transmission capacity restrictions described could be to build further generation in Northern Ireland.

29 It is conceivable that a new conventional generation plant constructed in Northern Ireland would improve security of supply issues in the medium term; however, it must be recognised that investment in new generation is at the discretion of independent commercial ventures, and market forces have not produced any proposal for new conventional generation to date.

30 Enforcing the construction of a new power station to improve security of supply in Northern Ireland could not be achieved without creating fundamental distortions in the SEM. Such distortions would, in their turn, have a consequential adverse impact on other existing generators, further jeopardising future investment in generation.

31 It should also be noted that this solution to electricity security concerns would not address either of the other two primary strategic needs, i.e. improving market competition or enabling the increased use of renewable energy.

32 The addition of further power generation capacity in Northern Ireland, without addressing the need to transfer and exchange power flows across the border, would further exacerbate distortions in the electricity market, and would perpetuate conditions in which all-island electricity prices would remain higher than necessary.

4.4.3.2 Potential Alternative: Longer Life for Existing Conventional Generation in Northern Ireland

33 The generation shortfall in Northern Ireland is exacerbated by European emission restrictions that are precipitating the closure of its existing generation before its mechanical end-of-life. It is possible that the security of supply shortfalls described in **Chapter 2** of this volume of the EIS could be deferred for a period by the introduction of time limited derogations such that certain generators may be able to continue to operate for a longer period of time. However, such a move would introduce significant market costs and would prolong elevated environmental emissions associated with the use of older plant. At best, it would also be a short term market solution, and would not therefore remove the need for additional interconnection.

34 It should also be noted that this potential solution to electricity security concerns would not address either of the other two primary strategic needs, i.e. improving market competition or enabling the increased use of renewable energy.

35 The life-extension of additional conventional generation in Northern Ireland, without addressing the need to transfer and exchange power flows across the border, would extend conditions in which all-island electricity prices would remain higher than they should be.

4.4.3.3 Potential Alternative: Increased Dependence on Renewable Energy

36 Whilst there are ambitious plans for onshore and offshore renewable generation to connect in Northern Ireland and Ireland in future years, the intermittent nature of wind, wave or solar generation precludes it from being relied upon for secure electricity supplies in the way that conventional power stations are. The future connection of renewable sources of electricity generation would therefore not remove the need for a level of access to conventional generation in the SEM to supply NI electricity needs.

37 It is also important to note that investment proposals for renewable energy projects invariably depend upon an expectation that there will be a network pathway to transport the electricity produced to a party that wishes to purchase and use that electricity. If there is no development of increased interconnection capacity and there are therefore continuing restrictions in access to the all-island network, then these restrictions will continue to limit the viability of investment cases for renewable energy, and will therefore limit the number of such developments that can be achieved in reality.

4.4.3.4 Conclusion on Non-Transmission Network Solutions

38 It is considered that to achieve the objectives listed in **Section 4.3** whilst avoiding the security of supply, economic and environmental risks discussed, there is no feasible or desirable alternative to the development of a transmission network solution. The only way to meet the strategic needs described in **Chapter 2** of this volume of the EIS whilst also delivering a downward pressure on electricity prices is to enhance the transmission interconnection capacity between Ireland and Northern Ireland.

4.5 PROJECT OBJECTIVES / DESIGN CRITERIA

39 In assessing technical alternatives for the design and construction of the proposed interconnection infrastructure, it is necessary to acknowledge the need for a technical solution that ensures a transmission system that, although connecting two separately owned systems within two separate jurisdictions, will be operated as an integrated transmission system and which will service a single integrated market in which operational constraints are minimised.

40 It is also a requirement of this development that the new interconnector connects between appropriately robust points on the transmission networks north and south of the border and that it be physically remote from the existing north-south interconnector. This strategic technical consideration, which has implications for the choice of study area, is addressed in **Chapter 5** of this volume of the EIS.

41 Transmission alternatives were therefore considered against a number of key performance objectives which must be achieved regardless of the particular technological alternative that is actually employed. These objectives derive from the overall performance requirements of the proposed interconnector as described in **Chapter 2** of this volume of the EIS, and also from EirGrid's statutory obligations.

42 The objectives and / or design criteria for the proposed development are to:-

a) Comply with all relevant safety standards;

b) Comply with all system reliability and security standards;

c) Provide an environmentally acceptable and cost effective solution;

d) Have a power carrying capacity in the region of 1,500MW, and connect between appropriately robust points on the transmission networks north and south of the border;

e) Facilitate future reinforcement of the local transmission network in the north-east area;

f) Facilitate future grid connections and reinforcements; and

g) Comply with ‗Good Utility Practice'[31] or ‗best international practice'.

43 EirGrid's statutory obligations are noted in the recent *Government Policy Statement on the Strategic Importance of Transmission and Other Energy Infrastructure* (July 2012) where it states that:

> *―The State network companies are mandated to plan their developments in a safe efficient and economic manner. They are also required to address and mitigate human, environmental and landscape impacts, in delivering the best possible engineering solutions*.
>
> *The major investment underway in the high voltage electricity transmission system under EirGrid"s Grid 25 Programme is the most important such investment in Ireland"s transmission system for several generations.*
>
> *While the Government does not seek to direct infrastructure developers to particular sites or routes or technologies, the Government endorses, supports and promotes the strategic programmes of the energy infrastructure providers, particularly EirGrid"s Grid 25 investment programme across the regions, and reaffirms that it is Government policy and in the national interest, not least in the current economic circumstances that these investment programmes are delivered in the most cost efficient and timely way possible, on the basis of the best available knowledge and informed engagement on the impacts and the costs of different engineering solutions". (p.6)*

44 The project objectives / design criteria outlined guide the consideration and assessment of the alternative technology options for the proposed interconnector. It is within this context that the application of *―the best available knowledge and informed engagement on the impacts and the costs of different engineering solutions"* will ensure compliance with the Government Policy Statement.

[31] In this Chapter of the EIS the terms ‗Good Utility Practice' and ‗best international practice' are interchangeable. The term ‗Good Utility Practice' is widely recognised and adopted as a policy, either voluntarily or by regulation, within the industry. The principle behind good utility practice is that electric utilities will adopt the practices and methods of a significant portion of utilities within a specified geographic boundary. In the case of EirGrid the relevant utilities are the 41 members of ENTSO-E (European Network of Transmission System Operators for Electricity) that are drawn from 34 countries in Western Europe.
It should also be noted that compliance with good utility practice does not preclude the use of innovative practices, methods or technologies; however, when such innovative practices, methods or technologies are under consideration, the accompanying risk of failure and consequence of such failure must also be considered.

4.6 SPECIFIC STUDIES COMMISSIONED BY THE RESPECTIVE APPLICANTS ON ALTERNATIVE TRANSMISSION TECHNOLOGIES

45 The respective applicants have worked together over many years to jointly consider and assess the various technological alternatives available for the proposed second interconnector. In order to ensure that the development process was fully and properly informed with respect to the available technological alternatives (notwithstanding the initial presumption that OHL would represent a superior solution and that an acceptable OHL route could be identified for the proposed interconnector) the respective applicants jointly commissioned five studies to evaluate potential transmission alternatives specifically for the proposed interconnector. The main objective of the studies was to inform both companies about the latest available alternative transmission technologies, and also to assist the on-going consultative and planning processes relevant to the overall project as applicable to elements being proposed within each jurisdiction.

46 Four of these studies were informed by specific data on the actual technical characteristics of the transmission systems within each jurisdiction on the island of Ireland and by reference to the geographic locations and prospective routes applicable to the required transmission circuits. The studies were:

- **The PB Power Preliminary Briefing Note** (Parsons Brinckerhoff, Power Division [PB Power], 2008). A short report, published at an early stage in the project development process, drawing upon generic information to summarise in general terms the technical and cost issues associated with implementing the proposed transmission circuit.

- **The PB Power Study** (PB Power, 2009). A thorough report describing the conclusions drawn from a detailed study by PB Power following the publication of the Preliminary Briefing Note. The study was specific to the proposed project, and compared a high voltage OHL transmission option with UGC options utilising either HVAC or HVDC technologies.

- **The TEPCO Study** (TEPCO, 2009). A system wide study that considered the implications, for transmission system reliability and stability, of incorporating very long lengths, and large quantities, of High Voltage (HV) UGC transmission infrastructure on the all-island AC transmission network. The study was performed by Tokyo Electric Power Company of Japan (TEPCO) who, as owner and operator of the world's longest existing UGC circuit operating at a voltage of 400 kV or above, is uniquely placed to bring its specific experience to bear on the subject.

- **The TransGrid Study** (TransGrid, 2009). A system wide study that considered the implications for transmission system reliability and stability of incorporating HVDC circuits into the integrated all-island AC transmission network. This study was performed by TransGrid Solutions (of Winnipeg, Canada), a consultancy with extensive international experience in the evaluation of HVDC technology. The study included specifically an examination of the viability of using this technology for a second north-south interconnector.

- **The PB Power Technology and Costs Update** (PB Power, April 2013 and Supplementary Note July 2013). A report summarising the results of a further study carried out to update the information provided in the *PB Power Study* of 2009. This report includes a review of up to date technology and application developments worldwide. It also draws upon information and conclusions published within a number of recent relevant studies (including the IEC Report of 2012) into the subject of transmission technology alternatives. A key output from the updated study has been to provide up to date comparative costs for the identified alternatives.

47 The objectives of each of these studies, and the conclusions set out in each of the associated reports, are described in further detail in **Table 4.2**. A copy of each report is provided in soft copy as part of the Bibliography for this volume of the EIS.

Table 4.2: Reports on Alternative Transmission Technologies Commissioned Jointly by the Respective Applicants

Report Title	Context of Report	Main Findings / Observations of Report
PB Power Preliminary Briefing Note - *Island of Ireland Cavan-Tyrone and Meath - Cavan 400 kV projects Preliminary Briefing Note Overhead and Underground Energy Transmission Options* Prepared by Parsons Brinckerhoff this was issued as an interim report **February 2008**	The *Preliminary Briefing Note* sets out a comparative overview of the technical and economic issues arising in respect of OHL and UGC transmission infrastructure options, with particular reference to the proposed Tyrone to Cavan element of the proposed interconnector. The document notes that both OHL and UGC technologies are proven in service, but includes a number of observations. The Briefing Note focused primarily on HVAC technology. The document did not include a review of HVDC technology because, at this early stage in the project, it appeared that the high land-take and high costs of terminal stations would not offer any benefits over the AC solutions.	UGC technology has not yet been tried anywhere in the world for a transmission infrastructure circuit approaching the route length of that proposed. HVAC OHL technology accounts for over 99% of Extra High Voltage (EHV) transmission infrastructure worldwide as it is considered to represent the best balance from an economic, technical and environmental perspective. UGC technology is noted to play an important role in urban and congested areas, or where site specific environmental constraints occur, for example within an area of outstanding scenic beauty. UGC technology is significantly more expensive than OHL technology. There can be considerable variation in cost ratios dependent upon the terrain and the circumstances. The Briefing Note stated that further work would be undertaken to examine the specific feasibility issues relevant to the prospect of undergrounding the proposed interconnector.
The PB Power Study - *Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits Comparison of high-voltage transmission options: Alternating current overhead and underground, and direct current underground* Prepared by Parsons Brinckerhoff **February 2009**	This study considers use of alternative technologies for the proposed interconnector. It makes two sets of comparisons: • HVAC UGC as an alternative to the proposed HVAC OHL; and • HVDC UGC as an alternative to the proposed 400 kV HVAC technology. In each case the comparison of the technologies addresses routing feasibility, high-level environmental considerations, and the installation and cost differences that would be associated with the alternatives.	HVAC OHL transmission is the most widely used method of bulk power transfer in Europe and represents the lowest cost technically feasible approach to establishing and maintaining a secure electrical power grid. Global transmission development activity suggests that this preference by utilities for the use of OHLs is likely to persist into the future. The longest XLPE transmission cable (in the range 380 kV to 500 kV) is 40km and runs in a tunnel. If implemented using AC UGC the proposed interconnector would be the longest such cable circuit worldwide at approximately 135km. HVAC OHLs are susceptible to environmental effects and thus normally exhibit fault rates higher than those of UGC circuits. However, average repair times of UGC are much higher than those of OHL.

Report Title	Context of Report	Main Findings / Observations of Report
		High voltage UGC has the capacity to inflict considerable short term (construction period) and long term operational negative impact on the environment - however, mitigation measures can be put in place. Both high voltage OHL and UGC produce power frequency magnetic fields whose strengths would be directly proportional to the electrical load being carried at any instant. The insertion of a HVDC transmission circuit into the HVAC transmission network would introduce more system complexity than an HVAC OHL. Cost estimates for each option were calculated. The construction cost estimate for the UGC option was calculated by firstly identifying a potential route for the UGC alternative from County Meath to County Tyrone (See **Figure 4.1**)**;** then identifying the different types of landscape along this route as well as all rivers and roads that would have to be crossed; then calculating a cost per km per landscape type, a cost per major and per minor river and road crossing and using this data to build up a cost for installing UGC along the entire route. The cost of the OHL option was calculated by estimating a cost per km for 400 kV OHL (based on PB Power‘s international experience) and multiplying this by the length of the OHL in kilometres. Whole–of-project cost estimates (construction and lifetime running costs) for high voltage AC and DC UGC compared to 400 kV OHL shows OHL to be significantly more cost effective.
The TEPCO Technical Study *Assessment of the Technical Issues relating to Significant Amounts of EHV Underground*	The respective applicants jointly commissioned TEPCO to undertake a system-wide study that considers the implications, for transmission system reliability and stability, of incorporating very long lengths, and large	The study concludes: Part 1: Identified a potential for the occurrence of ‗severe‘ Temporary Overvoltage‘s (TOVs) which would exceed the withstand capability of the installed equipment. The Study concludes that the magnitude of these TOV‘s is such that there are no technical

Report Title	Context of Report	Main Findings / Observations of Report
Cable in the All-Island Electricity Transmission System Prepared by Tokyo Electrical Power Company of Japan (TEPCO) **November 2009**	quantities, of HV UGC transmission infrastructure on the AC transmission network of the island of Ireland. The Study was carried out in 3 parts: Part 1: Evaluation of the potential impact on the all-island transmission system of significant lengths of EHV UGC, either individually or in aggregate. Part 2: Feasibility study on the 400 kV Woodland – Kingscourt – Turleenan line as AC UGC for the entire length. Part 3: Feasibility study of the 400 kV Woodland – Kingscourt – Turleenan line as mixed OHL / UGC.	solutions currently available to mitigate this risk and the only option available would be to use operational counter measures. Part 2: To achieve the required 1,500MW capacity, the optimum UGC solution is a 400 kV double circuit 1,400mm^2 aluminium cable - requiring a total of 2,600MVArs (1,300MVArs per circuit) of reactive compensation would be required at the proposed terminal points and an additional reactive compensation installation approximately half-way between Turleenan and Moyhill (Kingscourt). Part 3: No significant TOVs were identified for the mixed OHL / UGC. However, further detailed studies relating to the particular positions and lengths of cable sections in order to determine the measures that may be taken to ensure safety and stability from the overall circuit would be necessary.
The TransGrid Study - *Investigating the Impact of HVDC Scheme in the Irish Transmission Network* Prepared by TransGrid solutions Inc. of Canada **October 2009**	The study involved a technical comparison of HVAC OHL versus HVDC UGC and one section dealt in particular with the proposed Meath-Tyrone 400 kV Interconnection Development.	There are no working examples in the world of a multi-terminal HVDC scheme, embedded in a meshed AC network as would be required for the proposed Meath-Tyrone Interconnection Development. Such a scheme is however in theory at least, technically feasible. Having carried out a technical comparison of HVDC versus HVAC technology for this proposed development it was found that there are no significant reasons to select HVDC over HVAC. The AC option showed significantly lower loses, fewer overloads in the Louth / Tandragee / Turleenan area, a stronger system at the Moyle Interconnector terminal and a less complex control and protection scheme. Embedding a HVDC circuit in a meshed AC network –*can impose an added complexity to future network planning and expansion. For instance when planning the system it is difficult and expensive to tap into an existing HVDC circuit whereas an AC circuit can be easily tapped to serve new load or build a new AC station and lines.”* A technical comparison of the two technologies (HVAC and HVDC) concluded that, for

Report Title	Context of Report	Main Findings / Observations of Report
		the scenarios and contingencies studied, there were no significant technical advantages identified for the use of a HVDC circuit in place of the HVAC circuit proposed.
The PB Power Technology and Cost Update - *Comparison of High Voltage Transmission Options: Alternating Current Overhead and Underground and Direct Current Underground* [This is an addendum to the 2009 PB Power Study and should be read in conjunction with that 2009 report] **April 2013**	EirGrid and NIE requested PB Power to update their 2009 report to take account of scientific advances in the development of new, feasible transmission technologies, and also to review the cost estimates for practical transmission configurations. The updated PB Power Report does not revisit the landscape aspects and most of the technical aspects as these remain unchanged. The *PB Power Electricity Transmission Costing Study* published in 2012 by the UK Department of Energy and Climate was used as a source of information for the technology and cost update.	The most cost effective solution for the proposed scheme would be a 400 kV AC OHL, estimated to cost around €165 million to construct A 400 kV AC UGC is estimated to cost €935 million, or over 5.7 times as much as an equivalent OHL to construct, and would also cost significantly more than an OHL to operate and maintain over its lifetime. A HVDC UGC is estimated to cost €1,005 million, or 6 times as much as an equivalent 400 kV AC OHL to construct, and twice as much as an OHL to operate and maintain over its lifetime.

Report Title	Context of Report	Main Findings / Observations of Report
The PB Power Technology and Cost Update – Cavan-Tyrone & Meath-Cavan 400 kV Transmission Circuits Technology and costs Update**.** *Supplementary Note to the April 2013 Addendum* **July 2013**	In April 2013 EirGrid published its *Final Re-evaluation Report* and at the same time announced its decision to defer the previously proposed intermediate substation near Kingscourt, Co. Cavan. A consequence of the deferment of this substation, regardless of which technology option is chosen, is that it would reduce the initial investment required to develop the interconnector so EirGrid requested PB to provide, in a supplementary note, an indication of the impact of the deferment on the initial investment.	The most cost effective technology option remains a 400 kV AC OHL, estimated to cost around €140 million. With the deferment of Kingscourt, 400 kV AC UGC becomes the most costly option, estimated at around €880 million, or €740 million more than the equivalent AC OHL. The deferment of Kingscourt has little or no impact on the cost differential with the AC OHL as similar costs are deferred in the case of both options. The deferment of the substation near Kingscourt will however have a significant impact on the initial investment required to develop the HVDC option. This is due to the very high cost of HVDC converters, and the fact that, with the deferment, converters would only be required initially at Turleenan and Woodland not Kingscourt. Under this scenario, the HVDC option, at an estimated cost of around €810 million, is no longer the most costly option. It is still, however, €670 million more costly than the least cost option, the 400 kV AC OHL. The initial investment cost of the HVDC option is reduced, due to the deferment of the substation near Kingscourt, by around €160 million (€970M - €810M), whilst the initial investment costs of the two AC options are only reduced by around €20 - €25 million. The disparity of the effects on the AC and HVDC options highlights one major disadvantage of the HVDC option for the Ireland N-S Link. This is that, if the N-S Link is developed using HVDC technology, future ‗tap-ins‘ to the circuit for the substation near Kingscourt and / or for some other (as yet unknown) requirement at some other location along the route, will be many times more expensive than tapping into an AC circuit.

Figure 4.1: Composite Map showing UGC Corridor from Woodland to border (PB Power - 2009) and the Preferred OHL Corridor[32]

[32] In 2009 PB Power identified a potential route corridor for high voltage underground cable. The UGC corridor was compared with the 2009 OHL corridor which is broadly the same as the 2013 OHL corridor. The potential UGC route was identified by PB Power for the purposes of developing a well-informed cost estimate for UGC.

4.6.1 Further Specific Technical Studies and Reports of Direct Relevance to the Proposed Interconnector

48 There are two other technical studies of relevance, which were specifically focused on the proposed interconnector. These are:

- **The Ecofys Study** (Department of Communications, Energy and Natural Resources (DCENR) 2008). A *Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables*, carried out by Ecofys on behalf of the Department of Communications, Energy and Natural Resources.

- **The International Expert Commission (IEC) Report** (2012). A review of the case for, and cost of, undergrounding all or part of the Meath–Tyrone 400 kV line (now known as the North-South 400 kV Interconnection Development – the subject of this application for planning approval).

49 The objectives of these studies, and the conclusions set out in each of the associated reports, are described in further detail in **Table 4.3**. A copy of each report is provided in soft copy as part of the Bibliography for this volume of the EIS.

Table 4.3: Other Reports Prepared on Alternative Transmission Technologies

Report Title	Context of Report	Main Findings / Observations of Report
The Ecofys Study - *Study on the Comparative Merits of Overhead Electricity Transmission Lines versus Underground Cables* Prepared by Department of Communications, Energy and Natural Resources (DCENR) **May 2008**	The aim of the study was to provide the best available professional advice on the relative merits of constructing and operating OHL compared to UGC, having regard to technical characteristics, reliability, operation and maintenance factors, environmental impact, possible health issues, and cost.	Globally the vast majority (approximately 99.5%) of UGC is generally used in areas of high population density or high land values – generally urban areas - where it is difficult to find suitable OHL routes. International experience shows that extra high voltage (EHV) UGC is generally not used for any great distance, e.g. the longest such UGC is in Tokyo and is only 40km in length. Whilst decisions may be taken to underground lower voltage networks of distribution systems, this is not normally applied to the higher voltage networks of transmission systems, as the technology involved is substantially different and more demanding. Both EHV UGC and OHL are found to have an environmental impact but these impacts are different for the different technologies, and in most cases mitigation measures are available, e.g. UGC has a greater impact on water resources and soils and geology, whereas OHL has a greater impact on Landscape and Visual and Communities. The study distinguishes between the perceived health risks associated with Electro-Magnetic Fields (EMF) and actual health risks associated with EMF and cites the International Commission of Non-Ionising Radiation Protection (ICNIRP) recommendation. The study concludes that the construction and operation of an EHV UGC in Ireland with a length of 100km would not be backed by worldwide experience. Mitigation measures are proposed to reduce the potential impact of the planned Interconnector on the environment.

Report Title	Context of Report	Main Findings / Observations of Report
The IEC Report - *Meath- Tyrone Report Review by the International Expert Commission* August – November 2011. *(A review of the case for, and cost of undergrounding all or part of the Meath-Tyrone 400 kV Interconnection Development*.) Prepared by Normak B., et al. **November 2011**	In July 2011 the Minister for Communications, Energy and Natural Resources appointed the IEC to:- Examine the case for, and cost of, undergrounding all or part of the Meath–Tyrone 400 kV line (now known as the North-South 400 kV Interconnection Development – the subject of this instant application); Review expert literature already available both in Ireland and internationally in relation to undergrounding high voltage [HV] power lines; Consider the route or routes proposed by EirGrid (see **Figure 4.1**); and Consult with EirGrid, the North East Pylon Pressure Committee and the County Monaghan Anti-Pylon Committee, and other bodies / organisations.	The main findings of the report are as follows:- Based on an analysis of a number of different high capacity transmission projects in Europe, it is clear –*that there is no single "right" solution. Each project must be judged on its own merits and hybrid solutions, i.e. combining different technologies, have been applied in many cases, for instance partially undergrounding a link. A specific technical solution must be derived accounting for local conditions*"; There have been advances in transmission technology in recent years, examples being –*the development of VSC HVDC technology and its deployment in transmission projects and the introduction of new tower designs for overhead lines*"; The only recommendation the IEC made was –*against fully undergrounding using an AC cable solution*"; While the report does not recommend that the interconnector be undergrounded it does find that if the interconnector has to be undergrounded for all, or a significant portion, of its length then with today's technology the best solution would be –*a VSC HVDC solution combined with XLPE cables*"; and The report concludes that a high voltage AC OHL solution for the proposed interconnector still offers –*significantly lower investment costs than any underground alternative and could also be made more attractive by investing slightly more in new tower designs than the classical steel lattice towers now proposed".*

4.6.2 Other Third Party Reports to Note

50 There are a number of other studies which are also referred to in this chapter. These are:

- **Denmark's Strategy for the Development of its 400 kV Network**[33] – (*Technical Report on the Future Expansion and Undergrounding of the Electricity Transmission Grid –: Summary – April 2008* and the *Cable Action Plan: 132-150 kV Grids – March 2009)*. The first report considers the long term strategy for the development of the electricity transmission network in Denmark. Six ‗Expansion Principles‘ were considered. These ranged from ‗Expansion Principle A - complete undergrounding‘ to ‗Expansion Principle F - no further expansion of the grid‘. Subsequently the mid-range strategy known as ‗Expansion Principle C‘ was adopted. The second report, the *Cable Action Plan* outlines how and over what period this strategy will be implemented.

- **Askon Report**[34] (*Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project* (2008) commissioned by North East Pylon Pressure (NEPP)).

- **Cigré**[35] **Technical Brochure 379 -** ***Update of Service Experience of HV Underground and Submarine Cable Systems,*** *ISBN 978 -2-85873-066-7* (April 2009). The study collected and analysed data relating to the installed quantities of underground and submarine cable systems rated at 60 kV and above together with the service experience and the performance of existing underground and submarine cable systems.

- **UK Electricity Transmission Costing Study (2012)**[36]. This study was performed on behalf of the UK Department of Climate Change (DECC) with the purpose of informing the Infrastructure Planning Commission (IPC) in regard to the costs of feasible transmission options.

4.6.3 Review Carried Out by EirGrid - 2010 to 2013

51 Since the withdrawal of the previous application for approval of the Meath-Tyrone Interconnection development, EirGrid separately carried out three further studies providing an update on available technological alternatives; an update on reliability statistics for high voltage

[33] Available at www.Energinet.dk.
[34] This report is not publically available but can be obtained from NEPP, refer to www.nepp.ie for further information.
[35] The technical brochure is available from Cigré. Cigré is an acronym in the French language for ‗The International Council on Large Electric Systems‘.
[36] Available at http://www.theiet.org/factfiles/transmission-report.cfm.

AC UGC and OHL; and an update on the world's longest high voltage AC XPLE cable circuits and the cost comparison between AC UGC and AC OHL. These reports are summarised below and their findings are contained in **Table 4.4**.

- **The *Preliminary Re-evaluation Report*** (PRR) (May, 2011). The PRR was published as part of the comprehensive re-evaluation of the previous application for the Meath-Tyrone Interconnector Project which was subsequently withdrawn. It included *inter alia* a review of the alternative technological alternatives for the proposed development

- **The *Final Re-evaluation Report*** (FRR) (April, 2013). The FRR represents the culmination of a detailed re-evaluation process, undertaken by EirGrid and its consultants, of all aspects of the proposed development. It considered documents issued since the publication of the PRR, which are relevant to the overall re-evaluation process including the IEC Report. It considers DC technology as an alternative to AC technology for this development, provides an update on reliability statistics for high voltage AC UGC and OHL, updates on the world's longest extra high voltage AC XPLE cable circuits and the cost comparison between 400 kV AC UGC, DC UGC and AC OHL.

- **The *Preferred Project Solution Report*** (PPSR) (July 2013). The PPSR provides detail on the preferred line design for the proposed development. It includes the identification of feasible locations for, and design of, the planned transmission line infrastructure, such as tower positions, tower types and associated construction related details (e.g. indicative access tracks). It includes reference to EirGrid's consideration of tower designs and the basis for confirmation of the IVI tower as the preferred support structure for the development.

52 A copy of the *Preliminary Re-evaluation Report* is included in **Appendix 1.1**; the *Final Re-evaluation Report* is included in **Appendix 1.2**, and the *Preferred Project Solution Report* is included in **Appendix 1.3,** all in **Volume 3B Appendices** of the EIS.

Table 4.4 Reports Prepared by EirGrid on Technology Updates

Report Title	Context of Report	Main Findings / Observations of Report in Respect of the Different Technologies
North-South 400 kV Interconnection Development Preliminary Re-evaluation Report *(PRR)*, EirGrid **May 2011**	This report comprises a comprehensive re-evaluation of EirGrid's previous application to An Bord Pleanála for approval of the Meath-Tyrone 400 kV Interconnection Development, being that portion of the proposed interconnector occurring within Ireland. It includes review and consideration of the approximately 950 submissions to An Bord Pleanála in respect of that previous application and the statements presented at the associated oral hearing of 2010.	Having reviewed all the technology options the report concludes that: HVDC technology and HVAC undersea cable do not comply with the project objectives / design criteria for the proposed interconnector. There have not been any developments in transmission technology which would alter EirGrid's opinion that the use of long HVAC cables on the Irish transmission system is not feasible within the constraints of EirGrid's statutory obligations. No new information has come to EirGrid's attention which would alter its opinion that a 400 kV AC OHL is the best technical solution for this development. Partial undergrounding using 400 kV AC technology may be feasible, but only if the length to be installed is relatively short.
North-South 400 kV Interconnection Development Final Re-evaluation Report *(FRR)* EirGrid **April, 2013**	The FRR represents the culmination of a detailed re-evaluation process, undertaken by EirGrid and its consultants, of all aspects of the proposed development. It includes consideration of the feedback received during the public consultation in respect of the PRR. It also considered documents issued since the publication of the PRR, which are relevant to the overall re-evaluation process including the IEC Report. It provides an update on reliability statistics for high voltage AC UGC and OHL, and updates on the world's longest high voltage AC XPLE cable circuits and the cost comparison between 400 kV AC UGC and AC OHL.	Having reviewed all the technology options the report concludes that: The DC option, even one using the latest VSC HVDC technology, is not acceptable for the proposed development as it would be too costly and (for this specific application) would not operate as effectively as a standard 400 kV AC OHL. An entirely underground 400 kV AC option is not an acceptable solution. There have not been any developments in transmission technology which would alter EirGrid's opinion that the use of long HVAC cables (that is greater than approximately 10km in length) on the Irish transmission system is not feasible. A 400 kV AC OHL is the best technical solution for this development and would be significantly less costly than any UGC alternative. Partial undergrounding using 400 kV AC UGC will be considered, but only if the

Report Title	Context of Report	Main Findings / Observations of Report in Respect of the Different Technologies
	It includes an Appendix setting out the review and consideration of the approximately 950 submissions to An Bord Pleanála in respect of that previous application and the statements presented at the associated oral hearing of 2010.	length of UGC to be installed is relatively short (less than approximately 10km in one continuous length or an accumulation of shorter lengths). The emerging preferred support structure for use on the proposed 400 kV OHL development is the lattice steel structure known as the ‗IVI‘ tower. However, EirGrid will further consider alternative structures, including consideration of any feedback on the matter received during the public engagement in respect of the FRR, before finalising the preferred project solution.
North-South 400 kV Interconnection Development Preferred Project Solution Report (PPSR) EirGrid **July 2013**	The PPSR provides detail on the preferred line design for the proposed development. It considers and includes responses to the feedback received during the public engagement in respect of the FRR. It includes the identification of feasible locations for, and design of, the planned transmission line infrastructure, such as tower positions, tower types and associated construction related details (e.g. indicative access tracks). It includes reference to EirGrid‘s consideration of tower designs and the basis for confirmation of the IVI tower as the preferred support structure for the development.	This report outlines the background to the identification of the preferred line design of the proposed development. It explains how the process generally involves consideration of a range of environmental and technical matters relevant to OHL design and how other considerations specific to the particular development (including feedback from stakeholders and landowners) have fed into the process. It identifies feasible locations for, and design of, the planned transmission line infrastructure, such as tower positions, tower types and associated construction related details (e.g. indicative access tracks).

4.6.4 Conclusions on Background to Identifying Strategic Technical Alternatives

53 The respective applicants have jointly carried out a comprehensive analysis of the various technological alternatives available for the proposed interconnector, over a period of many years. They commissioned a number of studies, supplemented with further internal analysis, in order to ensure that the development process was fully and properly informed with respect to the latest available technological alternatives. The studies informed the transmission technologies proposed, by EirGrid, for the previous application for approval of the Meath-Tyrone Interconnection Development (subsequently withdrawn).

54 Since the withdrawal of the previous application EirGrid has undertaken a comprehensive re-evaluation of that portion of the proposed interconnector in Ireland. The re-evaluation process included a review of the alternative transmission technologies. EirGrid has also considered documents issued since the withdrawal of the previous application including the *Report of the International Expert Commission.* EirGrid and its consultants are satisfied that, on the basis of the re-evaluation of updated environmental constraints and other information, a 400 kV OHL is the best technical solution for this development and would be significantly less costly than any UGC alternative. It was also concluded by EirGrid that there are no material considerations which would warrant the use of UGC along any part of the indicative line route.

55 The main strategic technical alternatives themselves and EirGrid's conclusions in respect of the preferred technical solution having regard *inter alia* to the conclusions of analysis and published studies are described in **Section 4.7**.

4.7 TRANSMISSION TECHNOLOGY ALTERNATIVES CONSIDERED FOR THE PROPOSED DEVELOPMENT

56 There are several technological alternatives by which a transmission circuit of the capacity required for the proposed development could, in theory, be implemented. Some of these alternatives utilise AC technology while others utilise DC technology.

57 Until relatively recently, DC technology was only used for high capacity electricity transmission in circumstances where it was the only technically feasible or cost effective option. In recent times, however, during consultations associated with transmission projects (including in the case of this proposed development) stakeholders have suggested that DC technology should be used not because of any technical, operational or cost advantage that might accrue but rather because it is seen as a way of facilitating the undergrounding of the proposed development.

4.7.1 High Voltage Direct Current (HVDC) as an Alternative to High Voltage Alternating Current (HVAC)

58 The first step in the in-depth consideration of the technological alternatives that are potentially feasible for this development is to carry out a general evaluation of HVDC technology, as an alternative to the standard HVAC technology regardless of whether the scheme is to be implemented using OHL, UGC or a combination of both.

59 The existing electricity transmission system in Ireland is, as in every other country in the world, a HVAC (or AC) system. Any new transmission project that utilises HVAC would therefore be an extension of the existing technology.

60 HVDC is an alternative method of transmitting electricity. HVDC technology is mostly used to transmit bulk power from one point to another over long distances where HVAC is not technically and / or environmentally acceptable (e.g. a long (> 50 km) high capacity submarine cable).

61 HVDC can also be the most effective option for very long transmission circuits. **Figure 4.2** illustrates graphically how the cost differential of HVDC UGC, HVDC OHL, HVAC UGC and HVAC OHL varies with circuit length. The HVDC options start at a cost disadvantage to any HVAC option due to the relatively high cost of the converter stations at the terminals however as the circuit length increases the difference in cost declines until eventually a breakeven point is reached and thereafter the HVDC option becomes the most effective. For example in the graph below the cost breakeven point for the HVDC UGC option versus the HVAC OHL option occurs when the circuit length is in the region of 600-800km whereas in the case of the HVDC UGC option the breakeven point with HVAC UGC is in the region of 80–120 km. On the graph the curve representing the HVDC UGC option (dashed purple) and the curve representing the HVAC OHL option (light blue) do not intersect within the 0 to 1,000 km range thus indicating that under these circumstances a HVDC UGC would never be more cost effective than a HVAC OHL option. In addition the graph would suggest that the breakeven or crossover point between these options would occur at some circuit length far in excess of 1,000 km, a distance that is of no relevance for a country the size of Ireland..

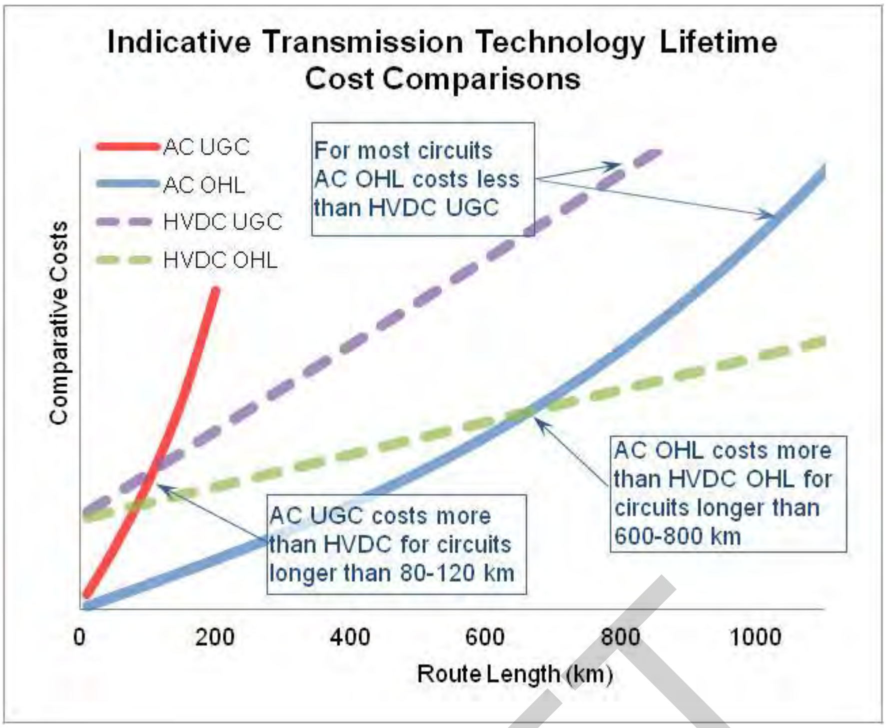


Figure 4.2: Comparison of HV Transmission Options – Cost versus Circuit Length

(Source: Parsons Brinckerhoff, incl. *Electricity Transmission Costing Study* 2012)

62 HVDC is also used for linking independently operated (synchronous) HVAC systems (e.g. an interconnector such as EirGrid's East West Interconnector) where it is impossible to link such systems using a standard HVAC circuit.

63 Inserting a HVDC circuit between any two points in a HVAC network would require the HVAC electricity to be converted into HVDC electricity at one end, transmitted through cable or OHL to the other end, where it would be converted back from DC to AC, and then transmitted back into the HVAC network. This is inefficient (unless the HVDC circuit is very long) and costly (in terms of the requirement for converter stations) but it is technically feasible.

64 There are two main HVDC convertor station technologies – Current Source Convertors (CSC) also known as Line Commutated Converters (LCC) and the emerging Voltage Source Converters (VSC). Both can be applied in combination with OHL and UGC.

65 VSC DC is considered a more flexible technology than LCC DC as it can be less difficult to integrate into an AC grid. This VSC DC technology continues to develop with converter stations becoming more efficient, reliable and compact; these advances were specifically referred to in the findings of the IEC Report.

66 In response to the *IEC Report*, EirGrid in its FRR reviewed its comparative assessment of an UGC VSC HVDC circuit[37] versus a standard high voltage OHL AC circuit for the implementation of the proposed development against the previously identified project objectives / design criteria. The findings are as follows:-

a) Comply with all relevant safety standards;

67 Both options are equally compliant. In the case of this criterion EirGrid does not see any difference in the two technology options.

b) Comply with all system reliability and security standards;

68 The proposed development as part of the 400 kV network will form a necessary extension of the backbone of the ‗all-island‘ transmission network, and is required in order to enable the two networks, north and south, to operate as if they were one network. It will be an integral part of the ‗all-island‘ meshed network, and as such the power flow (quantity and direction) in the circuit is required to react instantaneously to dynamic system changes such as rises and falls in system demand, and sudden and unplanned changes in system configuration due to unplanned outages of other circuits or generators. If the proposed interconnector is a standard AC circuit then the power flow will react naturally and instantaneously, without any input from a control system or human operator, to such dynamic changes to the system.

69 The power flow on DC circuit on the other hand will not react naturally to such changes. The DC circuit will only react if prompted to do so by a controller. However, a human operator would not be able to react quickly enough, so the control would have to be by means of a computerised control system. Such a control system would be bespoke and very complex, and would therefore introduce the very real risk of mal-operation. Analysis of the risk of mal-operation of the computerised system controlling the operation of a HVDC north-south interconnector has shown that this could (due to its relatively high capacity and strategic location within the network) result in the collapse of the entire ‗all-island‘ electricity system. Taking such a risk is unnecessary when there is a technically superior (for this type of application) and less risky option readily available. Therefore it is EirGrid‘s opinion that under the heading of ‗comply with all system reliability and security standards‘, a standard AC circuit is preferable to a DC circuit for the specific characteristics of the proposed development.

[37] The IEC disregarded DC OHL in its report (page 18) on the basis that the cost of a DC OHL option would be similar to a DC UGC option if the cables were to be installed under optimum conditions (as described in point c below). While this is debatable it can be said that from a technical and operational perspective there is no difference between DC OHL and DC UGC other than the fact that the time required to repair a fault on a DC UGC would be considerably longer (many weeks longer) than that required to repair a fault on a DC OHL.

c) Provide an environmentally acceptable and cost effective solution;

70 Both the DC UGC option and the AC OHL option can be installed in such a way as to be environmentally acceptable. It is the cost difference therefore which will be the deciding factor in the case of this criterion.

71 The IEC estimated that the standard AC OHL circuit would cost €167 million whereas the DC UGC alternative would cost €500 million. That is a difference of €333 million. The PB Power Technology and Costs Update Report (July 2013),[38] on the other hand, found that the standard AC OHL circuit would cost €140 million whereas the DC UGC alternative would cost €810 million (see Table 3-2, page 3 of the Supplementary Note). That is a difference of €670 million.

72 This significant variation between the cost estimates in the IEC Report and the PB Power Update Report for the DC alternative can be explained as follows. Both reports agree that the converter stations will cost approximately €300 million (that is €150 million each). The cost difference arises in the difference in cost per km for the DC UGC connecting between the two converter stations.

73 The IEC assumes optimum conditions are available for the installation of the DC cables. By ‗optimum conditions‘ they mean that the cables will be installed in the wide soft margin of a major road for almost the entire length and that the cables will be installed side by side in a single 3 metre wide trench (**Figures 4.3** and **4.4** are extracted from the IEC Report and were included in that report for the purpose of illustrating the assumptions that formed the basis for the UGC cost estimate). This results in a cost per km of €1.36 million for 140km[39] giving a total cable cost of €190 million.

[38] The *Supplementary Note* of July 2013 to the *PB Power Technology and Costs Update Report* of April 2013 revise the comparative cost estimates by excluding any provision for the intermediate substation near Kingscourt (refer to summary details of report in Table 4.2). This results in the PB estimates being directly comparable with those of the IEC as the IEC also excluded any provision for the intermediate substation.

[39] The IEC assumed that the route for UGC would be 140km in length whereas PB Power identified a route for UGC and measured it at 135km in length.

Figure 4.3: Wide Soft Margin of a Major Road

(Source: IEC Report p. 46)

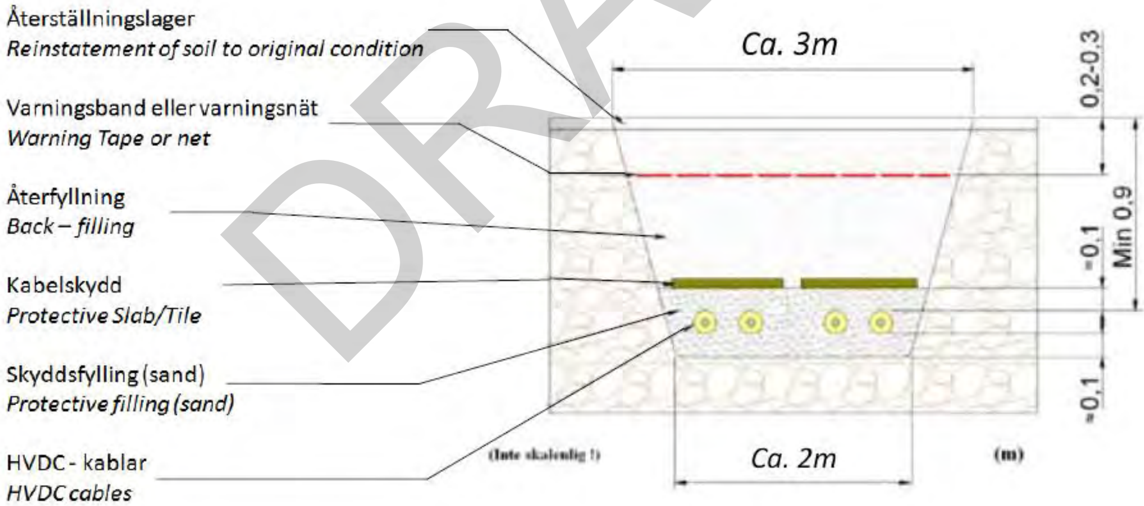


Figure 4.4: Section through cable trench for two parallel HVDC circuits

(Source: IEC Report (p. 46) with translation to English by EirGrid)

74 The PB Power estimate is based on the assumption that the DC cables will be installed along a route across country through farmland in the corridor identified in the PB Power Report of 2009. This results in a cost per km of €3.76 million for 135km giving a total cable cost of €508 million.

75 In EirGrid's view, the IEC estimate is understated. A long major road, with a wide soft margin, linking Batterstown in County Meath to Turleenan in County Tyrone does not exist. Instead the roads in the five counties to be traversed are generally narrow and winding. The IEC itself recognises that installing cables under such roads would result in a higher cost per km than the €1.36 million previously indicated. It is also the case that due to the winding nature of the roads that any route that follows the public roads will be longer than a more direct cross country route.

76 In their consideration of the DC option, the respective applicants follow the costing approach adopted by PB Power for the following reasons:

- It will allow the two pairs of DC cables that would be required for such a scheme to be installed in two separate trenches that are sufficiently far apart (> 5 metres) that it reduces the likelihood, to a level that can be considered to be negligible, of a single event causing damage to both sets of cables at the same time. This will result in a significantly better level of service availability and as a result improved security of supply.

- It will result in a shorter more direct route.

- It will avoid extensive road closures and the considerable disruption to local communities that that entails.

77 Installing cables along a cross country route would likely however result in a greater environmental impact than that of any option that involves their installation under or adjacent to public roads.

78 However no matter which approach is assumed for routing the DC UGC, across country or under public roads, the cost difference between the proposed AC OHL and the DC technology options is so great that it renders the HVDC UGC option unacceptable under this criterion.

79 While not the only reason the excessive cost of the HVDC technology is, on its own, sufficient reason for EirGrid to discount it as an option for the implementation of the proposed development. In this regard, Regulation 8(3) obliges the TSO, when discharging its functions to take into account the objective of minimising overall costs of the generation, transmission, distribution and supply of electricity to final customers.

d) Have a power carrying capacity in the region of 1,500MW, and connect between appropriately robust points on the transmission networks north and south of the border;

80 Both technology options are equal under this criterion.

e) Facilitate reinforcement of the local transmission network in the north-east area

81 Both technology options are equal under this criterion. Although the need to reinforce the north-east area for security of supply reasons is no longer an immediate driver of the delivery of the proposed development (as that reinforcement is not now expected to be required for at least a decade), the early presence of the interconnector will nevertheless provide reinforcement to the area by increasing interconnection between Ireland and Northern Ireland. Based on current predictions, such reinforcement will provide sufficient additional transmission capacity in the area to cater for growth in electricity consumption for many years (assuming median growth rates) and will also put the north-east area in a good position if an even stronger economic recovery should emerge in the coming years.

f) Facilitate future grid connections and reinforcements

82 All circuits forming a meshed transmission network have the potential to be ‗tapped‘ into at an intermediate point to provide a new grid connection or reinforcement sometime in the future. It is envisaged that the circuit that forms the proposed development will require an intermediate substation in the vicinity of Kingscourt at some future point in time (although not now expected to be required for at least a decade), and others (where and when they will be required cannot be predicted at this juncture) are probable. The facilitation of future grid connections and reinforcements is therefore an important consideration of the technology choice.

83 As stated previously, a DC circuit does not naturally integrate within an AC network and a consequence of this is that a DC circuit embedded in an AC network would not facilitate future grid connections and reinforcements. If the north-south interconnector were to be developed using HVDC technology, then the cost of the planned ‗tap in‘ to the circuit near Kingscourt, based on the estimates of the IEC, would be in of the region of €150 million more than the cost of tapping into an equivalent AC circuit. This would in all likelihood make the plan ultimately to reinforce the north-east area by developing a new substation near Kingscourt uneconomic. Consequently that reinforcement would have to be achieved by some other means, such as the building of new AC transmission lines into the area.

84 In addition to the excessive cost of tapping into a DC circuit, the only practical way of tapping into such a circuit would result in the creation of a ‗multi-terminal‘ DC circuit (i.e. a DC circuit with more than two terminals). A multi-terminal DC circuit would require an even more complex

control system than a two terminal circuit, thus increasing the already unacceptable risk of mal-operation.

85 The poor facilitation of future grid connections and reinforcements presented by the DC option makes the use of HVDC technology less preferred than a standard AC circuit when compared against this criterion for the implementation of the proposed development.

g) Comply with good utility practice

86 There are no working examples in the world[40] of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland. The examples of planned DC interconnectors in Europe that were identified in the IEC Report (that is the proposed France-Spain Interconnector and the proposed Norway–Sweden Interconnector) are not comparable with the proposed interconnector. The electricity networks in those four countries are much larger (six times larger in the case of Norway-Sweden and almost 20 times larger in the case of France-Spain) and stronger than those on the island of Ireland and they already have multiple AC interconnections with each other.

87 The risk of failure, and the consequence of failure, is an important factor in deciding whether the embedding of a DC circuit in an interconnected network is, or is not, good practice. There is currently only one interconnector between Ireland and Northern Ireland and these two networks are required to merge into each other and to operate as if they were one network. The proposed development, with a power carrying capacity of 1,500MW, will become the ‗backbone‘ of this ‗all-island‘ network.

88 By contrast the proposed France / Spain and Norway / Sweden DC Interconnectors are upgrades in cross border power transfer capacity between networks that are already highly interconnected[41] with each other. Also unlike the network on the island of Ireland the Norway / Sweden and France / Spain networks form part of a wider continental network and have multiple interconnections (both synchronous and non-synchronous) with other third party countries. In addition **Table 4.5** illustrates that the power carrying capacity of the proposed north south interconnector relative to the combined ‗all-island‘ system demand is far greater than the comparable figure in the case of the proposed France / Spain and Norway / Sweden Interconnectors. The North South Interconnector would have the capacity to carry 23.8% of the ‗all-island‘ peak demand whereas the comparable figures for the France / Spain and Norway /

[40] There are a few working examples in the world (December 2013) of a DC circuit embedded in an AC transmission network however these networks are not representative of the small and isolated AC transmission network on the island of Ireland. The closest comparable scheme is probably the 1,400MW Kii Channel project in Japan which uses OHL and submarine cable. Although an island network, Japan represents a much larger generation and load base than Ireland.

[41] There are five existing AC transmission interconnectors between Norway/Sweden, four between France/Spain and one between Ireland/Northern Ireland.

Sweden Interconnectors are 2.9% and 1.4% respectively and that this in turn results in the north south interconnector having a far greater level of strategic importance than those proposed interconnectors.

Table 4.5: Comparison of Interconnected Networks and the Relative Importance of Proposed Interconnectors

Interconnected Countries	Power Carrying Capacity of Proposed Interconnectors	Combined System Peak Demand[42]	Capacity of Proposed Interconnectors as a % of Peak Demand	Measure of Strategic Importance of Proposed Interconnectors
Ireland - Northern Ireland	1,500 MW	6.311 MW	23.8%	13.7
Norway - Sweden	2 X 720 MW	49,643 MW	2.9%	2.1
France - Spain	2 X 1,000 MW	145,625 MW	1.4%	1.0

89 The capacity of the proposed North-South Interconnector relative to the ‗all-island' system peak demand together with the relatively limited level of interconnection with each other and with third party networks means that the North-South Interconnector will have a far greater level of strategic importance to Ireland

90 The strategic importance of the proposed new France/Spain and Norway / Sweden DC interconnectors will be far less critical to the overall system security of their combined networks than the proposed north south interconnector will be to the ‗all-island' network. These proposed DC interconnectors are therefore not representative of a DC circuit embedded in a small and isolated AC transmission network, such as that on the island of Ireland.

91 It is on this basis that implementing the proposed development using HVDC technology would not be considered as complying with ‗good utility practice' or complying with ‗good international practice'.

[42] The annual instantaneous peak loads were obtained from the Entso-e website. The instantaneous peak loads for the respective pairs of networks did not occur at the same time (although they were within days of each other). The combined figures are therefore a slight over statement of the actual combined instantaneous system peak demand.

92 The re-evaluation of the HVDC VSC (OHL or UGC) option and the standard AC OHL option which included regard for the findings of the IEC report is outlined above (i.e. points a to g) and a summary of same is shown in **Table 4.6**. The overall conclusion is that the DC option is least preferred, primarily on the basis of cost effectiveness, its poor ability to facilitate future grid connections and because it would not be considered as complying with ‗best international practice‘.

Table 4.6: Overview AC versus DC - Strategic Constraints of Potential AC and DC Transmission Alternatives

Points	Description	AC OHL	DC (UGC or OHL)
	Comply with EirGrid‘s Statutory and Regulatory Obligations		
a)	Safety	***	***
b)	Reliability and security	***	**
c)	Cost effectiveness	***	*
	Due regard to the environment	**	**
	Meet the Specific Needs of the Project		
d)	1500MW capacity and appropriately strong points of interconnection	***	***
e)	Reinforce the North-East transmission network	***	***
	Meet the General Objectives for All Projects of this Type		
f)	Facilitate future grid connections and reinforcements	***	*
g)	Good Technical Solution – Be ‗best international practice‘ with proven technology	***	*

***	Preferred, limited impact, acceptable
**	Some impact, some difficulty
*	Least preferred, major impact, unacceptable

4.7.1.1 HVDC Offshore Submarine Cabled Alternative

93 During public consultation some stakeholders suggested that consideration be given to an offshore cable that is a submarine cable off the east coast, for linking the two transmission networks on the island of Ireland. This suggestion was made without specifying whether the submarine cable would utilise AC or DC technology. The DC submarine option is considered here while the AC submarine option is considered later in **Section 4.7.2.2.**

94 There are numerous examples of long high capacity DC submarine cables in Europe so this alternative is potentially feasible. However, all of the disadvantages of the ‗on-land' DC option vis-a-vis a standard AC transmission technology option identified in **Section 4.7.1** apply in the case of the sub-sea DC option. In addition to those disadvantages the following also applies.

95 For any on-land UGC option there is a concern about the relatively long time it takes to find and repair faults. In the case of the undersea options the time to repair will be significantly greater than for the equivalent on land option. Reference can be made to the example of the six months that it took to repair a fault on the NorNed[43] HVDC cable during commissioning in 2007 / 2008. Much of the delay was due to poor weather conditions during the winter months and the resulting concerns for health and safety of repair crews. For this reason a DC submarine cable off the east coast, is considered to be even less preferred when rated against the criteria of ‗Reliability and Security' than an on-land DC cable.

96 The circuits required for the proposed development must connect into the existing transmission grid at appropriately strong points north and south of the border. In the case of the undersea option long on land cables are required to reach the coast (in excess of 40km from Woodland to the coast). An entirely on-land cabled option can take a more direct cross country route and as a result be considerably shorter and by implication less expensive than its undersea equivalent. For this reason a DC submarine cable, is considered to be even less preferred when rated against the criteria of ‗Cost Effectiveness' than an on-land DC cable.

97 EirGrid's overall conclusion on the HVDC offshore submarine alternative is that it is not acceptable for this development and merits no further consideration.

4.7.1.2 Overall Conclusion on High Voltage Direct Current (HVDC) as an Alternative to High Voltage Alternating Current (HVAC)

98 The respective applicants have considered the option of using HVDC technology for implementing the proposed interconnector. This consideration is supported by the findings of the PB Power Study (2009, April 2013 and July 2013) and the TransGrid Study (see summary in **Table 4.2**). In addition consideration has been given to the findings of the International Expert Commission (see summary of IEC Report in **Table 4.3**).

[43] NorNed is a HVDC undersea interconnector between Norway and the Netherlands. It was first put into service in May 2008.

99 The overall consideration found that any DC option whether implemented using UGC, OHL or off-shore submarine cable would not facilitate the future development of the transmission network as well as any AC option. Nor would the DC option be considered as complying with ‗best international practice‘.

100 While the cost of the DC options (UGC or OHL) would be comparable with an AC UGC option they would all be significantly more expensive to implement than the proposed 400 kV AC OHL option, €670 million more according to the findings of the *PB Power Technology and Cost Update* (July 2013) and €333 million according to the findings of the IEC Report.

101 In addition the proposed interconnector is required to be an integral part of the ‗all-island‘ AC transmission network and will therefore be required to operate like any other AC circuit within the network. It is possible, in theory at least, to embed a DC circuit into an AC transmission network and make it operate like an AC circuit however this would require a complex and be-spoke control system. The risk of failure, and the consequence of failure, must be a factor in the consideration of any technical alternative. Introducing a complex and be-spoke control system into the operation of a strategically important part of the ‗all-island‘ transmission network brings with it considerable risk for system security and stability. Such risk taking is unnecessary in the case of this proposed development as there is a technically superior and less risky option readily available.

102 As a result of all of the foregoing it was concluded that any option using HVDC technology is not an appropriate or acceptable option for implementing the proposed interconnector.

4.7.2 Consideration of High Voltage Alternating Current (HVAC) Options

103 The use of HVDC technology whether implemented by OHL or UGC, on-land or offshore, has been discounted in **Section 4.7.1**. All further consideration and comparison of OHL and UGC is therefore restricted to HVAC technology particularly at the 380 kV / 400 kV level.

4.7.2.1 High Voltage AC Overhead Line (OHL)

104 Over 98% of the on land Extra High Voltage (EHV - 315 kV to 500 kV) electricity transmission network in Europe is of HVAC OHL construction. For comparative purposes the extent of the 380 kV / 400 kV network in ten Western European countries including Ireland, is shown in **Table 4.7**.

Table 4.7: Extent of the 380 kV / 400kV AC OHL and UGC Installations in **Western Europe** [45]

Country	Overhead Line (km)	Underground Cable (km)	% Cable
Belgium	1,335	0	0.00%
France	21,361	3	0.01%
Germany	20,237	70	0.34%
Great Britain	11,979	229	1.91%
Ireland	439	0	0.00%
Netherlands	2,061	30	1.43%
Portugal	2,236	0	0.00%
Spain	19,567	55	0.28%
Sweden	10,700	8	0.07%
Switzerland	1,780	8	0.45%

(Source: *ENTSO-E Statistical Yearbook* 2011)

105 400 kV OHL technology conventionally utilises steel lattice towers to support the electricity conductors. As the construction of a 400 kV OHL requires limited civil works with a simple mechanical construction, it is very cost effective compared to an equivalent UGC system which has a more complicated construction and design. **Chapter 6** of this volume of the EIS provides a description of the proposed OHL structures for this development.

106 400 kV OHLs have a high level of availability for service, that is, most faults are temporary and automatically cleared without impacting the integrity of the transmission network, and the permanent or persistent faults can be located easily and quickly repaired. Where there is a temporary fault (e.g. a lightning strike), restoration can occur within a number of seconds. In the case of permanent faults, restoration times are on average, less than 48 hours[46].

107 Compared to equivalent UGCs, 400 kV OHLs result in a relatively low physical impact to the land they cross (limited to the tower locations and land within the OHL corridor). It is a very flexible technology which can be routed and constructed in a wide variety of topographies. With longer spans it can also be constructed to pass over waterways or obstacles.

[45] Denmark is deliberately excluded from Table 4.6 as it is a special case and is discussed in greater detail in **Section 4.7.2.4.**
[46] Refer to **Section 4.7.2.5.**

108 HVAC OHL technology is considered international best practice and is a proven technical solution for transmission of high voltage electricity. It is the technology around which the transmission network in Ireland has been developed to date. It is the clear position of the respective applicants, based upon professional and technical expertise, extensive experience, and international best practice that, on the grounds of achieving an overall balance between environmental, economic and technical objectives, the approach to the establishment and routing of high voltage transmission circuits in rural areas will normally be effected through an OHL construction methodology (refer to **Chapter 5** of this volume of the EIS for routing considerations).

4.7.2.2 High Voltage AC Underground Cable (UGC)

109 High voltage UGC technology involves installation of specialised insulated cables under the ground. The cables can either be direct buried or placed within ducts / concrete trenches or tunnels. Direct burial installation requires the use of heavy equipment along the entire length of the route, not only for excavation but also for the transport and installation of the cables. However, it does not require the level of civil engineering required by cut and cover tunnels and deep bore tunnelling type installations. Cable tunnels in contrast to cable trenches are very costly to build and are normally used over short distances and typically only in densely developed urban areas where lack of space precludes the use of OHLs and direct buried cables.

110 The installation of direct buried UGC is highly dependent on soil type. There are two main influences: excavation and backfill. Trenching for UGC requires the excavation of significant quantities of soil. The suitability of the excavated soil as a backfill material and its thermal resistivity are important considerations. Special techniques such as directional drilling are also used for crossings under roads, railways and waterways resulting in a reduced disturbance to the surrounding environment.

111 In terms of reliability of UGCs, reference is made to the most comprehensive study to date carried out by Cigré *Update of Service Experience of HV Underground and Cable Systems, ISBN 978 -2-85873-066-7* (2009). This study was based on the results of a survey of 73 utilities from around the world. The study found, that once located, the average time taken to repair a fault on a 400 kV XLPE cable (a cable type which would be considered for the proposed interconnector) is 25 days if the cable is direct buried, and 45 days if installed in a tunnel. On the basis of potential for prolonged unplanned circuit outages, 400 kV OHLs are therefore considered to have a better service availability than equivalent UGCs (this is discussed in greater detail in **Section 4.7.2.5**).

112 Long term reliability is also considered to be an issue. The expectation and international experience is that as an UGC gets older, it becomes less reliable. This is principally due to deterioration of the material used in the manufacture of the cable and the long term impact of electrical and thermal stresses over the operational life of the cable.

113 In relation to the use of UGC for HVAC transmission, the high capacitance of the cable presents design and operational difficulties. The most notable of these is the risk of temporary high voltages within the network which exceed the rating of the cable and can cause critical failure of either the cable equipment or transmission assets in a wider area. The TEPCO report and subsequent internal analysis has shown that equipment ratings could be exceeded.

114 The IEC Report recommended against using a total HVAC UGC solution for this particular project advising that *"AC cables are technically possible, but have never been found attractive for long distance, high power transmission"* and *"For AC connections, the solution by underground cables is only used for limited distances".* In fact, there are no 400 kV HVAC UGC in the world that approach the length required for the proposed development.

115 One of the main advantages of installing UGCs is the reduction in landscape and visual impacts associated with the OHL option. However installing buried cables across the country side introduces environmental issues specific to that technology, e.g. potential impact on archaeology as a result of excavation works and permanent loss of habitat due to removal of hedgerows.

116 Because of their higher cost and lower level of availability for service, high voltage transmission cables are generally only used in urban areas or wherever a constraint has been identified such that no alternative exists other than to use a cable. In Europe some examples of circumstances where such cables have been used would be :

- In densely populated areas and where no alternative exists;
- In congested areas of infrastructure where no alternative exists;
- Where it is necessary to cross water and no alternative exists; and
- Where no alternative exists but to route through an environmentally sensitive area and undergrounding is deemed to be less of an impact on the environment.

4.7.2.3 Undergrounding the Entire Interconnector Using AC UGC

117 In 2009, when preparing the EIS associated with the previous application for approval (which was subsequently withdrawn) EirGrid considered the option of undergrounding the proposed development using AC UGC. EirGrid‘s conclusion at that time was that the entirely undergrounded AC alternative would not be an acceptable solution as:

- It would not be the least cost technically and environmentally acceptable solution; and
- Its use would not be in compliance with good utility practice.

118 Many of the observers who participated in the consultation process associated with the previous application disagreed with EirGrid‘s conclusion, and referenced, either directly or indirectly, the Askon Report (*Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project)* which was commissioned by North East Pylon Pressure (NEPP) in support of their contention that the development should be undergrounded.

119 The IEC reviewed the Askon Report as part of its review of the proposed development. The IEC Report stated that, while the author of the Askon Report, Professor Noack *“is well known in the industry for his work on lightning protection and overvoltages”* the *“Commission, is however, not aware of his expertise in grid development, grid operation, economic aspects and undergrounding*”. The IEC then went on to state that it had found *“several questionable statements*” in the Askon Report. The more significant of these were:–

- The IEC does not agree with the Askon Report when it states that long 400 kV AC UGC *“are not really a problem and that experience is there”.* The IEC found that there are no 400 kV UGC circuits in the world that approach the length required for the proposed interconnector and that this is because of sound technical reasons;
- The analysis by Askon of the reliability of AC UGC circuits is not valid as it *“is not backed up by actual data”; and*
- The costs estimates for AC UGC in the Askon Report are significantly understated as insufficient provision is made for the cost of installation.

120 Overall, the IEC concluded that the findings of the Askon Report *“are not consistent with industrial practice for other projects in Europe”* that are similar in size and form to the proposed development and which *“have been executed, are under construction or are in planning”.* The IEC Report goes on to make only one recommendation and that is that the proposed development should not be implemented using the entirely undergrounded AC cable option.

121 The position of the IEC regarding the Askon Report is consistent with EirGrid's position on that report. Having reviewed the undergrounding issue as part of the re-evaluation process and, in particular, having considered the IEC Report, EirGrid concurs with the recommendation of the IEC that the proposed development should not be implemented using the entirely undergrounded AC cable option.

122 Undergrounding the entire interconnector, approximately 135km in length, using AC UGC is therefore eliminated from further consideration for this development.

123 It is stated in **Section 4.7.1.1** that during public consultation some stakeholders suggested that consideration be given to an offshore cable that is a submarine cable off the east coast, for linking the two transmission networks on the island of Ireland. As an AC offshore option would require an even longer length of AC cable than the approximately 135km length of the on land option it is also eliminated from further consideration for this development.

4.7.2.4 High Voltage AC XPLE UGC and Extent of its Use

124 Although the entirely undergrounded AC option was eliminated, the option of using a hybrid AC solution, i.e. a combination of AC UGC and AC OHL, commonly referred to, and herein after referred to, as ‗partial undergrounding', remains an option for consideration. Indeed the IEC found in this regard that the partial undergrounding is technically feasible but within limitations on the cumulative length of the UGC sections. It is appropriate therefore that consideration continue to be given to the use of high voltage AC UGC for this development but within these recognised constraints.

125 XLPE (cross linked polyethylene) insulated cable is the ‗state of the art' for HVAC UGC in the world today. EirGrid adopted the use of high voltage XLPE cable at an early stage in its commercial development. The first 110 kV XLPE cable in Ireland was installed in 1978. The first 220 kV XLPE cable in Ireland was installed in 1984. The installation of long lengths (greater than 1000 metres) of 400 kV XLPE UGC only became possible in the late 1990s with the development of a suitable cable joint for connecting lengths of such cable together.

126 In the period 1997 to 2009, eleven significant 380 kV / 400 kV XLPE projects[47] (i.e. projects that involved a circuit length in excess of 2km) were completed in Europe. The longest of these was the 20km long Elstree - St John's Wood 400 kV cable project in London. This cable is installed in a three metre diameter air conditioned tunnel. The combined circuit length of these eleven

[47] Entso-e & Europacable Joint paper to EU Commission: *Feasibility and technical aspects of partial undergrounding of extra high voltage power transmission lines*, December 2010, available at http://ec.europa.eu/energy.

European ‗projects of significance' amounts to approximately 196km[48], with a cumulative single phase cable length of some 640km. It should be noted that a minimum of three single phase cables is required per circuit.

127 If the proposed development was to be implemented in its entirety using 400 kV XLPE cable, it would require approximately 810km (2 X 3 X 135km[49]) of single phase cable. This means that this single project would require more 400 kV XPLE cable to be installed in Ireland (in one circuit) than has been installed throughout Europe during the period 1997 to 2009. It appears, based on an analysis of reports (Europacable, Cigré T&D World[50]) of major EHV (extra-high voltage - in the range 315 kV to 500 kV) UGC projects carried out across the world in the fifteen year period up to 2012, that if the proposed interconnector was to be implemented entirely using UGC, there would be more EHV XLPE cable installed on the island of Ireland than in all of mainland Europe or in North America.

128 In contrast to the relatively small quantity of EHV UGC that has been installed in Europe during the period 1997 to 2009, it is interesting to note that in the period 2000 to 2009 over 10,000km of EHV OHL was installed in mainland Europe (17 member states of UCTE[51]). The reason for this overwhelming preference among UCTE members for OHL can be clearly understood in a letter[52], dated 14 January 2008, from the Secretary General of the UCTE to APG (the Austrian Power Grid Company) wherein it states:

> ―*For the time being 400 kV AC cable systems cannot compete with overhead power lines in the transmission grid. Using cables for lines in interconnected operation (400 kV backbone) presents serious technical, financial and environmental drawbacks.*"

and

> ―*UCTE therefore recognizes overhead power lines as the most reliable and most secure technical solution for transmitting electricity over long distances. Furthermore based on different studies within UCTE an overhead line is the more efficient and more economical way for the transportation of electricity* compared with underground cables at the 400 kV level".

[48] In the case of some of these projects the circuits consisted of two cables per phase giving a total of six single phase cables per circuit.
[49] The distance of 135 km is derived from the length of the route identified by PB Power in its 2009 report. The requirement for two cables per phase is also identified by PB Power in that report. There are three phases in the AC system.
[50] Transmission and Distribution World magazine, available at http://www.tdworld.com
[51] UCTE is an association of Transmission System Operators from mainland Europe (excluding Scandinavia and the countries of the former USSR). UCTE is now a part of ENTSO-E. The data was obtained from the UCTE Statistical Yearbooks 2000 and 2009
[52] Available at http://www.eirgridprojects.com/projects/northsouth400kvinterconnectiondevelopment/projectactivity/2008/

129 This overwhelming preference for OHL among European utilities is expected to continue into the future. In this regard, the *Ten Year Network Development Plan (TYNDP)* 2012[53] issued by ENTSO-E (European Network of Transmission System Operators for Electricity) indicates that in the period covered by the TYNDP, a further 28,400km of new EHV (i.e. greater than 330 kV) AC OHL is planned to be installed in Europe while during the same period only 420km, in predominantly short lengths, of 400 kV AC UGC is planned (p 62). The reason for the preference for 400 kV OHL is explained in the TYNDP (p 81) as follows:

> “*New 400 kV AC OHL projects are in technical, economic, and ecological terms the most efficient solution for long distance electricity transmission. Indeed, such reinforcements integrate straightforwardly into the existing grid since this technology has been the standard for a long time*”.

130 It is clear therefore that the electricity utilities of Europe still consider the use of OHL for 400 kV circuits to be best practice, and that 400 kV UGC is only used in very limited situations and only over relatively short lengths. The installation of 270km (2 X 135km) of 400 kV UGC in Ireland in one project, or even in a multiple of different projects, could not be described as complying with good utility practice.

131 During consultation in respect of the previous application for planning approval (and subsequently) it was stated by numerous stakeholders that the strategy adopted by Denmark for the undergrounding of its transmission grid should be considered as the standard for what constitutes ‘best international practice’. EirGrid does not agree and instead considers ‘best international practice’ to be the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry in Europe’ and not just the practice in a single European country. The practices in a broad range of European countries with regard to the undergrounding of 400 kV transmission circuits are set out above.

132 Notwithstanding the fact that the practice in Denmark is not the determinant for what constitutes ‘best international practice’ it is useful to consider the Danish strategy. In 2009 a plan[54] was published in Denmark for the undergrounding of the entire 132 kV / 150 kV grid over a period extending to 2040. The plan for the 400 kV grid is however quite different. Even though there appears to be a national desire and a willingness to pay for the undergrounding of the entire 400 kV grid it was determined that it was not achievable due to the technical difficulties, uncertainties and risks associated with the installation of long lengths of 400 kV UGC.

[53] Available at https://www.entsoe.eu/major-projects/ten-year-network-development-plan/tyndp-2012/
[54] Energinet.dk - Cable Action Plan:132 - 150 kV Grids - March 2009

133 The technical difficulties and risks associated with the installation of long 400 kV UGC are explained in a technical report[55] published by the Committee set up by the Danish Government to develop the strategy for the undergrounding of the transmission grid. At page 19 it states:

> *"When a 400 kV cable is disconnected, the large energy volumes stored in the cable and the cable substations will oscillate and cause overvoltage. The installation of long cables or a large number of short 400 kV cables increases the risk of such phenomena becoming a serious problem. The over voltages may become very large with the ensuing risk of other components being disconnected. This increases the risk of power failures."*

134 It was as a result of these concerns that the Danish Committee recommended that those 400 kV circuits that form the backbone of the transmission grid should not be undergrounded as to do so would carry too high a risk for system security and stability. Based on this it was decided that the required increase in interconnection capacity with Germany would be achieved by constructing a new double circuit 400 kV OHL. That line is currently under construction and is due for commissioning in 2014.

135 It is clear therefore that new 400 kV OHLs are being, and will be, constructed in Denmark. The map of Denmark at **Figure 4.5** shows the planned extent of 400 kV grid by 2030. The proposed new OHLs can be seen on this map as solid orange lines.

[55] Technical Report on the Future Expansion and Undergrounding of the Electricity Transmission Grid – Summary – April 2008www.energienet.dk.

Figure 4.5: Planned 400 kV Infrastructure for the Danish Transmission Network

(Source: *Technical Report on the Future Expansion and Undergrounding of the Electricity Transmission Grid – Summary* – April 2008)

136 The longest AC UGC in the world, with a voltage rating greater than or equal to 380 kV, is a 40km long cable in Tokyo, Japan. Denmark aspires to having the longest such UGC in the world. However recognising the technical difficulties, uncertainties and risks associated with such long 400 kV UGC a research and development programme has been instituted, in cooperation with Danish universities which, it is hoped, will conclude with the installation and testing of a long length (between 40km and 60km) of 400 kV UGC. The Technical Report states (p.8) that –if *targeted efforts are made, these tests can be implemented within 6 – 10 years”*. If successful, plans will proceed to underground all future –*non-vital backbone”* 400 kV

circuits. The 400 kV circuits proposed for undergrounding over the following decades can be seen on **Figure 4.5** as dashed orange lines.

137 The *Denmark Cable Action Plan*[56] envisages that the expansion of the 400 kV network will proceed as shown in **Table 4.8.** From this it can be seen that (assuming the technical uncertainties mentioned in the previous paragraph are resolved) approximately 55% (290km) of the expansion will be achieved by means of 400 kV OHLs and the remaining 45% (240km) by 400 kV UGC.

Table 4.8: Denmark 400 kV Network Expansion Plan

Year	400 kV Overhead Line	400 kV Underground Cable
2009	1,270 km	80 km
2030	1,560 km	320 km

4.7.2.5 Reliability Statistics for High Voltage AC UGC and OHL

138 From a transmission adequacy point of view the availability for service, or more correctly the lack of availability for service, of a transmission circuit is a more important measure of reliability than simple ‘failure rate’. A circuit‘s ‘availability’ is derived from the expected failure rate and the average time it takes to repair a fault.

139 The vast majority of faults on transmission OHLs are transient in nature. Most of these are caused by lightning; the lightning does not cause any damage; the fault only exists as long as the lightning exists. The protection systems for the OHLs are designed to trip the line when a fault occurs and, based on the assumption that the fault is transient, will automatically switch the line back into service within one second. If the fault is not transient but a ‘permanent’ fault then the OHL will re-trip and the line will remain out of service until repair crews can find and repair the fault.

140 In the case of transmission UGCs however almost every failure can be assumed to be a permanent fault as usually the very act of failing results in an explosion at the point of failure which destroys a section of the cable.

[56] Energinet.dk - *Cable Action Plan:132 - 150 kV Grids* - March 2009.

141 As the time it takes to repair a 400 kV UGC is much greater than the time to repair a 400 kV OHL it can be expected that such an OHL will have a much better level of availability for service than an equivalent UGC and this is supported by system statistics.

142 In April 2009, Cigré[57] published the results of the most comprehensive study of UGC reliability carried out to date (refer to **Table 4.8**). This study was based on the results of a survey of 73 utilities from around the world. Of interest is the information received on the performance of 1,388km of XLPE cable with a voltage rating in the range 220 kV to 500 kV. Applying the calculated fault rates of this 1,388km of installed cable, to the length of cable[58] (2 x 135 km) that would be required for the proposed development, gives a projected fault rate of ‗one fault per annum‘.

143 In addition, the Cigré study found that the average time taken to repair a fault on a 400 kV XLPE cable is 25 days if the cable is direct buried, and 45 days if installed in a tunnel. A direct buried cable is, however, ten times more likely to be damaged due to external factors than a cable installed in a tunnel the study concluded.

144 Compare this ‗fault rate‘ and ‗average time to repair‘ of UGC with that of an equivalent OHL. There are 439km of existing 400 kV OHLs in Ireland. This length of 400 kV OHL is too small a sample for determining meaningful performance statistics. Meaningful statistics can, however, be obtained by considering the fault statistics of the combined quantity (approximately 2,245km) of 400 kV, 275 kV and 220 kV OHLs under EirGrid‘s control[59]. Taking the fault statistics of this existing 2,245km of OHL for the period 2004 to 2012, gives a projected fault rate for the proposed (approximately 140 km long) 400 kV OHL of one permanent fault (that is a fault that requires repairs before the OHL can be returned to service) every 20 years.

145 The statistics also show that the average duration that a 400 kV / 275 kV / 220 kV OHL circuit will be out of service for repair after a fault is considerably less than that of an equivalent UGC circuit - less than two days in the case of OHLs, and 25 days in the case of a 400 kV UGC. This is summarised in **Table 4.9**.

[57] Cigré Technical Brochure 379 - *Update of Service Experience of HV Underground and Submarine Cable Systems, ISBN 978 - 2-85873-066-7* (April 2009).

[58] The distance of 135km is derived from the length of the route identified by PB Power in its 2009 report. The requirement for two cables per phase is also identified by PB Power in that report.

[59] This is reasonable compromise because the existing 220 kV and 275 kV OHLs are of similar design and experience similar operating conditions to that of the existing 400 kV OHLs.

Table 4.9: Summary of Comparative OHL and UGC Statistics

UGC and OHL	Projected Fault Rate for N-S Interconnector	Average Time to Repair
UGC – directly buried cable (statistics based on 1,388 km of XLPE cable with a voltage rating in the range 220 kV to 500 kV) **Source:** Cigré Technical Brochure 379	1 fault per annum	25 days
OHL (statistics based on 2,245km of 220 kV, 275 kV and 400 kV OHL in Ireland) **Source:** EirGrid (2004 – 2012)	1 fault (permanent fault requiring repairs) every 20 years	Less than 2 days

146 The comparative analysis indicates that OHLs have a substantially better level of availability for service than UGCs. This result is consistent with the findings of the independent Ecofys Report[60] in which the ‗availability‘ (the term Forced Outage Rate is used in the report) of OHLs was found to be at least ten times (at least one order of magnitude) better than that of UGCs. This comparative performance must always be a factor when a TSO is considering UGC particularly when the circuit in question is to be a backbone circuit of the transmission network and therefore of the highest strategic importance[61].

4.7.2.6 The World's Longest High Voltage AC XPLE Cable Circuits

147 The longest high voltage AC XLPE cables operating in the world today are submarine cables. The longest is the 105km long 90 kV 40MW interconnector from Great Britain to the Isle of Man. The record for the longest HVAC cable in the world is likely to be broken when the proposed 125km[62] long 220 kV and 200MW interconnector between the islands of Sicily and Malta is commissioned. These long cables are radial connections and as such they do not form part of a meshed transmission network, unlike the proposed development. They also have a much lower power carrying capacity than that which is required of the proposed interconnector (i.e. 1,500MW). The environmental impacts of UGC, the technical difficulties of UGC, and the cost of UGC increase rapidly with increase in voltage rating and power carrying capacity. These

[60] *Study on the Comparative Merits of Overhead Electricity Transmission Lines Versus Underground Cables*, carried out by Ecofys on behalf of the Department of Communications, Energy and Natural Resources and available at www.dcenr.gov.ie.
[61] Refer to **Section 4.7.2.4** for the impact that this consideration had on the Government approved plan for the extension of the transmission grid in Denmark.
[62] The circuit consists of 100km of submarine cable plus 25km of on-land UGC.

examples of long HV undersea cables are therefore in no way comparable with the requirements of the proposed development.

148 The longest ‗on-land' AC XLPE cable circuit, with rated voltage of 400 kV or higher, operating in the world today is a 40km double circuit cable in Tokyo, Japan. These 500 kV, 900MW cables were commissioned in 2000. The longest such cable in Europe, at 20km, is the Elstree - St John's Wood 400 kV 1,600MW circuit in London, which was commissioned in 2005. Unlike the long undersea cables, these cables have power carrying capacities, and voltage ratings, that are comparable with that of the proposed interconnector: There, however, the similarities end, in that:-

- The cables in London and Tokyo are installed under the streets and buildings of two of the largest cities in the world. Both of these cable circuits are installed in air conditioned tunnels. The proposed development would traverse open farm land in the main;

- The proposed interconnector UGC route (as identified by PB Power) is about 135km in length. The cables in London and Tokyo are a fraction of this length. The technical difficulties associated with long lengths of EHV UGC increase with increase in circuit length; and

- The transmission networks in Great Britain and Japan are orders of magnitude bigger and therefore unlike Ireland are far better able to accommodate such long lengths of EHV UGC.

149 One of the project objectives / design criteria for the proposed interconnector, as stated in **Section 4.5**, is that it will have a power carrying capacity in the region of 1,500MW and connect between appropriately robust points on the transmission networks north and south of the border. To try to achieve this using an entirely UGC option would require the installation of two circa 135km-long UGC circuits. It is clear from the above that no country in the world has ever implemented such a project, or anything comparable. It is also evident from ENTSO-E's *Ten Year Network Development Plan 2010-2020* that there are no plans to install anything comparable in Europe in the next ten years.

150 It is concluded therefore that to implement the proposed interconnector using long lengths of high voltage AC UGC would not comply with good utility practice.[63]

[63] The term ‗good utility practice' is defined in this context in a footnote in **Section 4.5.**

4.7.2.7 Cost Comparison of AC UGC and AC OHL

Capital Costs

151 Three separate comparative studies of UGC versus OHL were carried out in Ireland during the period 2008 / 2009 as follows:

- Askon Report (commissioned by North East Pylon Pressure (NEPP)),
- Ecofys Report (commissioned by the DCENR) and
- PB Power Report (commissioned by EirGrid / NIE) supplemented by the *PB Power Technical and Costs Update* (April and July 2013).

152 The studies found that the capital cost of UGC ranged from three to eight times that of an equivalent OHL64.

153 The most up to date site specific comparative cost estimate available for this development can be found in the *PB Power Update Report, Supplementary Note* of July 2013. This report found that the AC UGC option would cost €740 million more than the proposed 400 kV OHL.

154 The extent of the cost differential between AC OHL and AC UGC is so great that, and regardless of the additional technical problems of UGC, if EirGrid is to comply with its statutory obligations[65] it effectively discounts using UGC for any significant length in this development.

Life Cycle Costs

155 In some of the written and oral submissions presented by observers during the previous application process, it was acknowledged that the capital cost of UGC was much greater than that of OHL. It was, however, asserted in these submissions that UGC is more efficient than OHL and that over its life cycle a UGC would incur lower electrical losses and, therefore, lower operating costs than an equivalent OHL. It was further stated that if the cost of the two technologies were compared over a typical life cycle, then UGC might well prove to be the more cost effective option.

[64] Note: As these studies were only interested in calculating the cost differential between the options, they did not include in their estimates provision for project costs that are common to all options. Their cost estimates for each option cannot therefore be considered as ‗whole of project' cost estimates.
[65] Regulation 8 of SI 445/2000.

156 These assertions are incorrect as they are based on a misunderstanding of transmission networks operation. UGCs and OHLs have different electrical characteristics with the result that a lightly-loaded UGC (typically less than 50% loaded) will have higher electrical losses than an equivalent lightly-loaded OHL, while a heavily-loaded UGC (typically greater than 50% loaded) will have lower losses than a heavily-loaded OHL. This is well illustrated in the graph in **Figure 4.6** which compares the energy losses of a 400 kV OHL 1,500 MVA circuit with two 400 kV UGC alternatives (2 X 1,200 mm² and 2 X 1,600 mm² aluminium cables) of comparable capacity. The breakeven point (crossover point) for the 1,200 mm² UGC (in comparison with the OHL) is 900 MVA while the comparable breakeven point for the 1,600 mm² UGC is lower at 840 MVA.

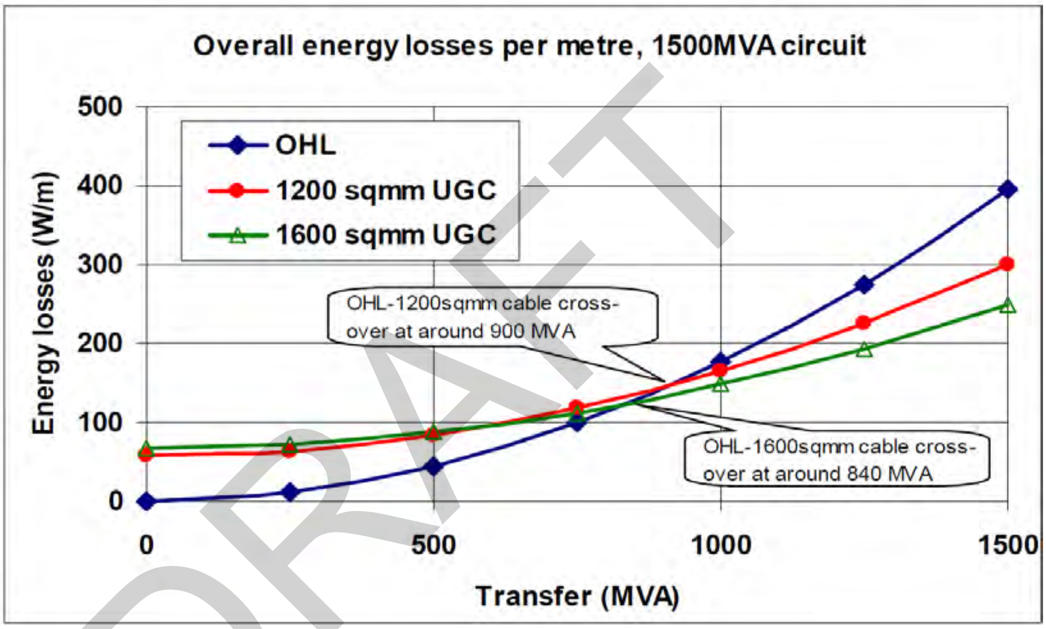


Figure 4.6: Comparison of Energy Losses for OHL and UGC

(Source: Figure 3-7 *PB Power Report* (2009))

157 Circuits in a meshed transmission network are required, under normal system conditions, to have a contingency capacity. In other words, they are required to have sufficient spare capacity to cater for the sudden loss of another circuit on the network. In practice, this means that transmission circuits, and particularly backbone circuits, typically operate at less than 50% of their power-carrying capacity. Therefore, OHL transmission circuits incur lower electrical losses than equivalent UGC transmission circuits during their lifetime. This is confirmed, in the case of the transmission networks of mainland western Europe, in the letter from the Secretary General of UCTE (as previously referenced), dated 14 January 2008 to the Austrian Power Grid Company (APG), in which it was stated that, "*based on different studies within UCTE an overhead line is the more efficient and more economic way for the transportation of electricity compared with underground cables at the 400 kV level*".

158 The average energy transfer on the proposed interconnector, over its lifetime, is expected to be less than 33% of its nominal power carrying capacity. This is on the basis that the peak load on the circuit (under normal system conditions) should not exceed 50% of capacity[66]. It is therefore the case that using OHL for the new interconnector will incur lower electrical losses than using equivalent UGC alternative.

159 The *PB Power Update Report* of 2013 estimated that over its lifetime the cost of operating and maintaining the proposed 400 kV OHL would be €55 million while the comparable cost for the UGC option would be €90 million. This estimate was based on an assumed average loading of 33% of capacity (500MVA).

4.7.3 Partial Undergrounding of AC Transmission Circuits

4.7.3.1 Background to Partial Undergrounding

160 In the context of this EIS, ‗partial undergrounding‘ is the term used to describe the undergrounding of a short section, or short sections, of a long transmission circuit that is comprised predominantly of OHL.

161 As the use of any HVDC technology, whether OHL or UGC is not an appropriate or acceptable option for this development (refer to **Section 4.7.1.2**), the following consideration of partial undergrounding is restricted to high voltage AC technology and has little or no relevance to HVDC technology.

162 Partial undergrounding of 110 kV circuits is common practice in Ireland. There are no examples of partial undergrounding at the 400 kV level in Ireland however there are numerous examples elsewhere in Europe. Partial undergrounding of 400 kV AC circuits is therefore technically feasible.

163 In the 2009 EIS, it is stated that the joint development philosophy of EirGrid and NIE for the proposed transmission line, which will follow an alignment across a rural area, is ―*firstly to seek a viable and environmentally acceptable OHL solution; the use of short lengths of UGC will only be considered in the event that an OHL solution cannot be found, and where it can be confirmed that the use of UGC does not exceed the system‟s capacity to absorb such cables*”.

[66] See Section 9.2.2 of the Ecofys Report (summarised in **Table 4.3**) for further discussion on this point.

164 As part of the previous application for approval, EirGrid identified a short section of the overall proposed circuit where UGC was deemed to be the most appropriate option. This short section of UGC was to be fully contained within the confines of Woodland Substation. During the subsequent review and Confirm Design Stage associated with the current application for approval EirGrid decided to alter the point of connection at Woodland Substation of the proposed new 400 kV circuit in order to eliminate the requirement for this short section of 400 kV UGC. Such a section of UGC within the confines of Woodland Substation does not therefore form part of this application for development consent.

4.7.3.2 Consideration of Partial Undergrounding for this Development

165 When considering partial undergrounding for a 400 kV project, it is essential to understand the environmental, technical and cost implications of such a development. These issues are assessed in general terms in a joint position paper prepared by Europacable and ENTSO-E that was submitted to the European Commission in December 2010 (*Feasibility and Technical Aspects of Partial Undergrounding of Extra High Voltage Power Transmission Lines* (December 2010)). The joint paper "*merges the experience European Transmission System Operators (TSOs) have gained with the inclusion of underground EHV cables into their transmission networks over many years with the technical expertise of the leading XLPE EHV cable systems manufacturers in Europe*". The implications, for the proposed interconnector are considered below.

4.7.3.3 Partial Undergrounding – Environmental Issues

166 The size of the AC UGCs required for the proposed interconnector would be such that they could not be installed under public roads or under the disused railway line (refer to **Chapter 5** of this volume of the EIS for consideration of potential route corridor alternatives), as these roads and railways are not sufficiently wide. The only practical option would be to install the cables directly across farmland. This would have the following environmental implications:

- The construction effort associated with the installation of the UGC section would be considerably greater than that of the OHL. The UGC would require a construction swathe of 20 to 22 metres, as wide as a dual carriageway[67], to be cut through the countryside. This would result in much greater disruption to farming and other activities during the construction phase than would arise from the construction of the OHL.

[67] High Quality Dual Carriagway as per the National Roads Authority.

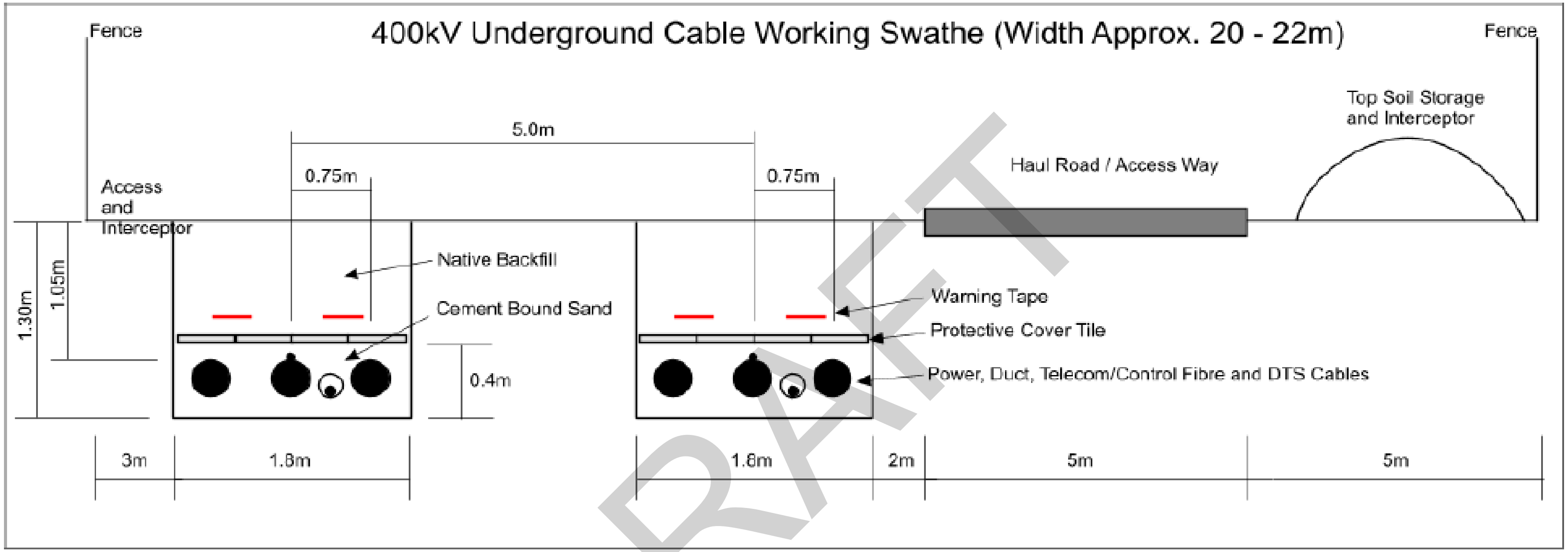


Figure 4.7: 400 kV Single Circuit, Two Trench, Working Swathe

(Source: Figure 7.1(b) *PB Power Report* (2009))

- The UGC construction swathe would cut through every hedgerow in its path, leaving a permanent gap. The hedgerow would not be allowed to re-establish itself as deep rooted vegetation cannot be permitted to grow in proximity to UGCs.

Figure 4.8: Photographs of a 400 kV Double Circuit Cable Being Installed Cross-Country

(**Note:** The first photograph shows the construction swathe with one trench and the haul road, the second photograph shows the construction swathe with two open trenches and haul road in the centre – Source National Grid Company, UK.)

- This is unlike the case of the OHL where in many cases the OHL will oversail hedgerows without unduly interfering with them. Where a tower is positioned straddling a hedgerow, a section of the hedgerow will be removed during construction, but it can be allowed to re-establish itself afterwards (see **Figure 4.9**), and management of the hedgerow thereafter will be required only to prevent its interference with the OHL.

Figure 4.9: Photograph of a Tower Straddling a Hedgerow with Vegetation Re-established

- Two underground chambers would be constructed approximately every 650m along the UGC route to accommodate the 400 kV cable joints. At these locations two inspection enclosures, either underground chambers accessed via a surface manhole or above ground kiosks similar to that shown in **Figure 4.10** are required.

Figure 4.10: Photograph of Above Ground Inspection Kiosks for UGC

(Source: PB Power (2009) Report, page A6 11)

- No buildings are permitted within a UGC reserve[68]. Buildings can, and have been, constructed below high voltage OHLs, most notably in the UK.

- It would be necessary to have a substation at every location where the 400 kV circuit changes from OHL to UGC. Where a substation is required solely for the purpose of accommodating a transition from UGC to OHL, it is known as a ‗transition station' or as a ‗sealing end compound'. A typical 400 kV transition station has the same appearance as a small 400 kV substation. It would require a land take of about one-half of a hectare. It would consist of an inner compound enclosing the live equipment and a small building, with a buffer strip around the compound to accommodate an earth berm, and / or vegetation, for screening and an access road.

Figure 4.11: Example of a 400 kV Underground Cable to Overhead Line Transition Station

(Source: 380-kV-Salzburgleitung Auswirkungen der möglichen (Teil) Verkabelung des Abschnittes Tauern-Salzach neu - Gutachten im Auftrag von Energie-Control GmbH Wien – Professor B. R. Oswald)

[68] Note: This applies where the cables are buried directly into the ground. If the cables are installed in a tunnel, and can be accessed via the tunnel, then buildings and other infrastructure can be constructed above, provided there is sufficient clearance.

4.7.3.4 Partial Undergrounding – Technical Issues

167 Inserting a section of UGC into an OHL circuit will have a negative effect on the reliability performance of the overall circuit. The latest performance statistics (refer to **Section 4.7.2.5)** confirm that, on a kilometre for kilometre basis, 400 kV OHLs have a much better service availability record than 400 kV UGCs.

168 The risk to transmission system stability associated with the installation of a long length of EHV UGC exists, regardless of whether that long length of cable forms an entire UGC circuit, a single section of partial undergrounding, or is made up of multiple shorter sections of UGC within a single hybrid OHL / UG circuit. As a result, some utilities have set down the maximum permissible length of EHV UGC that can be installed on their transmission system whether installed as a single UGC circuit or as part of a hybrid UGC / OHL circuit and the maximum permissible cumulative length of EHV UGC on the system. In the Netherlands, for example, the maximum permissible length of a single 400 kV UGC is 20km. It is also the case that the longest 400 kV UGC in Europe is a 20km cable installed in an air conditioned tunnel in London.

169 When considering what should be the maximum permitted length of 400 kV UGC on the island of Ireland, the respective applicants must take account of the accompanying risk of failure and consequence of such failure. The transmission system on the island of Ireland is much smaller than that on the island of Great Britain and of course much smaller than that of mainland Europe, to which the system in Netherlands is connected. The transmission system in Ireland is therefore able to accommodate much shorter lengths of 400 kV UGC than is the case in Great Britain or the Netherlands, for example. The Transmission System Operator (TSO) and the Transmission System Owner (TAOs) in Ireland are also much smaller than their counterparts in Great Britain and the Netherlands and must, therefore, carry correspondingly smaller risk.

170 Accordingly careful consideration was given to the issue of partial undergrounding as part of the overall re-evaluation process. Based on the present extent and configuration of the Irish network, EirGrid considers that the maximum length of 400 kV UGC that would be technically feasible to install as part of the proposed development (inclusive of that part of the interconnector located in Northern Ireland) is approximately 10km, whether installed in one continuous length or in an accumulation of shorter lengths. However, there are a number of environmental factors and costs issues which must also be considered in any appraisal of the alternative technological option of partial undergrounding.

4.7.3.5 Partial Undergrounding – Cost Issues

171 The *PB Power Technology and Costs Update Report*[69] of July 2013 (see **Table 4.2**) contains the most up-to-date detailed site specific cost comparison of UGC and OHL for the proposed interconnector. The Update Report found (Table 8-16 on page 27) that AC UGC would cost on average €5.4 million per km more to install than the AC OHL.

172 At least one, and potentially two, transitions stations are required for each section of the circuit that is undergrounded. Depending upon the length of an underground section (and therefore the facilities required at each end), transition stations could add an additional €5 - €15 million (approximately) per installation.

173 Unlike OHL, long sections of UGC would require electrical compensation equipment to be installed along its route to counteract the effects of the underground cable on the transmission network; a 10km section of UGC would require around 0.5 hectares of land to accommodate such equipment. The costs for this transition station compensation equipment are included in the overall cost estimate updates for the AC UGC option but may not be required for short sections of partial undergrounding - hence the spread in estimated costs. Likewise, the land-take of the transition station for a short section of undergrounding which would not require the installation of reactive compensation equipment could be reduced to around 0.3 hectares.

4.7.3.6 Conclusion on Partial Undergrounding for the Proposed Interconnector

174 Partial undergrounding is feasible if:

- The length to be undergrounded is restricted, for technical and operational reason, to less than approximately 10km in one continuous length or an accumulation of shorter lengths; and

- The cost of using the short length(s) of UGC can be proven to be an environmentally advantageous and cost-effective way of overcoming an otherwise unavoidable environmental or technical constraint to the preferred OHL.

175 Neither of the respective applicants have identified any section of the route of the proposed development where the above applies and are therefore proposing that the entire 400 kV circuit be implemented using 400 kV AC OHL.

[69] Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits: Technology and Costs Update – Addendum to the 2009 Report and Supplementary Note – July 2013 by Parsons Brinckerhoff.

4.8 OVERHEAD LINE (OHL) DESIGN CONSIDERATIONS

4.8.1 Operating Voltage and Circuit Configuration

176 It is concluded in **Section 2.2.4**, **Chapter 2** of this volume of the EIS that the appropriate nominal capacity for the proposed interconnector is 1,500MW. It is further concluded in **Section 4.6** that the only technical alternative that provides an acceptable method for achieving the strategic and specific objectives of the proposed interconnector is AC OHL. Based on the foregoing, consideration is now given to the configuration of such an AC OHL development.

177 As noted in **Chapter 2,** of this volume of the EIS, the EHV transmission network of the Northern Ireland system although operated at 275 kV, is constructed to a 400 kV standard. These 275 kV double circuits OHL comprise the most robust part of the Northern Ireland network. In Ireland, the 400 kV network extends between the Moneypoint Generation Station in County Clare, and Woodland Substation in County Meath, and Dunstown Substation in County Kildare (both within the Greater Dublin Area), again comprising the most robust part of the transmission network in Ireland. It is entirely appropriate that an interconnection development with a nominal capacity of 1,500MW[70] provide interconnection between the ‘most robust parts’ of the respective networks namely the existing Woodland 400 kV Substation in County Meath and a proposed new substation adjacent to the existing double circuit 275 kV OHL in County Tyrone (Turleenan) see **Figure 4.12**.

178 Consideration has been given to constructing the proposed Interconnector using a double circuit design of 275 kV, matching existing circuit operation in Northern Ireland, thereby meeting minimum technical requirements in the short term. However, such an alternative would have no longer-term or lifetime cost saving in comparison with a single circuit 400 kV option. The 400 kV option will result in better voltage performance and reduced power losses.

[70] The capacity of an OHL is determined by the maximum permitted operating temperature of its electricity conductors (wires). While the maximum operating temperature is mostly influenced by the quantity of electrical current passing through the wires, the ambient temperature and ambient weather conditions are also important factors. In Ireland therefore, OHL have a ‘winter rating’ based on average winter weather conditions and a ‘summer rating’ based on average summer conditions. The ‘nominal capacity’ of an OHL is a rounded off figure, somewhere between the higher ‘winter rating’ and the lower ‘summer rating’ and is only used for comparative purposes. As stated previously MVA (megavolt-amperes) is the technically correct unit of measurement for describing the capacity of transmission circuits however in this context and in this EIS MW is interchangeable with MVA.

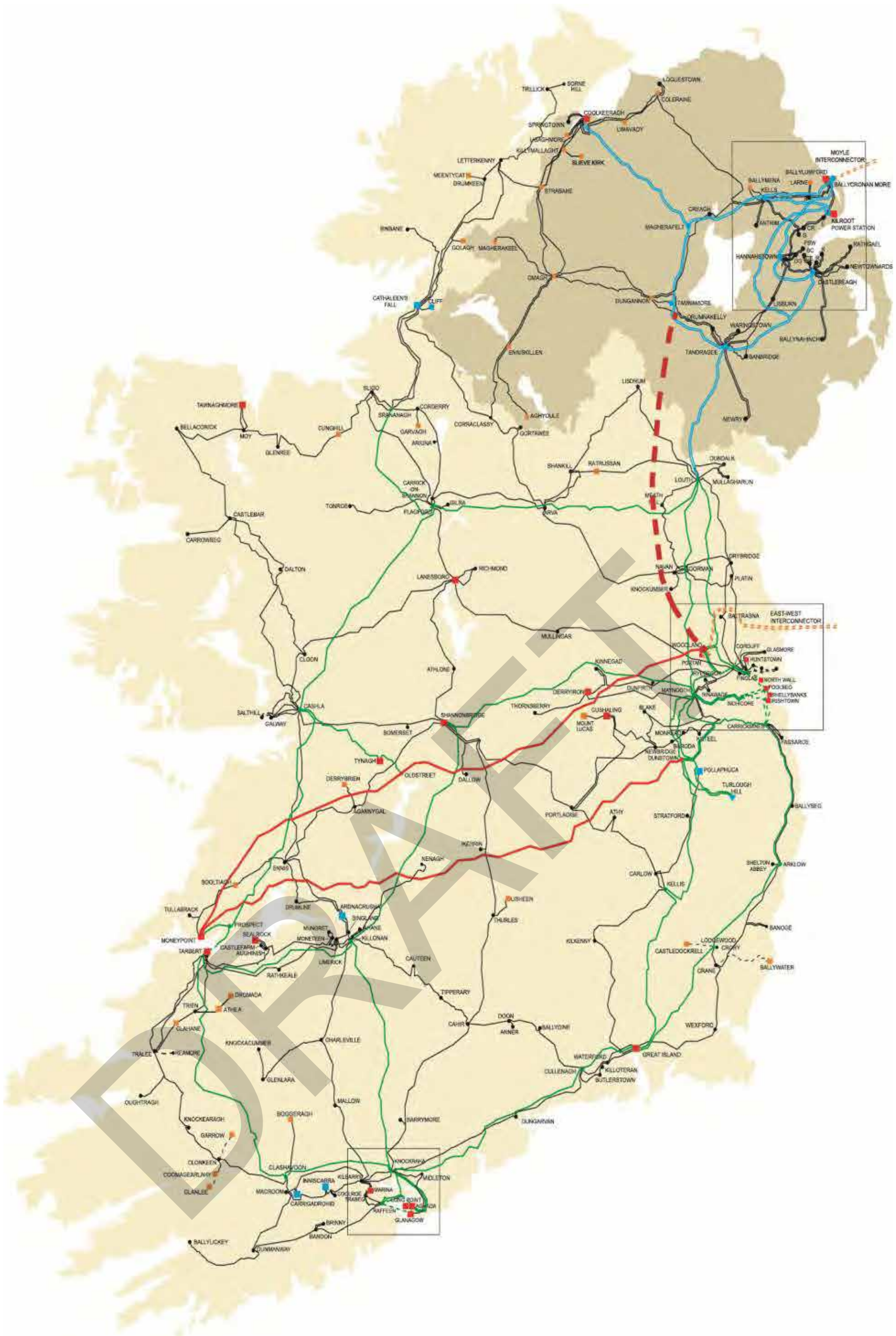


Figure 4.12: Map Showing Transmission Network and Proposed Interconnector

(The proposed interconnector is indicated in dashed red)

400 kV
275 kV
DC Interconnector
220 kV
110 kV

179 The circuit design and operating voltage are both important variables which determine the eventual size, scale, and ultimately, appearance of the support structures that would need to be constructed to facilitate an overhead transmission line. These variables therefore have a direct influence on potential landscape and visual impacts arising from the proposed OHL. It is acknowledged that the scale of a single circuit 400 kV OHL is likely to have a greater environmental impact than a single circuit 275 kV OHL. However, a single circuit 275 kV OHL would not be able to deliver the required 1,500MW capacity (see **Section 2.2.4** of **Chapter 2** of this volume of the EIS). The towers required for the double circuit 275 kV line that would be necessary in order to deliver the required 1,500MW capacity would be taller (see **Figure 4.13**) and likely to therefore have a greater visual impact than those required for a single circuit 400 kV OHL. There would effectively be no difference between the two options in terms of land requirements.

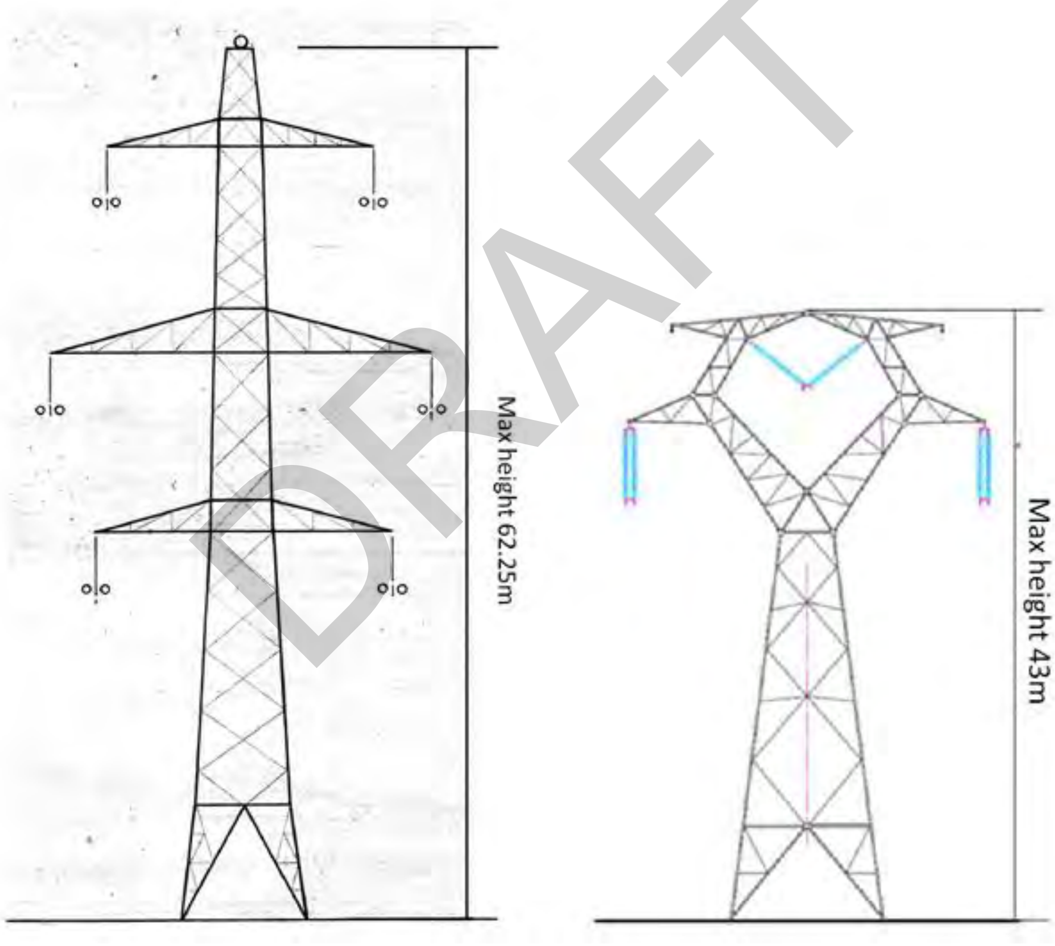


Figure 4.13: Outline Drawing of a 275 kV Double Circuit Tower and 400 kV IVI Tower

(Not to be scaled - for illustrative purposes only)

180 Overall, having regard to these factors, and including due consideration of environmental impact, the respective applicants determined that a 400 kV single circuit arrangement represented the most appropriate selection for the proposed Interconnector. This conclusion was accepted by both of the relevant regulatory authorities (CER and NIAUR).

4.8.2 400 kV Single Circuit Support Structure: Type Selection and Design

181 The type and design of support structure that is chosen has implications for the maximum achievable span length, angles of deviation and clearance requirements over obstacles (all of which need to be in accordance with the current EirGrid / ESB standards and specifications, which in turn are based on best international practice). Therefore support structure design is an important consideration for the detailed line design process.

4.8.2.1 Background to Support Structure Selection

182 In considering alternative designs for the 400 kV OHL support structures, the respective applicants commissioned a variety of studies which looked at a range of issues from visual impact on the landscape to electrical considerations. The studies evaluated a range of designs that included a number of lattice steel structures, wooden structures and steel monopole structures. A summarisation of these studies can be found in the *EirGrid / NIE Meath-Tyrone 400 kV Interconnection Development: Tower Outline Evaluation and Selection Report* (October 2009). This report reviews the methods and results of the previous studies.

183 The studies concluded that wooden structures would not be technically feasible for 400 kV OHLs in Ireland due to the heavy mechanical loading requirements and electrical clearance requirements. Steel monopole designs were found to be technically feasible with some benefits such as a small footprint requiring a reduced corridor width and relatively short construction duration when compared with traditional lattice steel structures. Due to these benefits a steel monopole design has already been used in Ireland to good effect for a 110 kV OHL running through an urban area in Cork (refer to **Figure 4.14**).

Figure 4.14: 110 kV Monopole Overhead Line in Cork

184 On balance however the studies found that for a 400 kV OHL, located in a rural setting in Ireland, a lattice steel structure is preferred. This was on the basis that while monopole designs are sometimes preferred in urban and suburban areas due to a combination of their reduced visual impact and reduced corridor width; the same advantages would not apply for a 400 kV OHL in an entirely rural setting. At 400 kV the superstructure of the monopole design would be a large dense visually intrusive steel pole with a diameter of up to six metres at its base. In addition due to the shorter maximum span that can typically be achieved with a monopole design a greater number of structures are required per kilometre than is the case with the lattice steel design.

185 Having identified lattice steel as the preferred design for the support structures for the proposed 400 kV OHL, a range of designs was considered in consultation with a designer / manufacturer of lattice steel structures. This resulted in four options being advanced for detailed comparative assessment. These were the classic or standard 401 type structure as used in the mid-1980s for the existing 400 kV OHLs in Ireland and the modern designs of the IVI type, VVV type and inverted delta type (refer to **Figure 4.15**).

186 For many stakeholders the visual impact of the proposed development was a significant concern (refer to **Chapter 3** of this volume of the EIS for details). In recognition of this, a visual assessment report which looked at delivering a reduced visual impact of a 400 kV OHL on the

landscape was commissioned by the respective applicants from AECOM. The four alternative lattice steel tower designs were subject to a comparative visual impact appraisal and ranked in order of preference.

187 The four options are illustrated in **Figure 4.15.** The preferred tower type represents a balance between landscape and visual impacts and technical requirements.

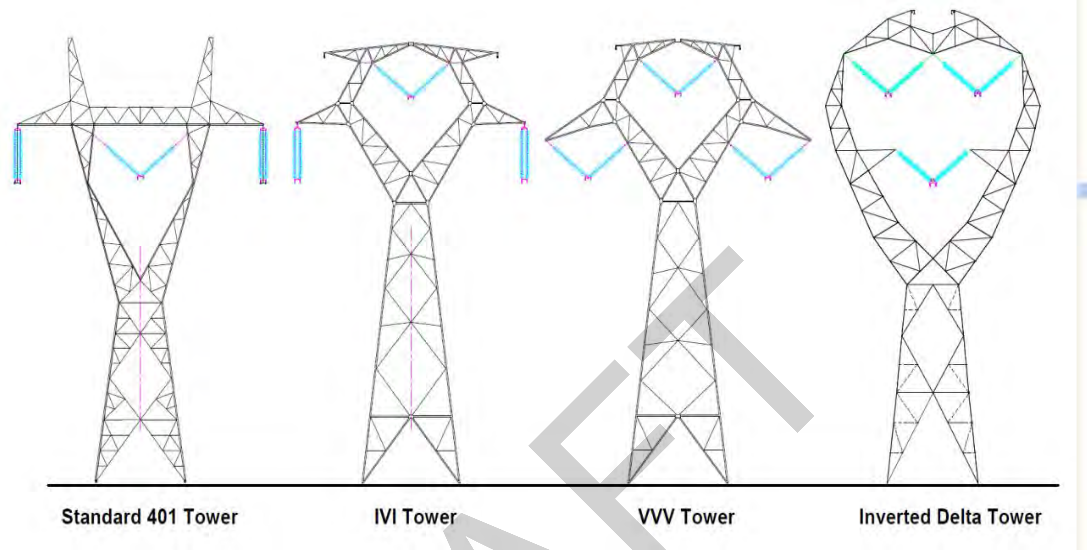


Figure 4.15: Outline Drawings of Lattice Steel Towers (not to scale)

188 All of the tower designs were symmetrical in form, with similar weight, footprint and finish. The span lengths were also the same, thereby resulting in a similar frequency of supports along a length of OHL. They also have a similar capacity for flexible routing. The overall height of the towers is also similar with the exception of the Inverted Delta tower type which is some 2.5m taller than the other alternatives.

189 The main difference in the visual appearance of the towers, and consequently their ability to more or less successfully be accommodated into the landscape, was related to specific design features, density, outline complexity and phasing arrangements. The 401 design features were such that a relatively denser and more complex structure was created, although the phasing arrangement was relatively compact and simple. Tower designs IVI and VVV followed a relatively similar structure, although the phasing arrangement and design density was more complex in tower VVV than IVI increasing the former's visual prominence in the landscape. The increased height of the Inverted Delta tower combined with its greater width and bulk creates the most substantial and visually prominent form out of all the structures.

190 Tower design alternative IVI had the lowest appraisal score (that is the best score) which was supported by a more qualitative analysis undertaken, including the use of photomontages. For these reasons it was considered to have the lowest visual impact in comparison with the other tower alternatives. As such, tower design alternative IVI was considered as the preferred tower type for the proposed development.

191 Additional studies examined matters such as foundation design, electrical parameters, insulation coordination and manufacturing processes.

192 From the results of each study, the following conclusions were made:

- Following the visual impact evaluation performed by AECOM it was considered that the IVI tower design visually imposes least on the landscape.
- It was considered that the costs of the cold formed tower compared to that of its hot rolled counterpart would be higher due to the limited availability of manufactures of this style of tower.
- Visually it was considered that the composite insulator type would have a lesser impact to that of glass insulators and given the comparative cost of both materials be the recommended insulator material to be used.
- Following a foundation study on each of the tower designs the small variation of the size and load of each foundation does not constitute preference of any design.
- In an electrical study performed by SAE Power Lines it was found that from an electrical performance perspective there is not much difference between the four lattice steel options.

193 From all the studies it was considered that the tower design that would most satisfy all required criteria is a hot rolled steel IVI tower with composite insulators. Accordingly, this tower was adopted as the support structure design for the previous application for approval for the Meath-Tyrone 400 kV Interconnection Development project (subsequently withdrawn).

4.8.2.2 Review and Confirmation of the Selection of a Single Circuit Support Structure for the Proposed Development

194 The *Final Re-evaluation Report* reviewed the pre 2009 studies and concluded that the lattice steel structure known as the ‗IVI Tower' shall be put forward as the emerging preferred option.

195 It also noted that in a report by the Government appointed IEC[71] it was concluded that while a high voltage AC OHL *"still offers significantly lower investment costs than any underground alternative"* it ―*could also be made more attractive by investing slightly more in new tower designs than the classical steel lattice towers now proposed*[72]". The IEC also identified that it may be possible to ―*reduce the visual impact of traditional lattice steel towers"* by ―*painting the steel dark green or another colour somewhat matching the terrain around. This method is efficient to reduce the visibility as most people will see the tower with nature as a background."* On the basis of the findings of the IEC Report, EirGrid committed to giving further consideration to alternative structures before finalising its preferred project solution.

4.8.2.3 Re-evaluation of Feasible Alternative Tower Overhead Line Structures

196 Separately to, and independent of, the proposed development, EirGrid had commissioned the consultants Atkins (with LSTC as sub-consultants) to develop conceptual 400 kV and 110 kV steel monopole designs. In the course of this study, Atkins identified a conceptual design for a single circuit 400 kV steel monopole that is potentially suitable for use on the Irish transmission system.

Figure 4.16: 'Atkins' Monopole Design and Proposed IVI Lattice Tower

[71] Available at www.dcenr.gov.ie.
[72] EirGrid considers the Type 401 tower to be the ‗classical' or ‗traditional' design for a 400 kV single circuit lattice steel tower. The Type 401 was never proposed for this development instead the modern IVI design with lower visual impact is the preferred option.

197 EirGrid asked ESBI to carry out a comparative assessment of the ‗Atkins‘ monopole versus the IVI tower specifically for use on this proposed development. In addition, as the option was raised by the IEC in its report, EirGrid requested that ESBI comment on the effectiveness of the painting of galvanised steel OHL structures as a visual impact mitigation measure in the Irish landscape in general and for this proposed development in particular.

198 ESBI concluded that, in general, the 400 kV monopole design identified by Atkins is technically feasible for use on the Irish transmission system, including for use on the proposed development. However, following a comparative assessment of the Atkins monopole versus the IVI tower for use specifically on the proposed development ESBI found that:

- A monopole design may provide some advantages over a traditional lattice steel design when set in an urban or semi-urban landscape. This proposed development however is set entirely within a rural landscape and in such circumstances it is not clear that the Atkins monopole design would provide any advantages over that of the IVI tower design.

- It is considered that due to the nature and size of the monopole structures (which are of similar heights to IVI towers), and the requirement for about 25% more structures in the case of the monopole design, there may be increased visibility.

- The construction effort and consequently the environmental impact of the construction, is considerably greater in the case of the monopoles due to a combination of the larger size and weight of the steel members, the larger foundations and the greater number of structures required.

- The monopole design will be more costly to implement in comparison with the IVI design in terms of raw materials and number of individual structures.

- The programme for delivery of the proposed development will be six to eight months longer if a monopole design is used as opposed to an IVI tower design.

199 Accordingly, it was recommended that the IVI tower be adopted by EirGrid as the preferred structure for the proposed development.

200 It was noted that it was technically feasible for a development that consisted primarily of IVI towers to insert monopoles in very specific and localised areas where doing so would result in a lesser impact than that of the IVI towers.

201 It was also noted that the painting of towers as a camouflage effect and the use of specially treated non-shiny ‗shadow‘ conductor can be a mitigation measure in specific situations.

4.9 CONCLUSIONS

202 Having re-considered all the technology options, EirGrid concludes as follows:

203 Any option using DC technology, even one using the latest VSC HVDC technology, is not an acceptable option for the specific nature, extent, and intended function of the proposed development. Implementing the development using VSC HVDC would be significantly more expensive and technically inferior to a standard AC solution. For these reasons, EirGrid is proposing a standard AC solution.

204 The Government appointed International Expert Commission (IEC) concluded that an entirely undergrounded AC option is not an acceptable solution for this project for technical reasons. EirGrid concurs with this conclusion.

205 Partial undergrounding may be feasible, but only if the length of UGC to be installed is relatively short; and where the cost of using the short length of UGC can be proven to be an advantageous and cost effective way of overcoming an environmental or technical constraint to the preferred OHL; and where it can be confirmed that the use of UGC does not exceed the transmission system‘s capacity to accommodate such cables.

206 EirGrid is obliged, within the terms of its licence and statutory obligations as TSO, to develop the transmission system using least cost, technically and environmentally acceptable solutions. Based on all of the above and in order to comply with its licence conditions and statutory obligations, EirGrid is proposing that the development is entirely comprised of 400 kV OHL. A 400 kV OHL is the best technical solution for this development and would be significantly less costly than any UGC alternative.

207 The preferred support structure for use on the proposed 400 kV single circuit OHL development is the lattice steel structure known as the ‗IVI‘ tower.

5 ROUTE ALTERNATIVES

5.1 INTRODUCTION

1 This section of the Environmental Impact Statement (EIS) outlines the main alternatives considered in the process of identification of the route alignment of the proposed development, and an indication of the main reasons for the final route alignment chosen by EirGrid, taking into account the effects on the environment. It describes the process of detailed route selection for the proposed development, in both Ireland and Northern Ireland, and options evaluated as part of a process to determine the final route for the proposed development.

2 The consideration of route alternatives has occurred over a considerable period of time. This has occurred contemporaneously with the consideration of transmission and technology alternatives, as set out in **Chapter 4** of this volume of the EIS, whilst continuously having regard to the strategic need for, and objectives of, the proposed development. The overall process has included ongoing review in order to ensure that the conclusions drawn by the respective applicants have resulted in the optimum route for the interconnection project.

3 This consideration of alternatives in respect of the route for the proposed development focuses primarily on a 400 kV High Voltage Alternating Current (HVAC) overhead line (OHL), as set out in **Chapter 4** of this volume of the EIS.

4 This chapter considers the main alternatives regarding the location of the proposed development. The strategic approach adopted by EirGrid in the route selection process is best understood as occurring in a number of phases. Each of these phases, including the re-evaluation of that phase, are described separately in this chapter.

5 The phased approach to route selection is summarised as follows:

Phase 1:

- **To identify Broad Study Area(s)** on the island of Ireland within which the proposed interconnector could best be developed in order to meet the overall objectives of the development while having regard to strategic technical and environmental constraints. This also entailed identification of ‗Project Study Areas‘ i.e. the portions of the proposed interconnector occurring within Ireland and Northern Ireland (see **Section 5.2**);

Phase 2:

- **To identify Feasible Corridors** and a preferred corridor (including identification of an indicative potentially feasible route within each corridor), within the identified project study area, following a strategic analysis of technical and environmental constraints (see **Section 5.3**);

- **To identify a Preferred Route Corridor** (of an indicative width, for comparative purposes, of approximately 1km wide) following a qualitative evaluation of the identified feasible route corridors, against a comprehensive set of technical, environmental, community and other criteria (see **Section 5.3**); and

Phase 3:

- **To identify a Preferred Line Design** – an ‗Indicative Line Route' within the identified ‗Preferred Route Corridor'. This indicative route formed the basis for the final site-specific line design (including the positioning of tower structures), which would be subject of the application for planning approval (i.e. the proposed development as described in **Chapter 6** of this volume of the EIS) (see **Section 5.4**).

6 The overall route selection process, was conducted by a multi-disciplinary technical, environmental, stakeholder, and strategic planning project team, and is considered to have concluded with the identification and selection of a route that provides the best balance between often competing community, technical, environmental and other criteria.

7 This chapter of the EIS has had detailed regard to the considerable body of work undertaken for the previous application for planning approval to An Bord Pleanála in 2009. It also has had regard to the extensive work carried out as part of the comprehensive re-evaluation of the portion of the proposed interconnector located within Ireland following the withdrawal of that previous application. The re-evaluation process is documented in detail in the *Final Re-evaluation Report* (April 2013) which is contained as **Appendix 1.2**, **Volume 3B Appendices** of this EIS The re-evaluation process included *inter alia* a review of the route alternatives, and other main alternatives, considered for the previously proposed development. This work is detailed in the following publications and summarised in the following sections where relevant:

- *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report* (May, 2011);
- *North-South 400 kV Interconnection Development Final Re-evaluation Report* (April, 2013); and
- *North-South 400 kV Interconnection Development Preferred Project Solution* Report (July, 2013).

5.2 IDENTIFICATION OF BROAD STUDY AREA(S) FOR THE PROPOSED DEVELOPMENT

8 It is important to note that the proposed development originated as two separate projects, a need to establish second interconnector and the need to reinforce for the reliability and supply of electricity of the transmission system in the north-east area of Ireland. The two projects are evaluated separately for Phase 1 in **Section 5.2.1** and **Section 5.2.2** for clarity and for legacy reasons.

5.2.1 Background to the Identification of the Broad Study Area for a Second Interconnector

5.2.1.1 Broad Study Area Alternatives for a Second Interconnector

9 Phase 1 included the identification of a ‗Broad Study Area' within which to route the planned second interconnector. This ‗Broad Study Area' derived from initial technical studies undertaken jointly by the respective applicants over the period from 2001-2004. The primary purpose of these studies was to jointly determine best options for the selection of transmission system connection points, the geographic positioning of all infrastructure needed for an additional further interconnection, and to quantify the potential improvements in transmission capacity and system security that would be provided by various interconnection solution options. The conclusions of the technical studies on the identified potential strategic interconnection options were set out in a joint report *Additional Interconnection between Northern Ireland and Republic of Ireland – Selection of Preferred Option* (Oct 2005).

10 A joint Steering Committee, comprised of members from the respective applicants, reviewed the proposed interconnection options. The joint Steering Committee identified four potentially feasible strategic interconnection options (see **Figure 5.1**), which were subject to technical investigation, with a high-level feasibility assessment of associated issues, including environmental and economic constraint analysis.

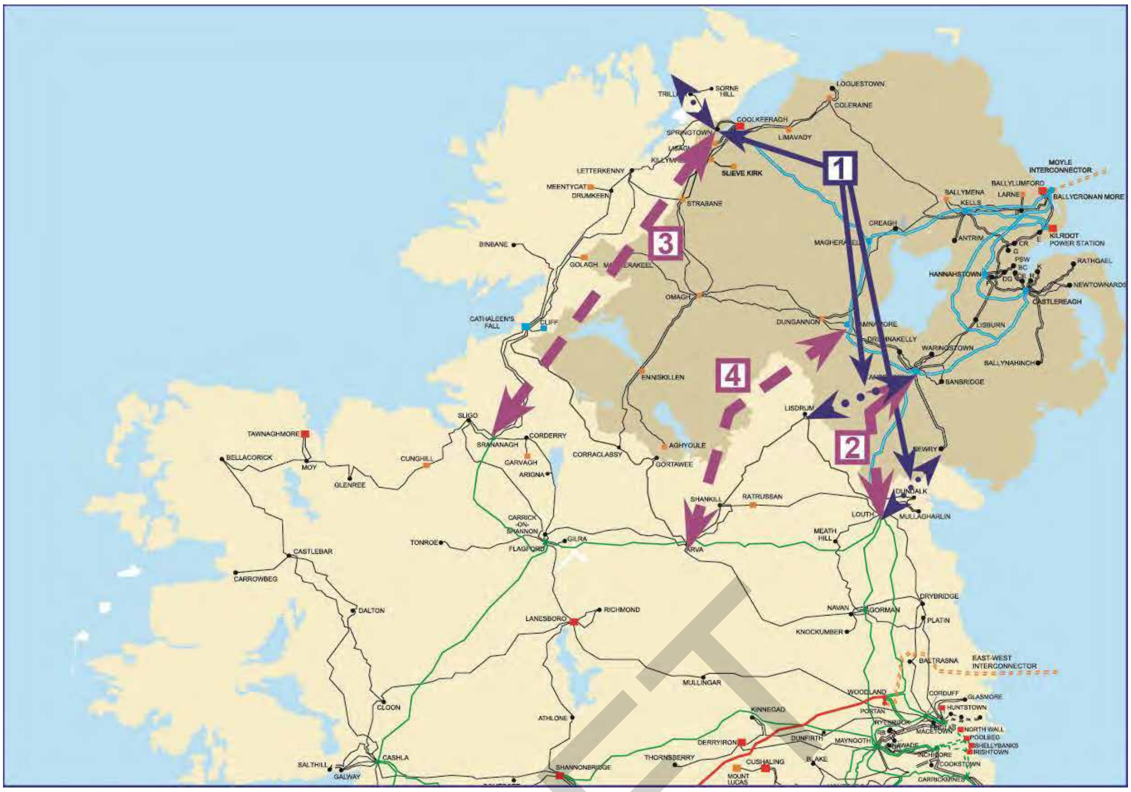


Figure 5.1: Potential Strategic Interconnection Options

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

11 The four potential connection options identified by the respective applicants are summarised below:

- **Option 1: Multiple 110 kV Development**
  This option consisted of development of 110 kV transmission lines between the following existing substations:
    - Coolkeeragh Substation, County Derry – Trillick Substation, County Donegal;
    - Louth Substation, County Louth – Newry Substation, County Down; and
    - Tandragee Substation, County Armagh – Lisdrum Substation, County Monaghan.

- **Option 2: Eastern Study Area**
  This option was primarily based on reinforcing the existing double circuit interconnection between substations at Tandragee, County Armagh, and Louth, County Louth, by constructing a third circuit, operated at either 275 kV or 400 kV, along or to the east of the alignment of the existing north-south interconnector.

- **Option 3: Western Study Area**
  This option was based on a new 275 kV transmission line between substations at Coolkeeragh, County Derry and the planned 220 kV station at Srananagh, County Sligo.

- **Option 4: Mid-Country Study Area**
  This option was based on a new 275 kV or 400 kV circuit between a new substation in the vicinity of Drumkee, County Tyrone and potential connection point at an existing substation at Arva, County Cavan.

12 The next stage in the process was to evaluate these identified broad study area options, in order to identify a preferred study area (or project study area) within which subsequent route corridor options might best be identified.

13 The conclusions for the technical studies were set out in a joint report *Additional Interconnection between Northern Ireland and Republic of Ireland – Selection of Preferred Option* (Oct 2005). In this regard, Option 1 and 3 would not increase the transfer capability in any direction and were not brought forward for further investigation. Option 2 and Option 4 did increase the transfer capability and were proposed for further investigations including a high-level feasibility assessment of associated issues, including environmental and economic constraint analysis.

5.2.1.2 Preferred Broad Study Area Alternatives for a Second Interconnector

14 The two identified preferred ‗Strategic Interconnection Options‘ (Option 2 and Option 4) were both contained within a geographical area where the northern boundary was defined by the existing 275 kV double circuit OHL between Tandragee and Dungannon, and where the southern boundary was defined by the existing 220 kV OHL between Louth and Flagford.

15 NIE and ESB National Grid jointly agreed a scope of works for undertaking environmental, technical and economic feasibility studies of the identified preferred broad study area alternatives. The outcome of the investigations were set out in the following documents:

Option 2: Eastern Study Area

- ESBNG, *Louth-Tandragee 275 kV Feasibility Study (South of the Border)* (2005); and
- NIE, *Tandragee–Louth 275 kV Feasibility Study* (2005).

Option 4: Mid-Country Study Area

- ESBNG / NIE, *Arva–Drumkee 275 kV Feasibility Study* (2004);
- ESBNG / NIE, *Drumkee–Kingscourt 275 kV Feasibility Study (South of the Border)* (2005); and
- NIE, *Drumkee-Kingscourt 275 kV Feasibility Study* (2005).

Option 2: Eastern Project Study Area

16 Two potential options within the Eastern Study Area were identified which minimised identified potential environmental impact. These are described below and illustrated in **Figure 5.2.**

17 **Option 2(a):** Reinforce the existing Louth-Tandragee Interconnector. This option would entail the construction of a third circuit along or adjacent to the general alignment of the existing double-circuit (meaning two circuits on a single set of towers) north-south interconnector. This option would increase transfer capacity in both directions. However, given that this option would most likely be located adjacent to, or otherwise closely follow, the alignment of the existing interconnector, there remained a consequent significant risk of a single event causing a simultaneous outage of all three interconnector circuits. This was a key technical constraint of this option.

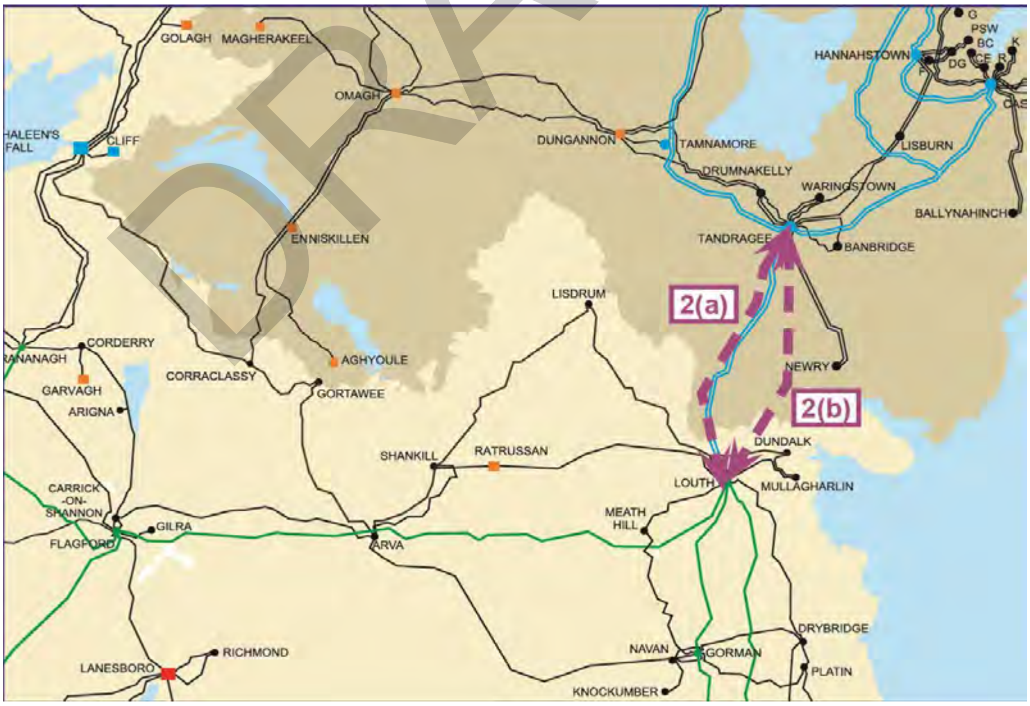


Figure 5.2: Options 2(a) and 2(b)

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

18 **Option 2(b):** A new Louth-Tandragee Circuit. This option would entail construction of a new circuit to the east of the existing north-south interconnector alignment, passing between Drumilly Mountain and Sturgan Mountain to avoid the populated area around Newry. This option passed through the Ring of Gullion Area of Outstanding Natural Beauty (AONB), with resulting significant constraints regarding landscape and visual impact.

Option 4: Mid-Country Study Area

19 Two potential options were identified for these areas that minimise potential environmental impact. These are described below and illustrated in **Figure 5.3.**

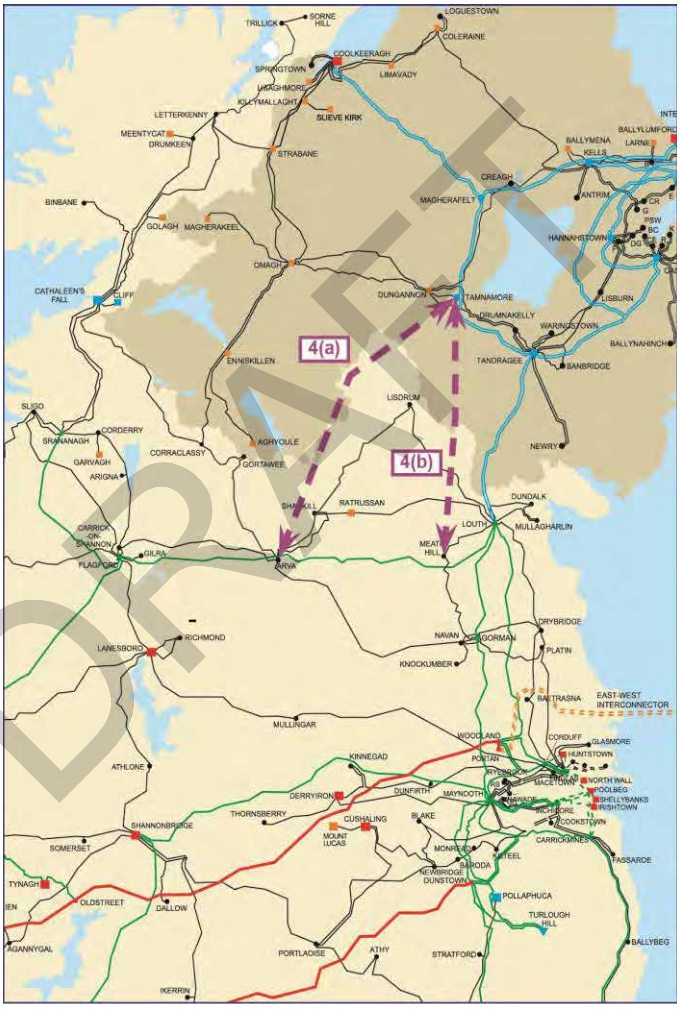


Figure 5.3: Options 4(a) and 4(b)

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

20 **Option 4(a):** New circuit between Drumkee and Arva. This option was capable of linkage to the existing strategic east-west Flagford-Louth 220 kV line; however, the option did not compare favourably with the option between Drumkee and Kingscourt (see below) in terms of route length and transmission synergy.

21 **Option 4(b):** New circuit between Drumkee and Kingscourt. This option originated in Drumkee, and extended southwards avoiding the Armagh Green Belt. It was determined that this option would be capable of accommodating the nature and extent of planned development, albeit with careful attention to detail, such as siting of towers, particularly in the vicinity of Tassagh, Aghavilla, the County Water River and the Armagh Green Belt. This option did not cross any designated landscapes or any land above 150m, it was also shorter in distance than Option 4(a), and ensured synergy with the planned reinforcement of the north-east area (refer to **Section 5.2.3**).

22 The technical and environmental studies carried out jointly by ESBNG and NIE identified Option 4(b) as the preferred broad study area within which to route the proposed second interconnector. This is set out in the ESBNG and NIE joint report *Additional Interconnection between Northern Ireland and Republic of Ireland – Selection of Preferred Option* (October 2005).

5.2.2 The Identification of Broad Study Area Alternatives for a New Circuit to Reinforce the North-East Area of Ireland

23 As noted in **Section 5.2**, separate (though concurrent) to the process of identification of the alignment of the proposed interconnector, ESBNG was undertaking a project with the objective of ensuring greater security and reliability of electricity transmission in the north-east area of Ireland (extending between Dublin and Louth). Network analysis for this area indicated that the network was approaching its capacity with the potential for future thermal overloads and widespread low voltages.

24 Two strategic alternatives were identified by ESB National Grid, as identified in **Figure 5.4** and summarised below.

Figure 5.4: Strategic Alternatives for Transmission Reinforcement in the North-East

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

5.2.2.1 Broad Study Area Alternatives for Transmission Reinforcement in the North-East

25 The broad study area alternatives for transmission reinforcement in the north-east of Ireland are summarised below:

- **Option A: New 220 kV Transmission Circuit**
  Several variations of reinforcement of the north-east area by means of a new 220 kV transmission circuit were considered, with all existing substations within the region identified as potential connection points. In particular, in the Greater Dublin Area, the existing substations of Corduff, Finglas and Woodland were considered as southern nodes, while the existing substations of Louth and Gorman, as well as a potential new 220 kV substation located in the vicinity of demand, were considered as alternative northern termination points.

- **Option B: Uprating of Existing 110 kV Circuits and Reactive Support**
  This option consisted of uprating the following existing 110 kV transmission circuits, which extend between the Dublin area, and the north-east area:
  - Corduff – Platin 110 kV line; and
  - Corduff – Drybridge 110 kV line.

26 In conjunction with these 110 kV upratings, a substantial amount of reactive support, such as substation capacitors or SVC (Static Var Compensation), would require to be installed in the north-east area to deliver a technically acceptable solution.

5.2.2.2 Preferred Broad Study Area Alternatives for Transmission Reinforcement in the North-East

27 Following the identification of potential technical reinforcement options within the north-east area of Ireland, a process of environmental evaluation of the broad study area options was undertaken in 2002. The outcome of this assessment is detailed in the feasibility study *North East 220 kV Reinforcement Project – Initial Feasibility Study– Final* (2002) prepared by ESB International (ESBI).

28 This feasibility study considered potential routes in the area between existing 220 kV lines in the north-east area and the coast line, as this would provide a more direct route to the demand centres in the area, and subsequently reduced new circuit length. As noted above, it also assessed the merit of uprating existing 110 kV circuits in the area. A summary of the findings in respect of the identified options is set out below.

Option A: New 220 kV Transmission Circuit

29 This option was divided into two sub options: **Option A1,** comprising an easterly route between the identified node points; and **Option A2** comprising a westerly route (see **Figure 5.5**).

30 **Option A1 – Easterly Option**: All variations of this option were technically acceptable. However, the environmental findings in the feasibility study identified that all eastern routes between Dublin and Drogheda were problematic, in that they were located close to the most densely populated areas along this part of the east coast, and traversed, or were immediately proximate to, designated Natural Heritage Areas (NHAs), Special Protection Areas (SPAs) and Highly Scenic Areas. The study concluded that the construction of a new 220 kV double circuit line in this area is not feasible, having regard to its potential visual impact on sensitive landscapes. While it was considered that a single circuit 220 kV line could be visually absorbed into the landscape, it would not on its own, achieve the level of reinforcement required to meet the demand as identified at that point in time in the north-east area. In addition, any new route served by the existing north Dublin substations of Corduff and Finglas would require a crossing within the environmental and heritage landscape of the River Boyne at Drogheda, together with visual and other environmental impacts.

31 **Option A2 – Westerly Option:** All the variations of this option were technically acceptable. Refer to **Section 5.2.3**.

Option B: Uprating of Existing 110 kV Circuits and Reactive Support

32 The technical studies identified this option as a solution which would remedy the limitations of infrastructure in the north-east area in the medium term only. It would, however, not be a long term solution for the north-east area, as it would not provide the desired transfer capacity or the required additional circuit into the area to secure electricity supply. It should be noted that this option has subsequently been implemented in the transmission system to remedy the identified limitations in the north-east area in the short term, prior to a longer-term reinforcement solution being implemented (see **Figure 5.5**).

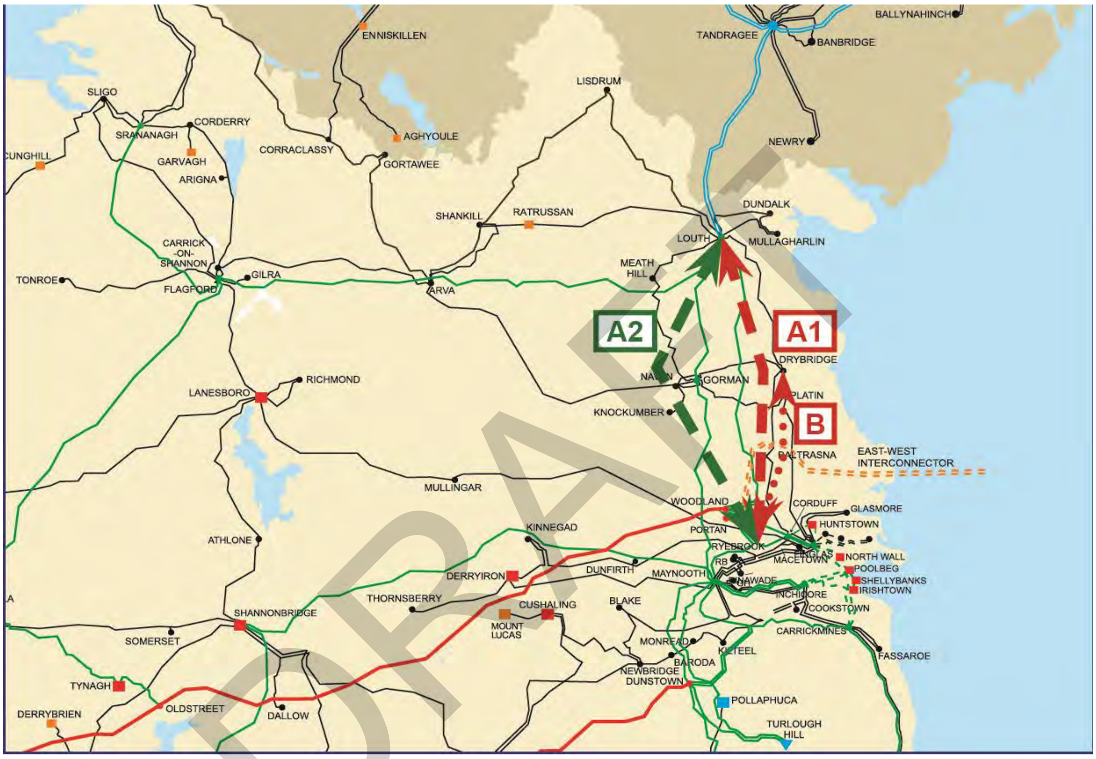


Figure 5.5: Potential Options (A1, A2 and B)

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

33 The evaluation studies, as summarised, confirmed that Option A2 (Western new 220 kV transmission circuit) was the preferred broad study area within which to reinforce security and reliability of electricity transmission in the north–east area of Ireland; this was primarily on the basis of avoiding highly sensitive environmental and settlement areas.

5.2.2.3 Further Consideration of an East of Navan Project Study Area Alternative

34 Some years subsequent to these investigations, EirGrid was advised by An Bord Pleanála, during formal pre-application consultation in respect of the previous application for the Meath-Tyrone 400 kV Interconnection Development, to present a full consideration and robust

examination of a wider project study area, incorporating that area east of Navan to the eastern coastline, taking into account social and environmental constraints (see **Figure 5.10**). This analysis was presented in the Socoin / Tobin Response to An Bord Pleanála – *Kingscourt to Woodland Route Comparison Report* (December 2008). This study confirmed the previously identified Western Route Option A2 project study area (i.e. to the west of Navan) as the preferred project study area for the southern portion of what, by this stage, had become a single project (see **Section 5.2.3**).

35 The constraints to the east included *inter alia:* high population density particularly concentrated in the settlements along the coastline, including at Drogheda; widespread ribbon development extending from those coastal settlements east of the M1 Motorway; potential to affect the visual amenity and setting of the Brú na Bóinne Complex (an Annex 1 World Heritage Site); the existence of a number of SPA / NHAs; and likely additional environmental impact and cost implications deriving from additional route length.

5.2.3 Opportunity to Link Strategic Transmission Projects

36 As highlighted in **Figure 5.6**, although separate projects, with – at that time – separate rationales, study teams etc., it was becoming clear that the preferred broad study area alternatives for the second interconnector project, and those for the reinforcement of transmission infrastructure in the north-east area, had a certain extent of potential overlap – at the southern end of the former, and the northern end of the latter. This provided a sound basis to investigate the synergies between the two projects, and in particular, the potential merits and benefits of linking the two projects. It emerged through further analysis that a single alignment transmission infrastructure project between the transmission systems of Ireland and Northern Ireland offered an appropriate solution for both additional interconnection, and for ensuring a secure and reliable supply of electricity in the north-east of the country. Consequently, additional studies were undertaken to identify a potentially suitable common connection point between the two projects

37 Given that the existing Flagford–Louth 220 kV circuit is a major part of the existing electricity infrastructure serving the north-east area, various potential nodal points (a new substation) along this existing circuit were examined, with a view to identifying an optimum interface area between the two projects. In addition to this, ongoing technical analysis included *inter alia* examining the potential for the planned second interconnector to link the most robust parts of the Ireland and Northern Ireland transmission networks. In Ireland, the strongest node on the transmission network in this area is Woodland Substation. In Northern Ireland, NIE separately identified that a node in the vicinity of Drumkee, County Tyrone, would constitute the most robust part of that network. As a result, it emerged that the preferred overall project study area for any such combined project was between Drumkee (Turleenan), Kingscourt and Woodland.

38 In tandem with this, other studies examined the potential performance increase of the total development being constructed at 400 kV.

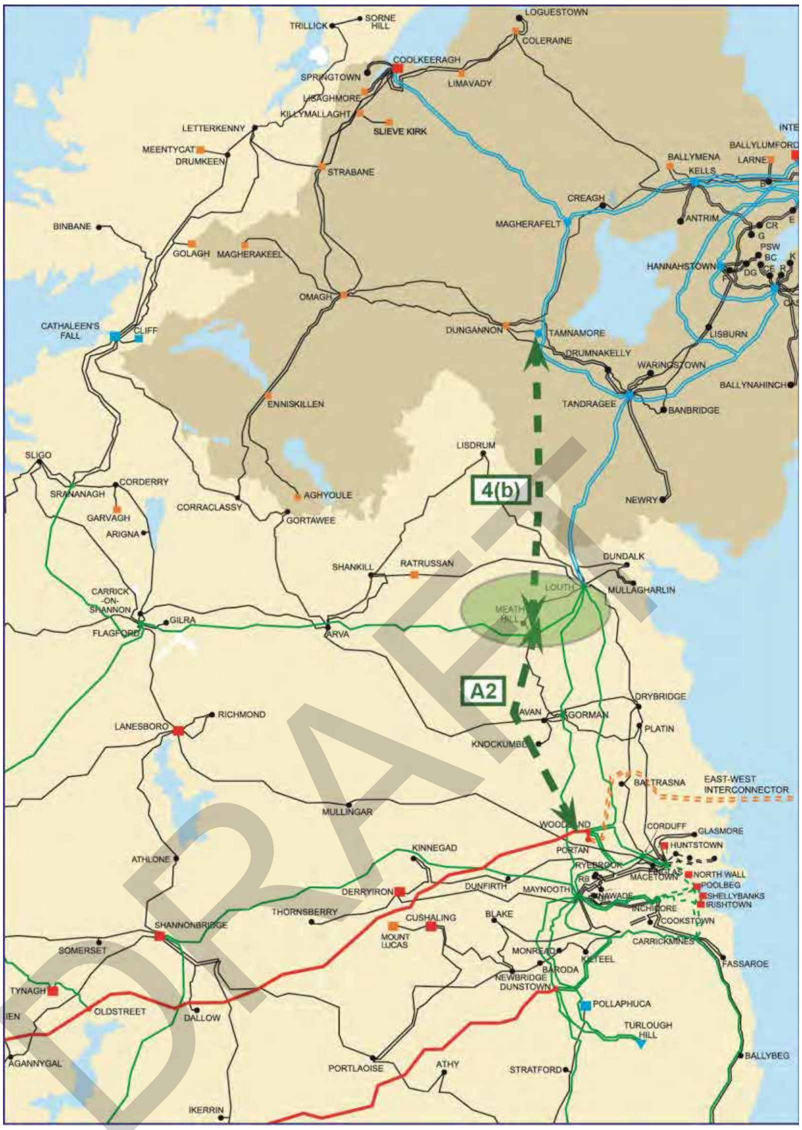


Figure 5.6: Opportunity for Strategic Linkage Between the Second Interconnector Project Option 4(b) and Transmission Reinforcement in the North-East Project Option A2 – at a Location along the Existing Flagford-Louth 220 kV Circuit

(NB: arrows are indicative of the Strategic Options, but not of any particular routing solution)

5.2.4 Re-evaluation of the Preferred Broad Study Area Alternatives

39 The re-evaluation process subsequent to the withdrawal of the previous application for statutory approval of the Meath-Tyrone 400 kV Interconnection Development included confirming the applicability, or otherwise, of the previously identified preferred broad study area alternatives within Ireland for the overall project.

40 As part of its re-evaluation, EirGrid considered updated need and technical considerations, environmental constraints and other information gathered since the original identification of the project's broad study area. The findings of the re-evaluation process are detailed in the *Final Re-evaluation Report* (April, 2013) contained as **Appendix 1.2**, **Volume 3B Appendices**, of the EIS.

5.2.4.1 Re-evaluation of the Points of Connection

41 During the re-evaluation process, EirGrid reviewed the effectiveness of the previously identified preferred broad study area alternatives in respect of the proposed interconnector in meeting the requirements of the project. Based on this re-evaluation, EirGrid reached the following key conclusions regarding the most appropriate points of connection of a new north-south interconnector to the existing transmission networks in Ireland and Northern Ireland:

- In Northern Ireland, the northern terminus of the proposed interconnector will be at a planned new substation at Turleenan in County Tyrone; and
- The existing 400 kV Woodland Substation in County Meath should be the southern terminus for the proposed interconnector.

42 The previous proposal included an intermediate substation on the proposed Turleenan-Woodland 400 kV OHL at a nodal location in the vicinity of the existing Flagford-Louth 220 kV OHL. As this intermediate substation is not now expected to be required within the next ten years (refer to **Chapter 2** of this volume of the EIS) it was decided, in accordance with proper planning and sustainable development, that such a substation would not be included in the new application for approval of the proposed development. However, it is still anticipated that this substation will be required at some future point in time, and its location remains most appropriately in the vicinity of the intersection of the proposed development and the existing Flagford-Louth 220 kV OHL. This is considered further in **Chapter 10** of this volume of the EIS. The conclusions regarding the project connection points formed the basis for the confirmation of the project study areas within which to route the proposed development (see **Section 5.2.5**).

5.2.4.2 Re-evaluation of Technical and Environmental Considerations in respect of the Broad Study Area

43 The re-evaluation of the broad study area alternatives for the project occurred in the context of the connection point parameters outlined at **Section 5.2.4.1**, while also having regard to normal practice in routing linear transmission infrastructure which is to seek the shortest environmentally and technically acceptable route between identified connection points.

44 In summary, having reviewed the broad study areas previously considered in relation to the proposed development, including the additional study area east of Navan, the additional submissions and other information available to EirGrid since June 2010, no new significant environmental or other relevant constraints, arose during the re-evaluation process which merited consideration of alternative or additional broad study areas within which to route the proposed development. The only significant technical issue which did arise was the decision not to proceed at this juncture with the intermediate substation in the vicinity of the point of intersection of the new circuit with the existing Flagford-Louth 220 kV OHL.

45 Following the re-evaluation process EirGrid concluded that the proposed interconnector between the existing Woodland Substation, County Meath, and the planned Turleenan Substation, County Tyrone, should best occur within a broad Mid-Country Study Area comprising in Ireland the counties of Monaghan, Cavan and Meath, and in particular, located to the west of Navan, County Meath.

5.2.5 Identification of Project Study Area for the Proposed Development

46 Based on the identification of a broad study area for the overall project, the specific project study area for the proposed development is presented in **Figure 5.7**. This project study area is essentially the amalgam, in spatial terms, of the two broad study areas, originally identified in respect of the previously separate projects – the second interconnector, and the reinforcement of transmission infrastructure in the north-east area.

47 Whilst comprising a single transmission infrastructure project, within an overall project study area, given the significant geographical extent of this study area, for clarity and convenience the overall study area is identified in two sections: the **Cavan Monaghan Study Area (CMSA)** refers to that portion of the overall study area north of the existing Flagford-Louth 220 kV OHL, and south of the border with Northern Ireland, having regard to the counties located within this area (this was termed Cross Border Study Area (CBSA) in the previous application for planning approval of the Meath-Tyrone 400 kV Interconnection Development); the **Meath Study Area (MSA)** refers to that portion of the overall study area, south of the existing Flagford-Louth 220 kV OHL, and extending to, and encompassing Woodland Substation, and which is almost exclusively contained within County Meath (this was termed the North East Study Area (NESA) in the previous application).

48 The nominal interface between the two sections of the overall project study area is therefore located in the vicinity of the existing Flagford–Louth 220 kV OHL line. The presentation of the overall project study area by means of two sections (CMSA and MSA) is intended to facilitate review by the public concerned and other parties of that section of the proposed development which is of most importance to them, rather than having to seek this information as part of a

much larger study area. It has also facilitated ongoing coordinated but focused technical and environmental analysis by the two teams of project consultants.

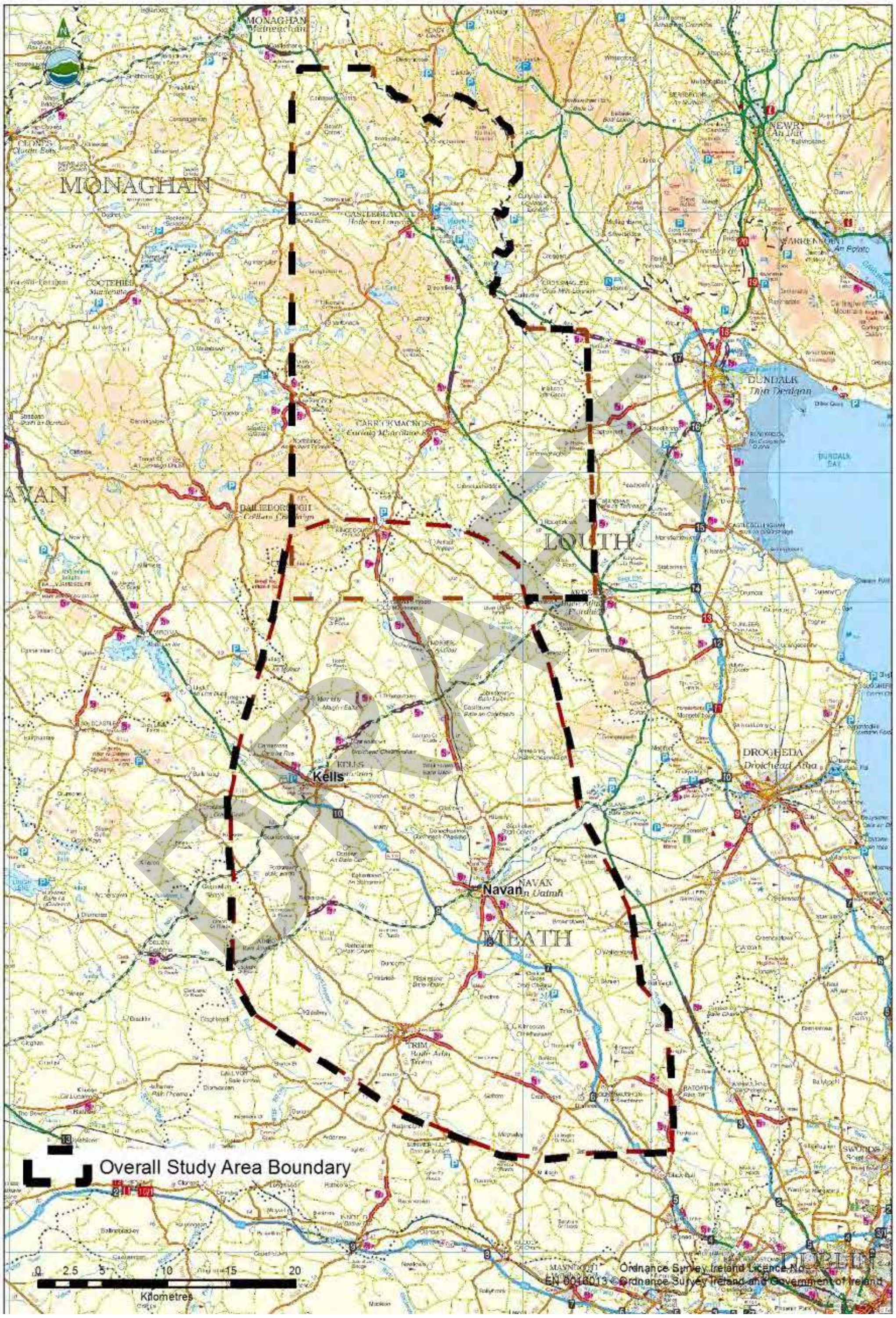


Figure 5.7: The Project Study Area for the Proposed Development

5.2.5.1 The Cavan-Monaghan Study Area (CMSA)

49 This area is primarily situated between the areas of the crossings of the jurisdictional border with Northern Ireland (in the townland of Lemgare, County Monaghan, east of Clontibret) to the north, and as noted above, the area of the existing Flagford-Louth 220 kV OHL (west of Kingscourt) to the south. The CMSA is approximately 30km in width and 40km in length. The primary settlements within the CMSA include Kingscourt, Carrickmacross, Castleblayney and Bailieborough.

50 The topography of the CMSA comprises a varied landscape of hedge-enclosed fields draped over drumlins and scattered lakes throughout. The land use within the CMSA, outside of the settlements, is predominantly agricultural.

51 The CMSA is illustrated in **Figure 5.8**.

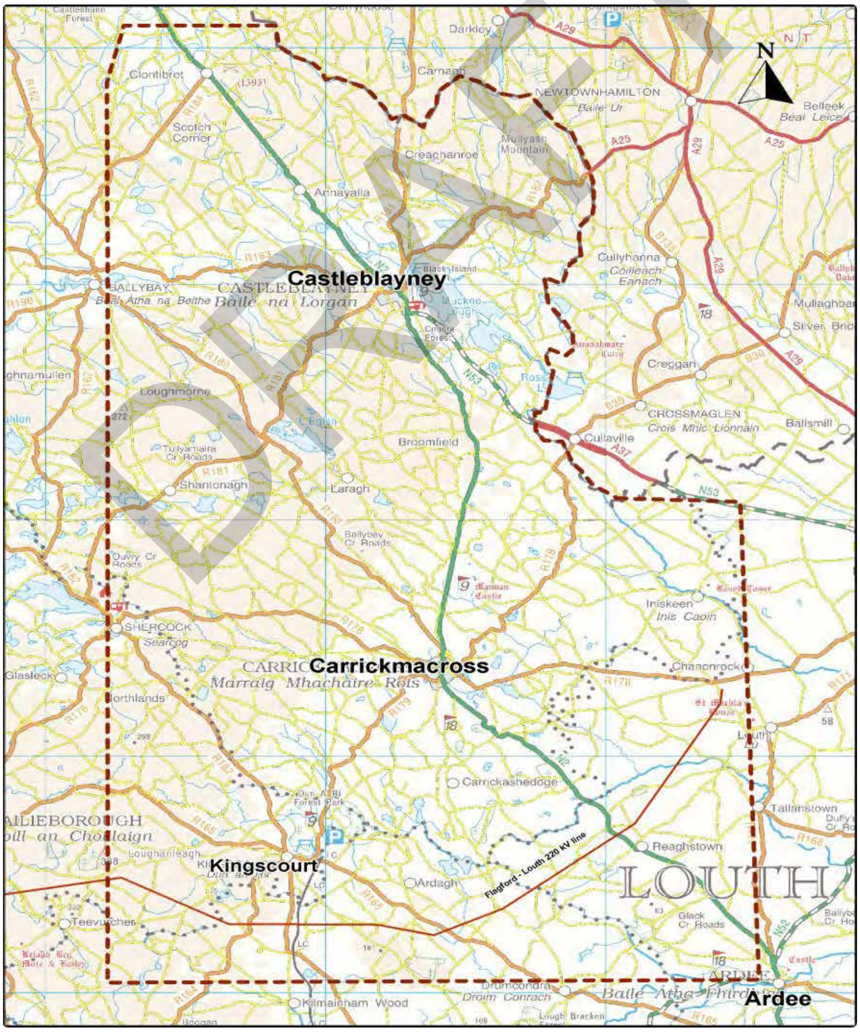


Figure 5.8: The Cavan-Monaghan Study Area (CMSA)

5.2.5.2 The Meath Study Area (MSA)

52 The MSA is situated between the existing 400 kV Woodland Substation in County Meath in the south, and the area of the Flagford-Louth 220 kV OHL (west of Kingscourt) in the north. The area is bounded to the east by the Hill of Tara and the town of Navan and to the west by the towns of Trim and Athboy. Settlements within the MSA include Athboy, Dunshaughlin, Kells, Navan, Nobber, Moynalty and Trim.

53 The study area contains two major rivers, the River Boyne and the River Blackwater. The land use within the study area, outside of the settlements, is predominantly agricultural.

54 The MSA is illustrated in **Figure 5.9.**

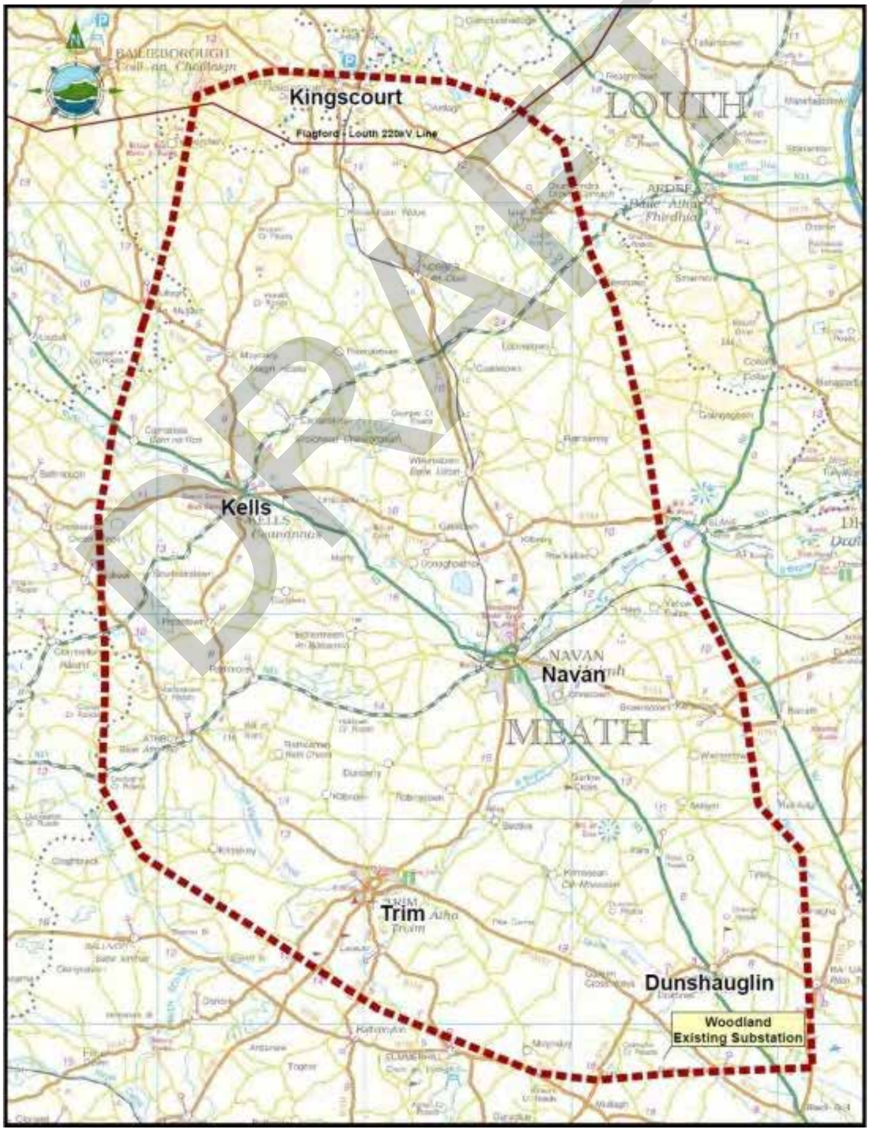


Figure 5.9: The Meath Study Area (MSA)

55 As noted at **Section 5.2.2.3** EirGrid was subsequently advised to present a full consideration and robust examination of a wider project study area, incorporating that area east of Navan to the eastern coastline. This area is illustrated in **Figure 5.10**. This analysis was presented in the Socoin / Tobin *Response to An Bord Pleanála – Kingscourt to Woodland Route Comparison Report* (December 2008). This study confirmed the area to the west of Navan as the preferred project study area for the southern portion of what, by this stage, had become a single project.

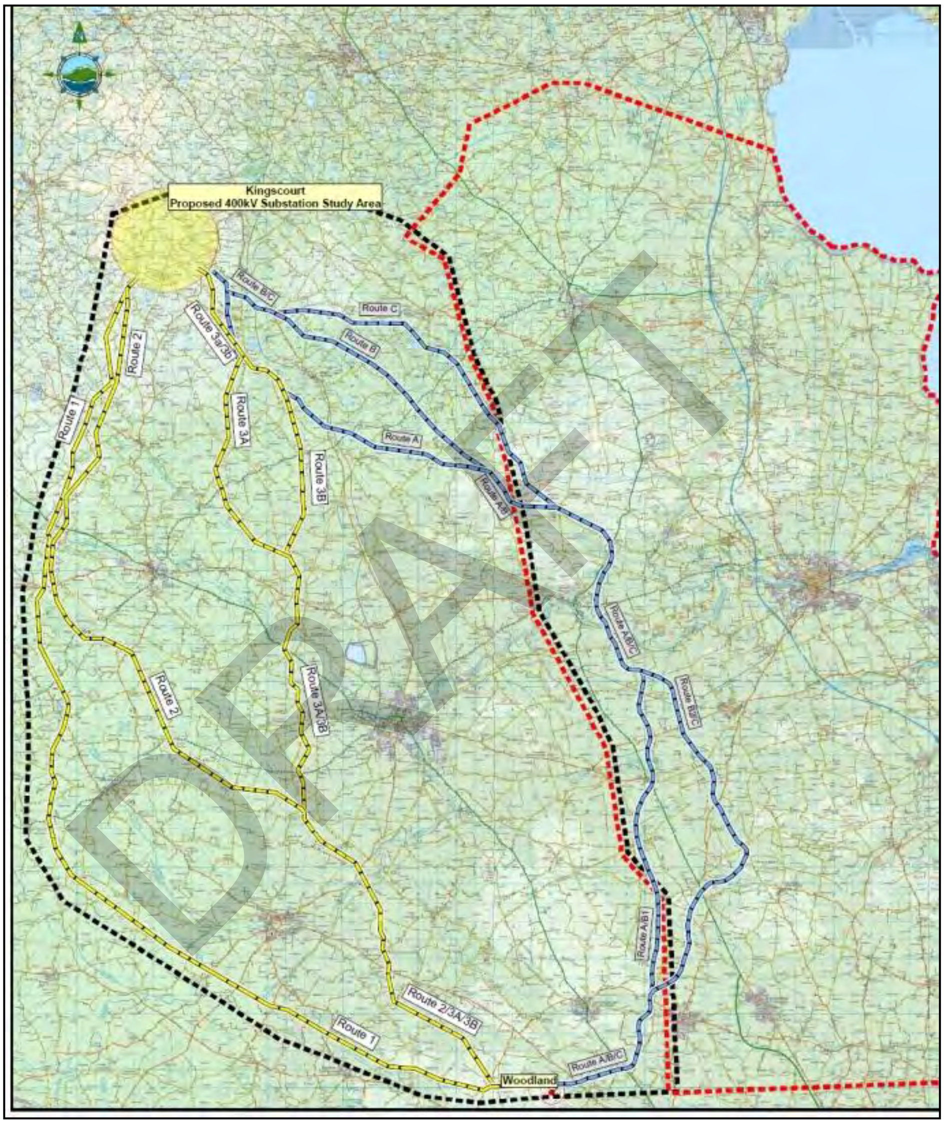


Figure 5.10: Subsequent Extended Study Area East of Navan to the Eastern Coastline

(Extended Study Area is outlined in red)

5.3 PHASE 2: IDENTIFICATION OF ALTERNATIVE ROUTE CORRIDOR OPTIONS AND A PREFERRED ROUTE CORRIDOR FOR THE PROPOSED DEVELOPMENT

56 As set out in **Section 5.1**, the next phase (phase 2) in the route selection process was twofold: firstly to identify alternative feasible route corridors within the identified project study area, and secondly to identify a preferred route corridor following a strategic analysis of technical and environmental constraints. This process included a high level evaluation of the likely impacts of each of the route corridor options on the key constraints, with some indication as to which, if any, of these are likely to be significant.

57 The identified route corridor alternatives are of a nominal indicative width of 1km. Such width has no technical or, scientific basis; rather the 1km wide corridor is intended to ensure that an adequate area is identified in which a potential line route, including all associated structures, can best be sited, while making provision for as great a buffer distance as possible to identified sensitive receptors (i.e. any element of the environment which has the potential to be significantly impacted). In addition, corridor options need to be of comparable width, to facilitate a robust comparative evaluation.

5.3.1 Background to the Identification of Alternative Route Corridor Options

58 As noted in **Section 5.2**, the proposed development originated as two separate projects. EirGrid therefore originally employed separate consultants to undertake studies, including route corridor feasibility studies, within the respective broad study areas within Ireland. ESBI and AOS Planning Ltd were appointed to identify and evaluate options relating to the planned second interconnector, and in particular within the preferred Option 4(b) Mid-Country Study Area; Tobin Consulting Engineers with Socoin (formerly Soluziona and now GasNaturalFenosa) were appointed to identify and evaluate options for reinforcement of the transmission system within the north-east area of Ireland, and in particular within the preferred Option A2 Western Study Area.

59 As set out in **Section 5.2.3**, these two originally separate projects merged into the single project. ESBI / AOS Planning Ltd continued their work on the northern portion of the overall project study area– previously termed CBSA and now termed the CMSA, while Tobin / Socoin continued their work on the southern portion of the study area – previously termed NESA and now termed the MSA. This work included carrying out baseline studies of all key environmental criteria, and the identification of indicative 1km wide route corridors. The scope and methodology of this work, as well as the subsequent identified route corridor options, are detailed in the following publications:

- ESBI and AOS Planning Ltd, *Route Constraints Report* (September 2007); and
- Socoin and TOBIN Consulting Engineers*, Kingscourt to Woodland Constraints Report Volume 1* (July 2007).

60 Subsequently, ESBI / AOS Planning Ltd and Tobin / Socoin prepared Addendum Reports, which complemented the earlier *Route Constraints Reports* by assessing the relative merits of each identified 1km wide corridor on the basis of further analysis undertaken, and having regard to a number of issues raised during public stakeholder and other consultation processes. This work is detailed in the following publications:

- ESBI and AOS Planning Ltd, *Route Constraints Report September 2007 ADDENDUM* (May 2008); and
- Socoin and TOBIN Consulting Engineers, *Kingscourt to Woodland Powerline Addendum Report 1* (May 2008).

61 The identified potential route corridors within the previously identified CBSA (now CMSA), and NESA (now MSA) project study areas are summarised below.

The CBSA (now CMSA) Project Study Area

62 Three ‗Potential Route Corridor‘ options were identified for the CBSA (now CMSA), avoiding where possible the most significant identified constraints (see **Figure 5.11**). These were:

- **Route Corridor Option A** runs from the area of the Flagford-Louth 220 kV line within the western part of the study area, west of the N2, Castleblayney and Carrickmacross. Extending generally northwards, it turns in a north-easterly direction approximately 1km north of Annyalla to cross the N2 and then turns in north-westerly direction at Lemgare to the border crossing locations;
- **Route Corridor Option B** runs within the central part of the study area, west of the N2, Castleblayney and Carrickmacross but closer to Castleblayney and Lough Muckno than the western route. It is straighter and slightly shorter than Route A; and
- **Route Corridor Option C** follows Route Option B to a point approximately 4km north-west of Carrickmacross before turning east to run to the east of the N2 and east of Lough Muckno. It is the longest of the routes.

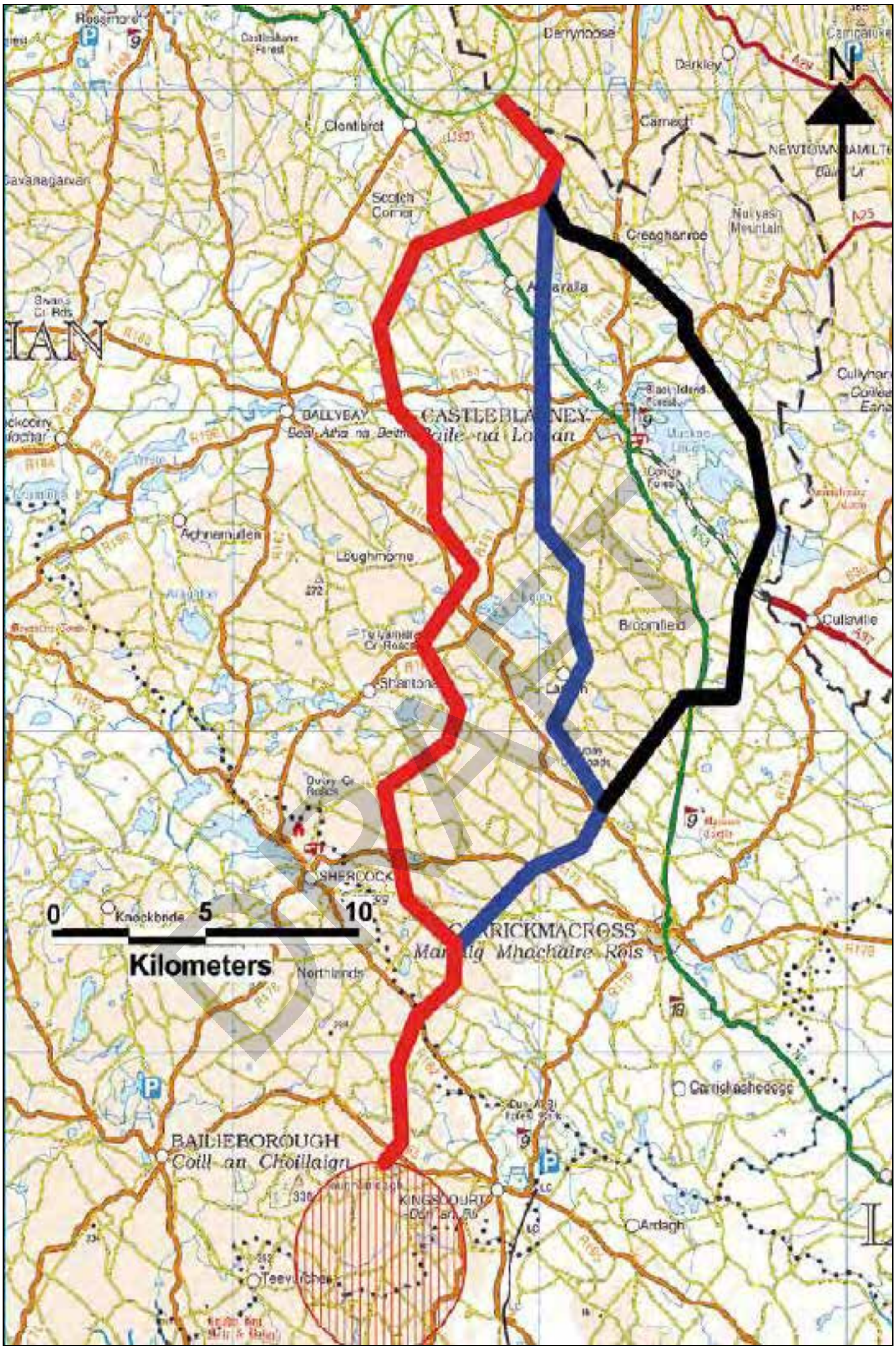


Figure 5.11: Potential Route Corridor Options A, B and C in the CBSA (now CMSA)

The NESA (now MSA) Project Study Area

63 Three potential route corridor options (with a sub-option of one of the options) were identified for the NESA (now MSA), taking cognisance of identified constraints (see **Figure 5.12**). These were:

- **Route Corridor Option 1** extends from Woodland Substation within the western part of the study area, to the west of Trim, Athboy and Kells and approximately 4km north of Ballivor and east of Mullagh.

- **Route Corridor Option 2** extends from Woodland Substation between the central and western section of the study area, staying to the east of Trim and Athboy, west of Kells and then runs parallel to Route Option 1, running approximately 1.5km to the east of Mullagh.

- **Route Corridor Option 3A** follows route corridor Option 2 initially before extending in a due north direction, running to the west of Navan and to the east of the town of Kells. Approximately 5km north of the M3, this route corridor option splits into two sub-options 3A and 3B. 3A runs to the west of Castletown and Nobber before joining together west of Whitewood Lough.

- **Route Corridor Option 3B** follows route corridor Option 2 initially before extending in a due north direction, keeping to the west of Navan and to the east of the town of Kells similar to route corridor Option 3A. This route corridor option splits into two options 3A (see above) and 3B. 3B runs to the west of Carlanstown before joining together west of Whitewood Lough.

64 All route corridor options extend out from Woodland Substation in a westerly direction along the alignment of the existing Oldstreet-Woodland 400 kV transmission line. The northern side of the double circuit structures along this OHL are currently unused and available for use. From an environmental perspective, it was considered that using the unused side of these double circuit towers has a much lower potential impact compared to using new route corridors into / out of Woodland Substation.

Figure 5.12: Potential Route Corridor Options 1, 2, 3A and 3B in the NESA (now MSA)

- Option 1
- Option 2
- Option 3A
- Option 3B

5.3.1.1 Other Potential Route Corridor Alternatives

The M3 Corridor

65 During the initial stages of the project EirGrid consulted with the National Roads Authority (NRA) regarding the possibility of locating the planned transmission infrastructure along the M3 Motorway corridor, either as OHL or UGC.

66 Locating OHL alongside the motorway was ruled out because it was considered that to do so, would not be environmentally sustainable within a highly sensitive receiving environment. This opinion was based on, among other things, the stated intention of the planning authority to protect ―*landscapes of exceptional value and sensitivity and in particular to protect the rural character, setting, amenity and archaeological heritage of Brú na Bóinne and the Hill of Tara, and of the surrounding areas including the area in the vicinity of the proposed M3 motorway and its related interchanges*". The motorway passes through this sensitive landscape.

67 Locating a 400 kV UGC within the reserve of the M3 was ruled out primarily because in EirGrid's opinion it would not be appropriate to use 400 kV UGC in place of 400 kV OHL for this project, as addressed in **Chapter 4** of this volume of the EIS.

68 In addition to this, the NRA advised that a 400 kV UGC would only be permitted within the motorway reserve if indemnities regarding damage, disruption, costs, etc. acceptable to both NRA and the PPP (Public-Private Partnership) company that constructed and operates the motorway, were received. This requirement introduces considerable complexity, uncertainty and risk to such an option, even if it was deemed to be technically appropriate, making it a less favourable UGC route than a direct cross country route, such as that identified in the PB Power Report *Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits Comparison of High Voltage Transmission Options: Alternating Current Overhead and Underground, and Direct Current Underground (2009)* (refer to **Chapter 4** of this volume of the EIS).

Disused Railway Line

69 During public consultation, but after commencement of the site specific part of the PB Power Report (referred to above), it was noted that there are disused railway lines in all five counties to be traversed by the planned transmission line, and it was suggested that these would provide a technically feasible optimum and least cost route for UGC. To consider this EirGrid carried out its own comprehensive study of the disused rail beds in the five counties, Meath, Cavan, Monaghan, Armagh and Tyrone to evaluate their suitability for accommodating the size and quantity of the UGC that would be required for the development. The findings of this study were published in the following EirGrid Report *Cavan-Tyrone and Meath-Cavan 400kV Power Lines – Considerations in Relation to Locating 400kV Cables in or adjacent to Rail Beds* (2009).

70 In summary, the EirGrid Report (referred to above) concluded that the rail bed routes represented a sub-optimal routing option for potential 400 kV UGC circuits, introducing significant additional environmental impact and cost, as well as safety risks to cables. It was concluded that the use of rail beds was not consistent with the development of a safe, secure, reliable and economical transmission system. Selecting a UGC route which follows the disused rail lines, insofar as they still exist, would not have the advantages of a route corridor selected to minimise community and environmental impacts, such as is identified in the PB Power Report.

71 The EirGrid Report concluded that the theoretical potential cross-country UGC route identified by PB Power (see **Figure 4.1**) in its report was superior to the option to make use of existing rail beds. In addition, it reiterated the consideration of EirGrid than any OHL solution for the proposed interconnector meets the requirements of the Transmission System Operator (TSO) and is superior to an UGC option on technical, security, reliability and economical grounds.

East of Navan

72 As set out in **Section 5.2.2.3**, EirGrid was advised by An Bord Pleanála during formal pre-application consultation in respect of the previous application for the then Meath-Tyrone 400 kV Interconnection Development, to carry out further analysis on possible routes within a study area east of Navan to the eastern coastline. This analysis comprised an evaluation update of the route corridor assessment process undertaken in respect of the NESA (now MSA). This was presented in the Socoin / Tobin *Response to An Bord Pleanála – Kingscourt to Woodland Route Comparison Report (*December 2008). A total of eight corridor options were analysed for the NESA option - the original four options to the west of Navan, and four new corridor options to the east of Navan:

- Woodland-Kingscourt Western Route Options, (1, 2, 3A and 3B – as previously described). The area is bounded to the east by the Hill of Tara and Navan and to the west by Trim and Athboy (see **Figure 5.12**).

- Woodland to Kingscourt, Eastern route corridor Options, (A, B1, B2 and C). The area is enclosed on the west by the Hill of Tara and Navan and to the east by the Irish Sea coastline (see **Figure 5.13**).

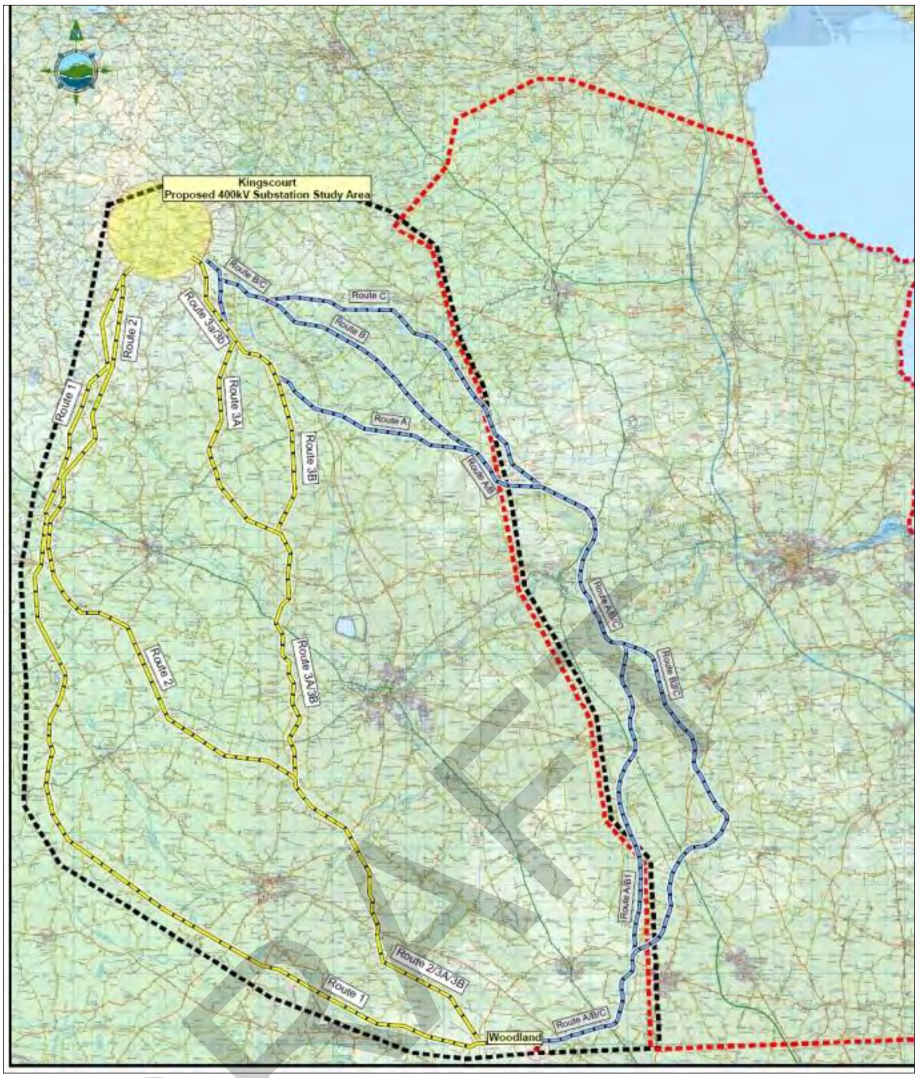


Figure 5.13: Potential Eastern Route Corridor Options A, B1, B2 and C in the NESA (now MSA)

(Potential Eastern Route Corridor Options indicated in blue)

73 The easterly corridor options (A, B1, B2 and C) were rejected *inter alia* because they pass in close proximity to Brú na Bóinne (an Annex 1 World Heritage Site) and the Hill of Slane. These constraints are discussed in detail in the Tobin / Socoin report (submitted to An Bord Pleanála). As noted in **Section 5.2.2.2**, the Western Route Option A2 broad study area (i.e. to the west of Navan – see **Figure 5.13**) was therefore confirmed; this evolved into the NESA (MSA) project study area, with the identified Indicative route corridor Options 1, 2, 3A and 3B (see **Figure 5.12**) comprising the focus for further studies as the project progressed towards identification of a preferred corridor and indicative line routes.

Direct Route Option

74 In its Scoping Opinion dated 11th December 2013, An Bord Pleanála requested consideration of alternative corridor options *"including the most direct route option"* (see **Figure 5.14**). The most direct route or shortest route is generally considered ‗best practice‘ for routing OHL; however, it is also necessary to avoid constraints. The direct option between Woodland, County Meath and Turleenan, County Tyrone would bring the route close to main population settlements including Armagh, Ardee, Slane and Dunshaughlin. Furthermore it would pass directly through or very close to a number of villages including Moy, Charlemont, Milford, Cullaville, Corcreeghagh, Newtown, Hays, Tara, Drumree. Additionally it would pass over a number of one-off houses, archaeological monuments and significant archaeological landscapes, and sensitive ecological receptors. A number of lakes would also have to be traversed with a straight line option.

Figure 5.14: Direct Route Option

5.3.2 Background to the Identification of a Preferred Route Corridor

75 The selection of a preferred route corridor for the previous Meath-Tyrone 400 kV Interconnection Development involved a comparative evaluation of the identified route corridor options taking account of a wide range of technical, environmental and other criteria. The original decision making process and diverse range of evaluation criteria was outlined in the Report *Tyrone-Cavan Interconnector & Meath Cavan Transmission Circuit – Corridor Evaluation Document* (2008) prepared by RPS Planning and Environment on behalf of EirGrid. The criteria are identified in **Table 5.1**.

Table 5.1: Original Evaluation Criteria (2009)

Technical Criteria	
1. Safety • Operational Safety Risk • Construction Safety Risk • Risk of Disturbance by Third Parties	**2. Construction / Operation** • Road Infrastructure • Availability of Construction Materials • Maintenance During Operation • Ground Condition / Stability • Extent of Civil Works • Road Closures
3. Design • Need for Temporary and Permanent Compounds • Watercourse Crossings • Road Crossings • Length of Route	**4. Other Technical Considerations** • Security of Supply • Reliability • Potential for Future Linkage • Assurance of Adequate MVA Capacity
Environmental Criteria	
5. Human Beings • Health Impacts • Noise • Potential for Negative Economic Impact	**6. Electrical & Magnetic Fields** • Impact of Electrical Fields • Impacts of Magnetic Fields
7. Flora & Fauna • Potential Impact on Livestock • Potential Impact on Bloodstock • Potential Impact on Other Fauna / Flora Including Specific Species / Birds • Potential Impact on Protected and Designated Habitats	**8. Visual Amenity & Landscape** • Potential Impact on Protected Views and Prospects • Potential Impact on Areas of High Scenic Value • Potential Impact on Non-Designated but Scenic Landscapes

9. Archaeology, Culture & Local Heritage • Potential Impact on Protected Structures and Their Settings • Potential Impact on Recorded Monuments (RMPs) & Places and Their Settings • Potential for Cultural Heritage Constraints	**10. Water** • Disruption to Groundwater • Risk of Pollution of Ground and / or Surface Water
11. Air Quality • Disturbance and or creation of Particle Matters (PM10s)	
Community Criteria	
12. Planning and Land Use • Impact on Rural Development and Land Use • Impact on Urban Development and Land Use	**13. Community Severance**
14. Number of Dwellings within the 1 km wide Corridor	**15. Number of Dwellings and Other Occupied Buildings within 100 metres of Indicative Routes**
16. Landowner Consent	**17. Potential Impact on Public Amenities** • Distance to Nearest School (within approximately 500m) • Playing Pitches (within approximately 200m) • Recreational Areas • Other Public Buildings / Institutions • Tourism Facilities • Airfield
Other Criteria	
18. Compliance with Current Planning & Development Policy & Guidelines **19. Project Programme and Deliverability** **20. Economic Feasibility** **21. Compliance with Best International Practice** **22. Adaptability for Future Development**	

76 No quantitative weighting system was applied to the various technical, environmental and community criteria in order to evaluate the corridors. Rather, the approach allowed the construction of a strategic profile of each of the corridors, and how they met the identified criteria. This qualitative comparative approach determined whether in respect of a particular criterion, a corridor was ‗More Preferred‘ or ‗Less Preferred‘, or indeed whether it had a considered neutral implication.

77 The multi-criteria comparative evaluation process confirmed the following as the preferred 1km wide corridor:

- **CBSA – Border – vicinity of Kingscourt (Option A):** Corridor A was approximately 48km in length. It extended from the border crossing point north-east of Clontibret, County Monaghan, south to a proposed substation in the vicinity of Kingscourt, County Cavan.

- **NESA – Vicinity of Kingscourt – Woodland (Option 3(b)):** Corridor 3(b) was approximately 57km in length. It extended from the proposed substation in the vicinity of Kingscourt, County Cavan to Woodland Substation, near Batterstown, Dunshaughlin, County Meath.

78 CBSA - Option A and NESA – Option 3(b) as illustrated in **Figure 5.15** were therefore brought forward for confirmation of line design, EIA and ultimately formed the basis for the proposed development which was the subject of the 2009 application for approval (subsequently withdrawn).

79 The omission of the previously proposed intermediate substation in the vicinity of Kingscourt from this current proposal has resulted in a southerly extension, and associated amendments, of the previously identified route corridor Option A so that it meets the MSA corridor, and a northerly extension, and associated amendments, of the previously identified route corridor Option 3B so that it meets the CMSA corridor. However, it is more appropriate to consider that there is a single route corridor for the proposed development, within a single overall project study area.

Figure 5.15: CBSA (now CMSA) - Option A and NESA (now MSA) – Option 3(b) – 2009

5.3.3 Re-evaluation of Alternative Route Corridor Options and a Preferred Route Corridor

80 The purpose of the re-evaluation process was to confirm the applicability, or otherwise, of the identified corridors outlined in the previous withdrawn application, in the context of updated constraints and other information gathered since the original identification of these potential route corridors in 2007. The re-evaluation process also provided an opportunity to review and update the evaluation criteria used in 2008 to identify a preferred route corridor.

81 The findings of the re-evaluation process are detailed in the *Final Re-evaluation Report* (April 2013), comprising **Appendix 1.2**, **Volume 3B Appendices**, of the EIS.

5.3.3.1 Re-evaluation of Alternative Route Corridor Options

82 The re-evaluation process, including the evaluation of potential route corridors to the east of Kingscourt**,** determined that no new significant environmental or other constraints have arisen since the previous application in 2009, which would result in any substantial change to the previously identified route corridor options (although it is noted that some minor localised changes did occur). In particular route corridor Option A/3B remains the preferred route corridor within which to route the proposed transmission circuit.

5.3.3.2 Re-evaluation of the Preferred Route Corridor

83 The re-evaluation process provided an opportunity to review and update the evaluation criteria used in 2008. For example, the criteria that previously yielded results that were generally ‗Neutral‘ were omitted, in order to focus on those other criteria which differentiate the route corridor options, and specifically on whether a particular route corridor option is ‗More Preferred‘ or ‗Less Preferred‘ in respect of that particular criterion. This is set out in the *Final Re-evaluation Report* (April 2013).

84 As with the previous comparative evaluation process, no quantitative or weighting system was applied to the criteria in order to re-evaluate corridors. Rather, a strategic qualitative evaluation system, based on professional experience and expertise, was applied to each corridor against the identified criteria.

85 A summary of the findings of the re-evaluation process, with reference to the updated evaluation criteria is set out in **Tables 5.2** and **5.3**. The tables initially categorise the significance of impacts (minor, moderate or major) with reference to each environmental criterion for the project in an overall context. The tables then indicate the degree to which potential impacts can be mitigated (no practicable mitigation possible, reduce scale of impact or avoid impact). Finally, the tables indicate the preference for one route corridor over another with reference to being more preferred or less preferred.

Table 5.2: Route Corridor Re-evaluation CMSA

Less Preferred ← → More Preferred

CAVAN - MONAGHAN STUDY AREA

	Significance of Impact	Ease of Mitigation		Corridor Option A	Corridor Option B	Corridor Option C
Ecology	--	--	Potential Impact on Wintering Bird Sites			
	--	--	Potential Impact on Designated Sites Potential Impact on Fisheries Potential Impact on Mature Deciduous Woodlands Potential Impact on Wetlands Potential Impact on Hedgerows			
Landscape	---	-	Potential Impact on Protected Views and Prospects Potential Impact on Areas of High Scenic Value Potential for impacts on non designated but scenic landscapes Potential Impact on Landscape Character including landscape values and sensitivity.			
Cultural Heritage	--	--	Potential Impact on Archaeological Sites Potential Impact on Architectural Sites			
Techincal	N/A	N/A	Length of Line Route			
Water	-	---	Potential Impact on River Crossings Potential Impact on River Catchments Impact on Lakes			
Geology	-	---	Potential Impact on Proposed Geological National Heritage Areas (NHA's) Potential Impact on County Geological Sites (CGS's)			
Settlements	--	--	Potential Impact on Urban & Rural Settlements			
Infrastructure / Utilities	-	---	Potential Impact on Road Crossings Potential Impact on Railways Potential Impact on Existing Electricity Lines Potential Impact on Airfields			

Table 5.3: Route Corridor Re-evaluation MSA

Less Preferred ⟷ More Preferred

MEATH STUDY AREA

	Significance of Impact	Ease of Mitigation		Corridor Option 1	Corridor Option 2	Corridor Option 3A	Corridor Option 3B
Ecology	--	--	Potential Impact on Wintering Bird Sites				
	--	--	Potential Impact on Designated Sites Potential Impact on Fisheries Potential Impact on Mature Deciduous Woodlands Potential Impact on Wetlands Potential Impact on Hedgerows				
Landscape	---	-	Potential Impact on Protected Views and Prospects Potential Impact on Areas of High Scenic Value Potential for impacts on non designated but scenic landscapes Potential Impact on Landscape Character including landscape values and sensitivity.				
Cultural Heritage	--	--	Potential Impact on Archaeological Sites Potential Impact on Architectural Sites				
Techincal	N/A	N/A	Length of Line Route				
Water	-	---	Potential Impact on River Crossings Potential Impact on River Catchments Impact on Lakes				
Geology	-	---	Potential Impact on Proposed Geological National Heritage Areas (NHA's) Potential Impact on County Geological Sites (CGS's)				
Settlements	--	--	Potential Impact on Urban & Rural Settlements				
Infrastructure / Utilities	-	---	Potential Impact on Road Crossings Potential Impact on Railways Potential Impact on Existing Electricity Lines Potential Impact on Airfields				

86 Following the comparative evaluation process, which incorporated consideration of public and stakeholder feedback arising both in respect of the previous proposed application, and in respect of the subsequent re-evaluation process, as well as updated studies carried out by or on behalf of EirGrid, route corridor Option A and Option 3B emerged as the preferred route corridor for the proposed development.

87 In the CMSA, route corridor Option A was the ‗most preferred‘ option, by virtue of the fact that it has the lowest potential for creating long term adverse significant residual impacts which cannot be mitigated. These potential impacts arise primarily in terms of landscape and visual impacts. All other potential significant environmental impacts, including potential impact on Whooper swans, are localised, and can be mitigated.

88 Similarly, in the MSA, route corridor Option 3B was the ‗most preferred‘ option, as it was considered to create the lowest potential visual impact on the landscape, with all other potential significant environmental impacts being localised, and capable of being mitigated.

89 The preferred route corridor is therefore termed ‗**Route Corridor A/3B**‘.

5.3.3.3 Re-evaluation of Alternative Route Corridor Options East of Kingscourt

90 Notwithstanding the decision not to proceed with a new substation as part of the proposed development at this stage, EirGrid gave consideration to the location of the substation, in anticipation that it will be required at some future point in time. As previously noted, from a transmission planning perspective, a suitable substation location is in the vicinity of the point of intersection of the proposed interconnector (Turleenan-Woodland) 400 kV OHL, and the existing east-west oriented Flagford-Louth 220 kV OHL, as this will minimise the additional lengths of 400 kV and / or 220 kV circuits that have to be constructed in the future in order to connect in the new substation.

91 Given, the fact that, while the substation may be in the vicinity of Kingscourt, it may not necessarily be located at Moyhill (the site of the previously proposed substation), EirGrid reviewed the wider area between Nobber (east of Kingscourt) and north of Kingscourt, to determine if it presented any route corridor alternatives that were preferable (in terms of being least constrained) to the previously identified Option A/3B route corridor.

92 The review process consisted of an environmental evaluation of additional identified potentially feasible route corridors. The process had regard to a number of environmental considerations (specifically ecology, archaeology, landscape / visual and the impact on settlements). Four route corridor options to the east of Kingscourt were compared against the preferred route

corridor option to the west of Kingscourt to determine if any were of equal or greater merit to those already considered. The options are illustrated in **Figure 5.16**.

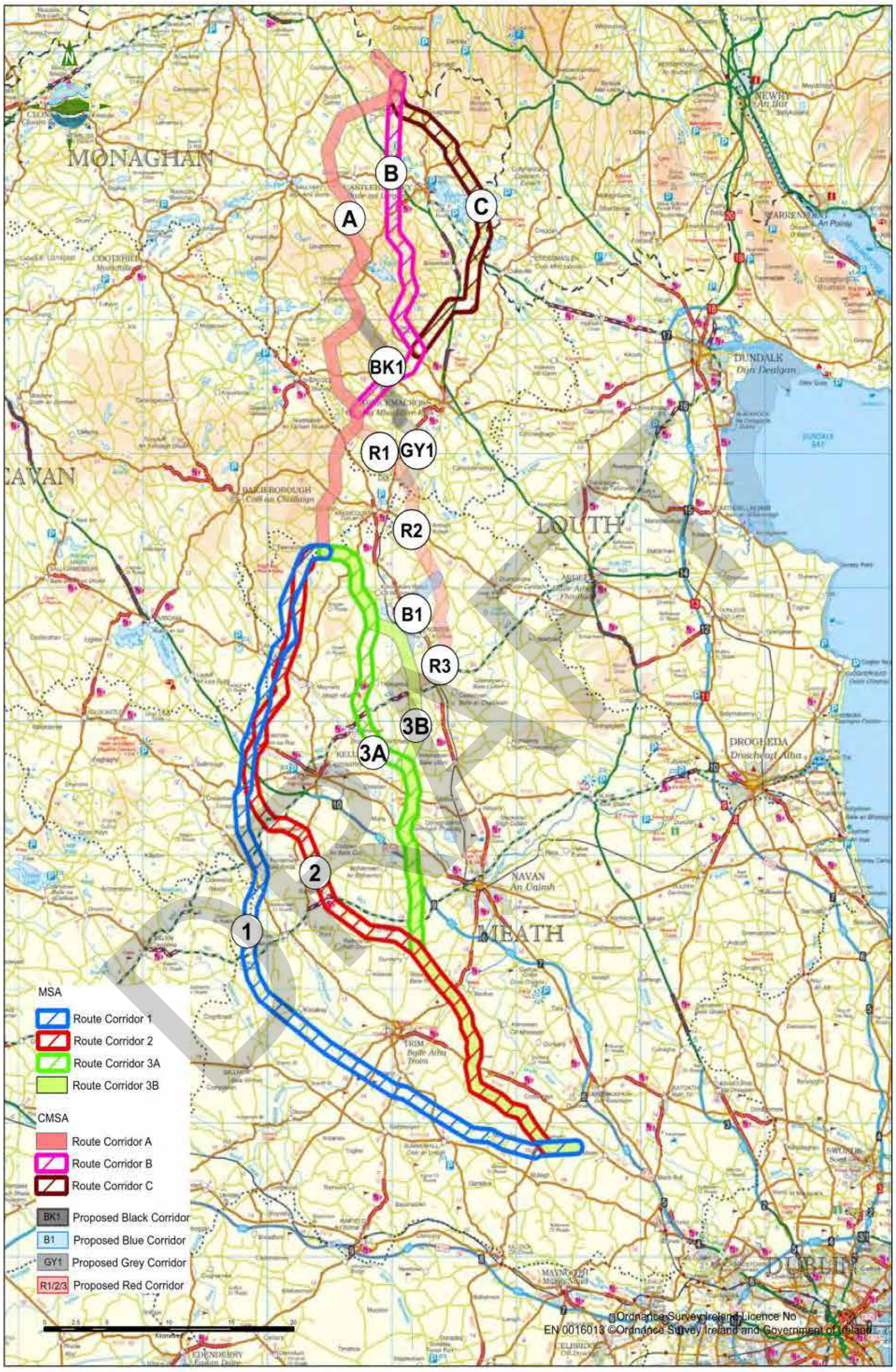


Figure 5.16: Identified Potential Route Corridor Options East of Kingscourt, and the Preferred Route Corridor A/3B West of Kingscourt

93 The analysis confirmed the preferred route corridor A/3B (see **Figure 5.16** to the west of Kingscourt) as remaining the least constrained (and thereby preferred) route corridor option, primarily on the basis of having the lowest number of dwellings within 100m of the indicative line route, and being at a greater distance from all of the key settlement in the area (i.e. Kingscourt, Nobber and Carrickmacross) with particular implications from a visual amenity perspective.

5.3.4 Confirmation of Preferred Route Corridor (and Indicative Line therein)

94 Following a comprehensive re-evaluation process of all corridor options, including the evaluation of potential route corridors to the east of Kingscourt, it was concluded that no new significant environmental or other constraints have arisen since the previous application in 2009, which would result in any substantial change to the previously identified route corridor options (although it is noted that some localised modifications did occur).

95 Route corridor option A/3B remains the preferred route corridor within which to route the proposed transmission circuit. **Figure 5.17** shows the preferred route corridor Option A/3B from Woodland to the jurisdictional border with Northern Ireland.

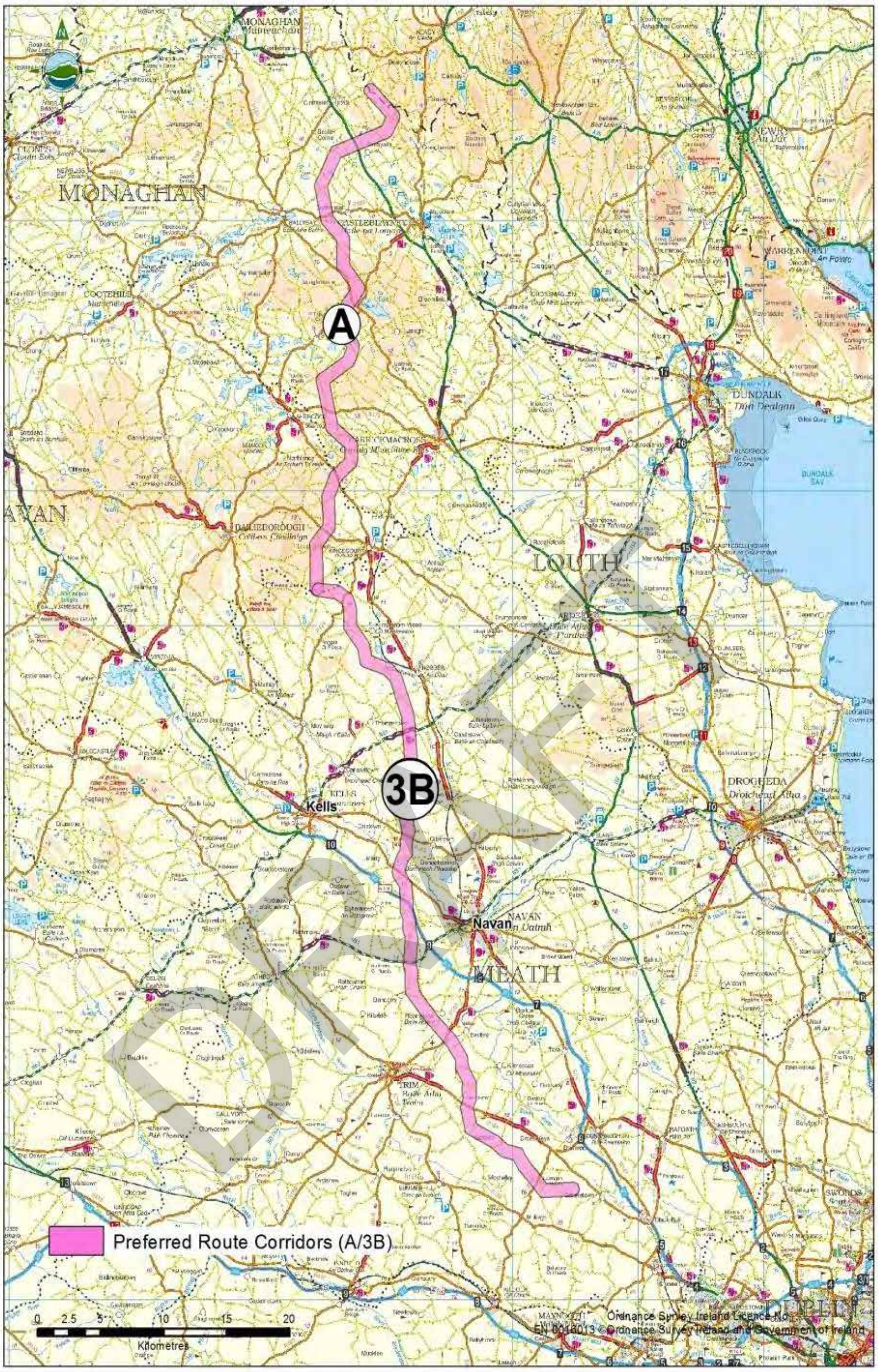


Figure 5.17: Preferred Route Corridor A/3B for the Proposed Development – 2013

5.4 IDENTIFICATION OF A PREFERRED LINE DESIGN

96 As set out in **Section 5.1**, , Phase 3 of the route selection process was to identify an indicative route alignment within the preferred route corridor, following more focussed technical and environmental analysis within the identified preferred route corridor A/3B.

5.4.1 Background to the Indicative Route Alignment and Line Design for the Proposed Development

5.4.1.1 2009 Planning Application

97 The line design approach for the previous application, was consistent with the general principles of environmental assessment which emphasise the following:

- Avoidance - Impacts should be avoided through selecting the route which avoids creating the highest level of significant impacts.
- Reduction – Where impacts are unavoidable they should be reduced by applying mitigation measures to the particular environmental impact.
- Remedy – Where impacts cannot be reduced to an acceptable level they should be remedied through environmental compensation (i.e. sensitive habitats may have to be recreated at an alternative location).

98 Technical routing limitations and considerations were also particularly important as they influence tower locations and heights. The technical considerations for the line design for the previous application for approval would have been informed by *inter alia*:

- Euronorm EN 50341, *Overhead Electrical Lines exceeding 1 kV and the associated National Normative Aspects (NNA) for Ireland* as defined by the Electro Technical Council of Ireland.
- CIGRÉ Document, *High Voltage Overhead Lines Environmental Concerns, Procedures, Impacts and Mitigations* (1999).
- UK National Grid Document, *Our Approach to the Decision and Routeing of New Electricity Transmission Lines* – which incorporates ‗The Holford Rules' and supplementary notes.
- EU Council Recommendation 1999/519/EC on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).
- Health & Safety Legislation.

99 A line design was developed by firstly assessing a potential tower location using a specialised computer aided design programme (PLS CADD) and ordnance survey mapping in order to determine its feasibility and to confirm it meets all technical requirements. Initially, a desk-based assessment was completed, which includes a review of aerial photography, LiDAR[74] data and other environmental datasets. Following this, vantage point surveys and, where land access was granted, site specific surveys were also carried out.

100 The result of the design process was the identified line route which formed the basis of the 2009 application for approval.

5.4.1.2 The Re-evaluation of the Indicative Line Route

101 The principal recommendation arising from the re-evaluation process is that the general alignment of the previously identified indicative line route within route corridor Options A and 3B remains the ‗best-fit' alignment for the proposed new transmission circuit within the preferred route corridor.

102 The *Final Re-evaluation Report* (April 2013) also concluded that, on the basis of the re-evaluation of updated environmental constraints and other information, a viable and environmentally acceptable indicative line route for a 400 kV OHL exists within the identified preferred route corridors A and 3B.

5.4.1.3 Description of the Indicative Line Route

103 The indicative line route identified in the *Final Re-evaluation Report* (April 2013) was broadly similar to the previously proposed line route (i.e. the subject of the 2009 application) but incorporates localised modifications as follows:

- Modifications to the line route in order to take account of the construction and granting of permission for new houses occurring since the preparation and submission of the previous Meath-Tyrone 400 kV Interconnection Development application in December 2009.
- Modification arising as a result of the decision not to proceed with the intermediate substation (in the area to the west of Kingscourt) development.
- Modifications arising from technical and environmental considerations during the re-evaluation process.

[74] LiDAR is a remote sensing technology that uses laser scanning to collect height and elevation data.

104 The preferred route corridor Option A/3B with the indicative line route therein is illustrated in **Figure 5.18**.

105 The *Final Re-evaluation Report* (April, 2013) also concluded on the basis of updated environmental constraints and other information, that at the strategic level of the re-evaluation process, no areas would warrant the use of UGC along any part of the indicative line route, other than on an identified section at the approach to Woodland Substation (albeit that this no longer forms part of the final design which is the subject of this application for statutory approval – refer to **Chapter 2** of this Volume of the EIS). However, it was noted that EirGrid would continue to investigate partial undergrounding as part of the detailed line design process and preparation of the EIS.

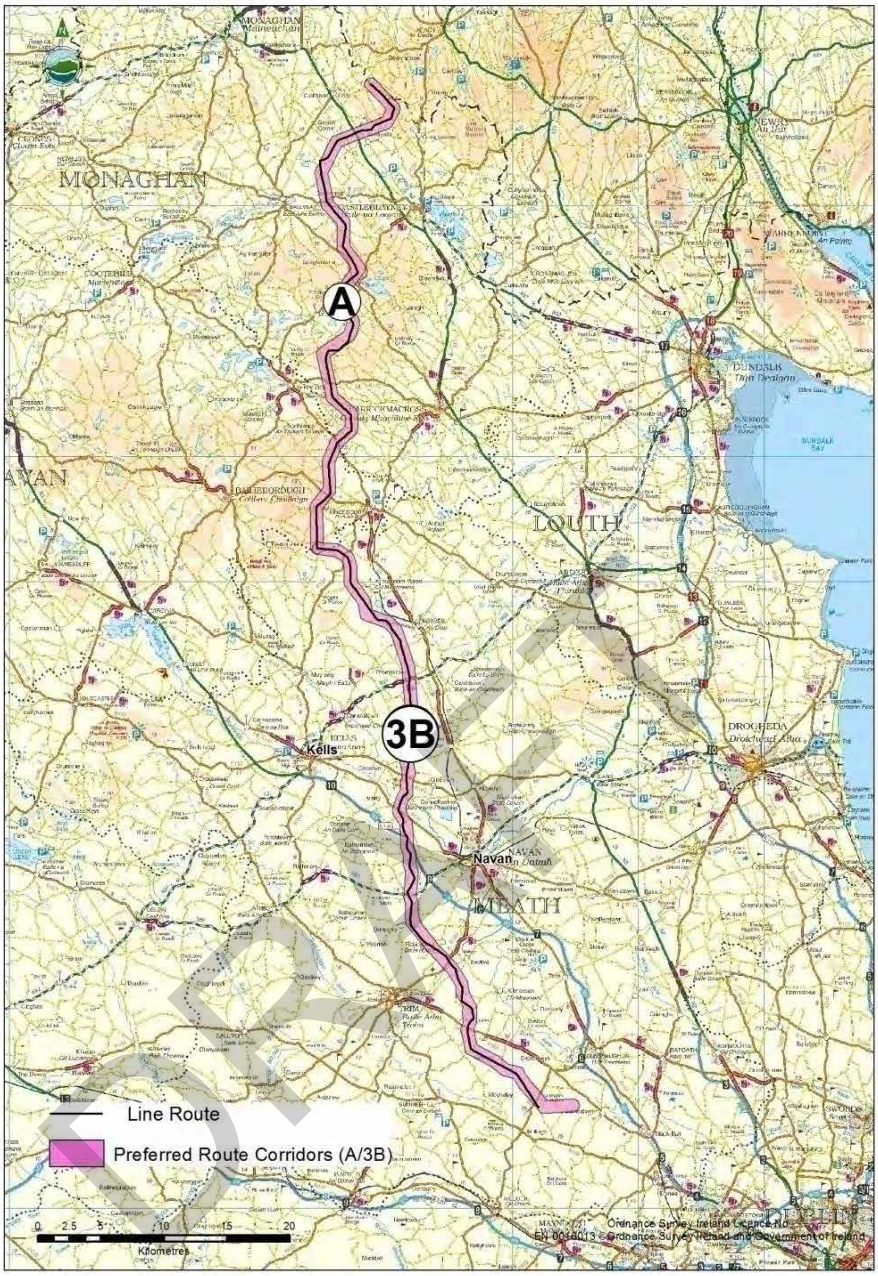


Figure 5.18: Preferred Route Corridor with Indicative Route Alignment

5.4.2 Confirmation of the Final Line Design for the Proposed Development

106 Following on from the *Final Re-evaluation Report* the *Preferred Project Solution Report* (July, 2013) provided detail as to the specific Preferred Line Design for the proposed development. This Preferred Line Design included identification of feasible alternative locations for, and design of the infrastructure, such as tower positions, tower types and associated construction related details (e.g. temporary access tracks). The evolution of the Final Line Design also had significant regard to previous feedback (including during the course of the previous Meath-

Tyrone 400 kV Interconnection Development application and consultation), as well as to public and landowner feedback received during the re-evaluation process.

107 The *Preferred Project Solution Report* and other relevant matters which influenced the final line design are addressed below.

5.4.2.1 Line Design Guidelines

108 In the *Preferred Project Solution Report*, EirGrid identified the main routing principles (focusing on technical, environmental and landowner considerations) which guided the line design process for the proposed development. These equally informed the line design approach for the 2009 application. The principles are:

Technical Routing Considerations

- The minimum clearance for a 400 kV OHL shall be 9m over ground and 10m over major roads / railways. Clearance over canals / navigable waterways shall be 14.7m minimum.
- EirGrid's line design standard requirements and technical limits of existing tower designs include *inter alia* a requirement to achieve the appropriate span length for the kV (i.e. the maximum span length at 400 kV is 500m; however the average is 350m).
- Avoid sharp changes in direction in the line (or Angle of Deviation (AOD)) and minimise the number of angle towers required, where possible.
- Minimise the number of crossings of other power lines, railway lines, roads and other infrastructure.
- Tower foundations should be located in stable flood free environments with minimal erosion to avoid excessive costs related to highly reinforced or piled foundations and for long term maintenance access.

Environmental Considerations

- On the grounds of general amenity, where possible EirGrid will avoid routing overhead transmission lines close to residential areas.
- With respect to individual houses, EirGrid will seek to maximise distances between OHL and existing dwellings and specifically, where possible, to achieve a lateral clearance of at least 50 metres from the centre of the proposed route to the nearest point of dwellings.

- Avoid known ecologically sensitive areas (e.g. cSAC / SAC / pNHA / NHA /SPAs) where possible.

- Sites of potential ecological importance (e.g. hedgerows and wetlands) shall be assessed via on-site survey. Where such surveys are not possible overhead towers should be sited away from the potentially sensitive areas and into adjoining managed agricultural fields where the ecological sensitivity is low.

- Cause least disturbance and minimise impacts to identified natural heritage interests (including watercourses).

- Avoid major areas of highest amenity value and deviate around areas of lesser amenity value, where possible.

- Integrate the line within the landscape, where possible including *inter alia*: utilising natural background and foreground features to visually absorb towers (e.g. hills, forests, vegetation etc.); avoiding axial views, breaking the skyline and a concentration of ‗wirescape' (arising from proximity to lower voltage or telephone lines); maintain uniformity of tower heights where possible, etc.

- When crossing a flat landscape characterised by a large visual field, poor complexity and a clear organisation of land pattern, it is preferable to use higher towers with longer span lengths (to match the simplicity of the landscape).

- Cause least disturbance to and minimise impacts to cultural heritage interests.

Landowner Considerations

- Minimise disturbance to current land use and farm / land management practices.

- Consult with landowners throughout the various stages of the design.

- Gather inputs from landowners on their farm practices and suggested locations for towers.

109 These guidelines informed and provided a starting point for identifying a potentially suitable line design which appropriately balances competing considerations.

110 Having regard to the above routing principles, a line design can then be developed by firstly assessing a tower location using a specialised computer aided design programme (PLS CAD) and ordnance survey mapping in order to determine its feasibility and to confirm it meets all technical requirements. The tower locations are then passed on for further iterative assessment by relevant specialists including ecologists, archaeologists, hydrologists, geologists,

agronomists and landscape consultants. Initially, a desk-based assessment is completed, which includes a review of aerial photography, LiDAR data and other environmental datasets. Following this, vantage point surveys and, where access is granted, site specific surveys are also carried out.

5.4.2.2 Transposition

111 As identified in the *Final Re-evaluation Report*, the consequence of the deferment of the intermediate substation near Kingscourt was the establishment of a continuous 400 kV OHL circuit from Woodland to Turleenan; such a circuit would be more than 130km in length. It was noted that the operating performance of such a long high voltage OHL can be sometimes improved by the insertion of one or more points of ‗transposition‘ along its length.

112 Transposition is the practice of transposing or rearranging the spatial arrangement of the three electricity wires or conductors that make up the three-phase circuit. The transposition takes place over four structures (the transposition alignment) as shown schematically in the **Figure 5.19**.

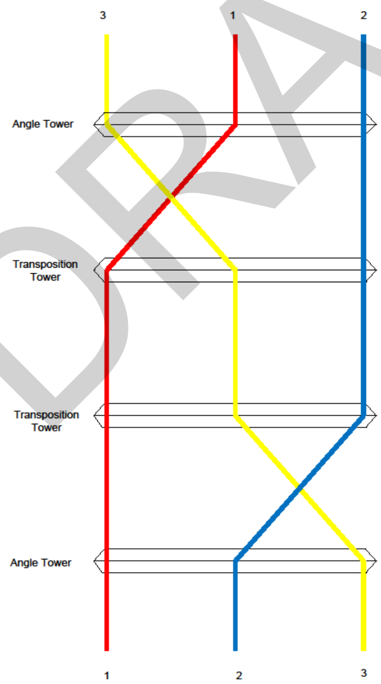


Figure 5.19: Schematic of Transposition Alignment

113 The three wires enter the transposition alignment orientated, left to right, 1 - 2 - 3 and exit the transposition alignment orientated, left to right, 3 - 1 - 2.

114 The *Final Re-evaluation Report* concluded that a *"transposition alignment will likely be required for this development*".

115 Following the conclusion of the *Final Re-evaluation Report* that a transposition alignment was likely to be required for this development, analysis by EirGrid showed that the OHL would benefit from a single transposition and that the optimum location for the transposition alignment was a general location 40 to 50km south of the proposed substation at Turleenan.

116 The exact location for such transposition required identification of a suitable straight section of the alignment capable of accommodating four structures installed in the following sequence, angle tower – transposition tower – transposition tower – angle tower.

117 A straight consisting of four structures was the optimum choice for a transposition alignment as it would avoid the requirement to insert an additional tower into the straight. Avoiding an additional structure has both environmental and cost advantages.

5.4.2.3 Feedback on the Preferred Line Design

118 The preferred line design as published in the *Preferred Project Solution Report* provided focus for ongoing landowner engagement, particularly in respect of the specific siting of structures on lands, as well as further environmental survey, design and assessment, primarily in engagement with directly affected landowners, as well as in consultation with prescribed bodies, other stakeholders and members of the public.

5.4.2.4 Partial Undergrounding

119 In the *Preferred Project Solution Report* (July 2013), EirGrid continued to consider the potential for partial undergrounding of the proposed development. This evaluation included having regard to submissions which specifically requested consideration to be given to undergrounding in particular areas and / or for certain sections of the proposed indicative line route, including a request by Cavan County Council to consider undergrounding in the area of Lough an Leagh. This latter submission was examined by the Project Team and its conclusion was set out in the *Preferred Project Solution Report* as follows:

> *"The scenic view point referred to in the submission, Lough an Leagh is approximately 2km west of the line route. It is an elevated area with extensive panoramic views. The visual assessment indicates that visibility of the line from this location would be confined to long distance views of the upper portions of some towers, and these would be difficult to discern against the background*

> *landscape. There is therefore no strong justification for undergrounding in the vicinity of Lough an Leagh."*

120 More generally on the potential for partial undergrounding, the *Preferred Project Solution Report* concluded:

> *"As part of the line design process, EirGrid and its consultants have reviewed the potential for partial undergrounding. At the conclusion of this review, EirGrid is of the opinion that a viable and environmentally acceptable OHL line route exists within which to design the proposed North-South 400 kV Interconnection Development. However, partial undergrounding as a measure to mitigate potential significant environmental impacts will be further considered as part of the preparation of the EIS and within the broader EIA process".*

121 With the identification of a preferred OHL line design, EirGrid and its consultants were in a position to identify potential significant environmental impacts and to consider likely mitigation measures, which included, *inter alia*, the potential for partial undergrounding. Reference is also made to the Scoping Opinion issued by the Board on 11th December 2013, which stated that ‗*the potential for alternative routing or partial undergrounding in sensitive landscape areas should be addressed*".

122 Both OHL and UGC technologies result in environmental impacts. These impacts are however different for the different technologies and in most cases, if not all, mitigation measures are available.

123 As referenced in **Section 4.8**, the circuit design and operating voltage are both important variables which determine the eventual size, scale, and ultimately appearance of the necessary support structures for an OHL. In general, the higher the voltage, the larger the support structure that is required with a consequential impact on landscape and visual resources. Therefore, careful route selection during the planning stages is critical in mitigating landscape and visual resources, particularly for high voltage OHLs. It is at this route selection stage where there is maximum potential to achieve avoidance and minimal adverse landscape or visual effects.

124 The potential for undergrounding as a mitigation measure required consideration of the potential environmental impacts associated with partial undergrounding. In this regard, reference is made to **Section 4.7.3.3** of this volume of the EIS which examines some of the environmental implications of partial undergrounding and Chapter 6 of the Government commissioned Ecofys *Study on the comparative merits of overhead electricity transmission lines versus underground cables* (2008) which examines a number of key environmental issues and compares OHL and UGC in terms of ‗Environmental Impact' and ‗Ease of Potential Mitigation'.

125 The Ecofys Report concludes, in Section 6.12, by stating: *"the purpose of this study is to provide decision-makers with an unbiased, comparative assessment of the general environmental implications of either scenario in environments typical of Ireland to enable them to make informed decisions in this regard."* It then presents its findings in tabular form, see **Figure 5.20** Table 6-1: *High Voltage Transmission Systems – Overhead Lines versus Underground Cables: Environmental Impact & Ease of Potential Mitigation*.

	Underground Cables		**Overhead Lines**	
Potential for Effect	**Signif**[1]	**Ease of Mitigation**	**Signif.**	**Ease of Mitigation**
LAND USE				
Time and Flexibility of Construction	***	●●	**	●●
Length of Construction	***	●●	**	●●
Disrupt. To Agric. Operations	***	●●●	**	●●●
Land Take	**	●●	*	●●●
Effect on Field Boundaries	***	●●	**	●●●●
Effects on Farm Buildings	**	●	**	●●●
Effects on Drainage Patterns	***	●●	*	●●●●
Catastrophic Event Implications	***	●●	**	●●●
Repair & Maintenance	***	●●	*	●●●●
GEOLOGY and SOILS				
Soil Cover	***	●●●	**	●●●●
Excavated Material	***	●●	**	●●●●
Quarrying and Mining	**	●●●	**	●●●
EFFECTS ON WATER				
Disruption to Groundwater incl. Wetland	***	●●	*	●●●●
Effect on Surface Waters	***	●●●	*	●●●●
GROUND RESTORATION	***	●●●	**	●●●
ECOLOGY and NATURE CONSERVATION				
Bird Strike	N/A	N/A	***	●●●

	Underground Cables		Overhead Lines	
Potential for Effect	**Signif[1]**	**Ease of Mitigation**	**Signif.**	**Ease of Mitigation**
Risk to Flora (construction)	***	●●	**	●●●
Risk to Flora (operations)	**	●●	*	●●●
Risk to Mammals	**	●●	*	●●●
Risk to Insects	**	●●	*	●●
Loss of Habitat (construction)	***	●●●	**	●●●
Loss of Habitat (operations)	**	●	**	●
Risk to Aquatic Ecosystems	***	●●●	*	●●●●
Restoration	***	●●●	*	●●●
LANDSCAPE and VISUAL				
Landscape Character	*	●●●	***	●●
Landscape Features	**	●●	*	●●●
Visual Impact (construction)	***	●●	**	●●
Visual Impact (operations)	*	●●●	***	●●
Access Tracks/Haul Roads	***	●●●	**	●●●●
Communities	**	●●●	***	●●
CULTURAL HERITAGE				
Archaeological Resources	***	●●	*	●●●
Cultural/Historic Resources	**	●●	**	●●●
Language and Culture	*	●●●	***	●●
TRAFFIC AND NOISE				
Traffic	***	●●	**	●●
Noise (construction)	***	●●	**	**
Noise (operations)	*	●●●●	**	●●
AIR QUALITY				
Construction	***	●●	**	●●

	Underground Cables		Overhead Lines	
Potential for Effect	**Signif[1]**	**Ease of Mitigation**	**Signif.**	**Ease of Mitigation**
Operations	N/A	N/A	**	●
COMMUNITIES				
Quality and Cohesiveness	*	●●●●	***	●●
Business, Economy and Employment	*	●●●●	**	●●
Tourism Industry	*	●●●●	**	●●
Fishing	*	●●●●	**	●●●
Animal Breeding	*	●●●●	**	●●●
Health & Safety and Electromagnetic Fields	*	●●●●	**	●●●●
Property Prices	**	●●	***	●
Severance	*	●●●●	***	●●
Educational Enrolment	*	●●●●	***	●●
Future Development	**	●●●	***	●●
RECREATION and TOURISM	*	●●●	***	●●

(Source: Ecofys *Study on the comparative merits of overhead electricity transmission lines versus underground cables* (2008))

Note: 1 = Significance of Impact

Significance:

*** Major: a fundamental change to a sensitive environment

** Moderate: a material but non-fundamental change to the environment

* Minor: a detectable but non-material change to the environment

N/A Not applicable

Mitigation:

● No practicable mitigation possible

●● Remedial measures only

●●● Mitigation likely to reduce adverse scale of impact

●●●● Mitigation likely to avoid adverse discernible impact

N/A Not applicable

Figure 5.20 Table 6-1: High Voltage Transmission Systems – Overhead Lines versus Underground Cables

(Source: Ecofys *Study on the comparative merits of overhead electricity transmission lines versus underground cables* (2008))

126 Of particular note, the table identifies that, for the majority of environmental topics an OHL has an equal or lesser environmental impact to a UGC, with obvious exceptions (including bird strike, landscape character, visual impact and certain community issues). This is generally consistent with EirGrid's findings.

127 In relation to landscape and visual impact, in particular, Ecofys reported a significance of impact of 'major – a fundamental change to a sensitive environment' in terms of landscape character, visual impact (operations) and communities. Mitigation is identified as 'likely to reduce adverse scale of impact'. Identified mitigation measures include *inter alia* avoiding conspicuous sky lines and horizons, particularly in visually sensitive areas and avoiding, to the extent feasible, areas of high visual amenity and areas with highly sensitive visual receptors. It is important to note that these measures have fed into the line design process for the proposed development (refer to **Section 5.4.2.1).**

128 **Table 5.4** below summarises EirGrid's consideration of partial undergrounding to mitigate potential significant environmental impacts arising from the preferred OHL line design, based on an understanding of the environmental issues associated with the Monaghan, Cavan and Meath study area. In this regard, the majority of environmental topics identified OHL as having an equal or lesser environmental impact to partial undergrounding. These findings are generally consistent with the comparative environmental implications described in Table 6-1 of the Ecofys Report (as replicated in **Figure 5.20**).

Table 5.4: Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
Human Beings – Population and Economic	Partial UGC could be considered as an effective mitigation measure in order to reduce the most significant impacts (localised visual impacts) on population, assuming that an appropriate location and screening plan can be identified for minimising the visual effect of the requisite sealing-end compounds. This has been considered by the landscape specialist and it is concluded that, having regard to the above, and the strategy of avoiding those parts of the landscape in the study area most sensitive to the landscape effects of OHL (as well as the generally robust character of the study area landscape), there is no particular location along the proposed route which has been identified as presenting a critical need for partial undergrounding within the technical parameters of this project.

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
Human Beings - Land Use	UGC would cause a greater level of disturbance to livestock, farming operations and has a higher potential to damage soil and land drainage during construction compared to OHL. During the operational phase both UGC and OHL may restrict development in the area immediately above the cable or under the towers, however, the permanently restricted area for both is low. Furthermore, while UGC will only be an obstacle to deep cultivation (e.g. land drainage and sub-soiling); the presence of towers has a higher potential to inconvenience other farming practices (all field operations). In summary both OHL and UGC are likely to have similar residual impacts however they are imperceptible. Therefore there are no impacts of such significance envisaged that would introduce the need for consideration of partial undergrounding for the proposed development from a land use and agronomy perspective.
Human Beings - EMF	A comparative assessment of OHL and UGC from an EMF emissions perspective for this proposed development can be found in the PB Power Report, 2009. The Report confirms that both the proposed 400 kV OHL and a comparable AC UGC (including partial UGC) would comply with the ICNIRP (1998) Guidelines and EC Recommendation (1999/591/EC). Partial undergrounding cannot therefore be considered as a way of mitigating EMF from the proposed overhead line as there is no difference between the two technologies from a compliance perspective. Partial undergrounding is not therefore proposed.
Human Beings – Tourism and Amenity	Partial UGC is an effective mitigation measure in order to reduce localised visual impact and resultant potential impacts on tourism assets, assuming that an appropriate location and screening plan can be identified for minimising the visual effect of the requisite sealing-end compounds. Partial UGC would result in higher temporary physical landscape effects at construction stage, but these effects can be mitigated with reinstatement of planting (excluding tree planting). However, having regard to the above, and the strategy of avoiding those parts of the landscape in the study area most sensitive to the landscape effects of OHL as well as the generally robust character of the study area landscape - no location along the proposed route has been identified where there is a critical need for partial undergrounding within the technical parameters of this project.
Flora & Fauna	Potential impacts on flora and fauna associated with OHL and partial UGC vary. UGC would eliminate the collision risk to Whooper swans and other such collision prone birds; however during the construction phase there is the potential for adverse impacts on sensitive habitats such as wetlands (including rivers and associated riparian habitats), woodlands, hedgerows and treelines. The construction of the cable would result in significant habitat disturbance arising from extensive ground excavations along the length of the cable section. In addition there would be some loss of habitat as a section of every hedgerow intersected by the cable route would be removed and grubbed out during construction and would not be reinstated in its

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
	original form. In addition the construction of the cable would result in greater potential for risk of disturbance to protected mammals and birds; for example permanent removal of breeding sites and greater risks of pollutant / soil water runoff to aquatic receptors. During the operational phase, habitat fragmentation could arise with reduced connectivity (e.g. gaps through hedgerows), due to the requirement for a non-wooded corridor along the cable length. In addition UGC would have a greater potential to impact aquatic habitats (rivers and streams – including the River Boyne and Blackwater cSAC / SPA in the case of the proposed development) during both construction and operational phases (i.e. maintenance). Trenchless directional drilling methods could be used to install the UGC under rivers and streams, however this introduces the risk of ‗frac-out' (fracturing of the bore hole) with the accompanying risk of the escape of bore hole grout into the water which has the potential for severe, albeit short term, impact on water quality (aquatic receptors). UGC would present a greater risk to water quality (aquatic receptors), protected fauna and habitats. The only reason for considering partial UGC from an ecology standpoint regarding the proposed development is to remove the risk of Whooper Swans colliding with an OHL at relevant sections identified in the EIS. In terms of the importance (legal protection) of identified relevant ecological receptors; the most important ecological features are European Sites. These will be subject to greater risk of a significant adverse impact with UGC compared to OHL. This fact must be weighed up when considering UGC in the catchment of the River Boyne and Blackwater rivers. In conclusion, there are no impacts of such significance envisaged that would introduce the need for consideration of partial undergrounding for the proposed development from a flora and fauna perspective.
Soils, Geology and Hydrogeology	The potential impacts from UGC are greater than OHL and would require additional mitigation measures particularly in sensitive areas (i.e. the River Boyne / River Blackwater cSAC). Potential impacts may occur on wetlands and peatlands identified along the line route. Potential impacts include groundwater impact adjacent to wetlands in the CMSA and the Boyne and Blackwater cSAC. Additional soil excavation and disposal will be required in the event of undergrounding. The use of bridge crossings where feasible and directional drilling for the crossing of major water courses would be required. Additional impacts are also likely to occur on the wetlands (i.e. Cashel Bog, Tassan Grassland and Clarderry Bog) and geological heritage sites along the proposed development including the Altmush Stream and Galtrim Moraine CGS. Additional potential impacts may include settlement / disturbance of overlying areas. Additional mitigation measures would be required to deal with the extra groundwater encountered during excavation work and directional

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
	drilling. In conclusion, notwithstanding mitigation measures, UGC would present a greater potential risk to soils, water and hydrogeology than OHL. Accordingly, partial undergrounding of the proposed development is not required.
Water	The potential impacts from UGC are greater than OHL and would require additional mitigation and detailed design particularly at the River Boyne / River Blackwater cSAC. Potential impacts include the diversion of numerous land drains and small streams connected to salmonid streams. Potential impacts may also occur on wetlands and peatlands identified along the line route. The use of bridge crossings where feasible and directional drilling for the crossing of major water courses would be required. Diversion of water courses should be avoided where possible to minimise disruption to aquatic ecosystems. Additional mitigation measures would be required to deal with the additional construction periods and excavation areas involved. In conclusion, notwithstanding mitigation measures, UGC would present a greater potential risk to water than OHL. Accordingly, partial undergrounding of the proposed development is not required.
Noise	The construction of UGC would result in greater noise impact than OHL (arising from more extensive, longer lasting and more machinery intensive works; higher traffic volumes; and construction of additional transition stations). In the operational phase the UGC would reduce the effect of corona noise in the UGC sections. However, additional noise and vibration impacts would arise for both the construction and operational phases of UGC due to the introduction of transition stations. When the construction phase and operational phase noise and vibration impacts are viewed as a whole, it is considered that there is no significant noise and vibration benefit to be gained by introducing partial undergrounding as part of the proposed development. Noise and vibration impacts of the proposed OHL are predicted to meet all relevant guidelines limit values.
Air - Climate	Undergrounding the proposed line would involve a greater level of groundworks, increased traffic emissions and increased use of natural resources such as concrete and aggregate materials. This would increase the level of impacts associated with the construction phase.
Landscape	The primary mitigation measure in landscape terms is avoidance at route selection stage. The determination of the best route for an OHL resulted in the avoidance of those parts of the landscape in the study area which are most sensitive to the landscape and visual effects of an OHL; including where possible, higher ground and ridgelines, waterbodies, landscape designations and important scenic views. Best practice routing principles (refer to **Section 5.4.2.1)** also informed the line

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
	design process including measures to integrate the line within the landscape where possible. The *Preferred Project Solution Report* states that the use of short lengths of UGC will only be considered in the event that an appropriate and acceptable OHL solution could not be found. This is considered to occur if *Profound* impacts, as defined in the EPA Guidelines, were predicted. A profound impact is defined in the Guidelines as one which *"obliterates sensitive characteristics".* This would be the case if, for example, there are major landscape and visual impacts on highly sensitive landscape features of National or International value. The proposed OHL does not result in effects of this magnitude within the study area and therefore there is no critical need for partial UGC along the route. However, the scoping opinion from the Board has also requested that the *potential for partial undergrounding be assessed in sensitive landscape areas*. The approach to landscape and visual impact evaluation for this EIS accepts that it is not possible to eliminate all the landscape and visual effects of OHL and significant visual impacts will potentially occur over the course of the entire length of the line route. The most sensitive landscape areas along the line route have been identified in the EIS (refer to Chapter 11 of **Volume 3C** and **Volume 3D)**. In terms of visual impact, it is acknowledged that removing towers from views would reduce the extent of visibility of the proposed development in short lengths of sensitive landscape locations such as the crossings of the Boyne and Blackwater. The precise locations where partial undergrounding may be appropriate have not been identified i.e. with the capacity to screen the UGC associated infrastructure such as sealing-end compounds and absorb the residual landscape effects of partial UCG. Areas where partial UGC might be considered are also the locations that would be most sensitive to the landscape and visual effects of the required sealing-end compounds and permanent haul roads. Partial UGC in these locations would result in new landscape and other environmental impacts. These have been described in detail in **Section 4.7.3.3** this volume of the EIS. For example from a landscape perspective, potential impacts at construction will arise from excavation, haul roads and vegetation removal; and UGC will also introduce additional new permanent features into the receiving environment such as haul roads, sealing-end compounds and manholes. While vegetation needs to be removed during construction stage, reinstatement / screen planting and appropriate siting can reduce the long term impact of, for example, sealing end compounds.
Material Assets – General	In comparison to OHL, the construction of underground sections of the proposed development would result in increased volumes of excavated soil (and potentially rock) material which may not be suitable as backfill material and may need to be sent to waste facilities. Furthermore, during the construction phase for both UGC and OHL there is the potential to disrupt other underground and overhead services. During the operational phase, UGC would have no impact on aircraft operating at

Environmental Topic	Consideration of Partial Undergrounding as a Mitigation Measure for the Proposed Development
	Trim Airfield or ballooning activities. OHL would also have no impact on these operations as they would be factored into flight planning considerations, along with all similar existing infrastructure in the area. Accordingly it is not considered that there is an overriding need for partial undergrounding along the proposed route.
Material Assets – Traffic	The construction of partially underground sections of the proposed development would have a somewhat different traffic impact to that of the construction of an OHL. The key difference would be the volumes of excavation required to lay the cable and the potential that some or all of that material would have to leave the site via the road network, thus increasing the volumes of traffic generated by the proposed development. The volumes of soil excavated when constructing the underground sections would be greater than those expected for the construction of a similar length of the overhead transmission line. The construction of UGC sections would therefore result in greater volumes of soil leaving the site and being disposed of as waste, thereby increasing the number of vehicles accessing the site compared to an equivalent section of the OHL. Dependent on the design and construction methods used for underground sections, the volumes of construction materials would also likely have implications for the volumes of traffic generated. In conclusion, the construction of underground sections of the proposed transmission line will increase the volumes of construction traffic using the public road network when compared to overhead line construction. Therefore, from a traffic impact perspective, there is no reason to consider the undergrounding of sections of the proposed development.
Cultural Heritage	The methods of construction for OHL and UGC have very different impacts upon cultural heritage. OHLs have a very small physical footprint and avoidance of all direct impacts upon known archaeological and architectural sites is usually achievable however, their potential to impact upon the setting of cultural heritage sites is much greater. UGC and associated works are unlikely to impact upon the setting of cultural heritage sites but are more likely to impact physically upon known and previously unrecorded archaeological and architectural sites. In relation to the proposed development, from an archaeological, architectural and cultural heritage perspective, there is no overriding need for partial undergrounding.

129 In conclusion, EirGrid's environmental consultants have considered the potential for partial undergrounding (and its likely environmental impacts) as a potential mitigation measure in the context the environmental issues associated with the Monaghan, Cavan and Meath study area and the preferred line design. However, no particular area(s) have been identified where there is an overriding need for partial undergrounding in order to mitigate significant potential impacts.

130 Also during this process, EirGrid and its consultants gave due consideration to specific requests to partially underground on particular landholdings on the grounds of general amenity; however, having regard to the environmental, technical and cost considerations set out in **Section 4.7.3** of this volume of the EIS, and the findings of specialists, as set out in **Table 5.4**, EirGrid and its consultants are of the view that, on the basis of the evidence presented to date, there are no areas along the proposed development that would warrant partial undergrounding.

5.5 FINAL LINE DESIGN FOR THE PROPOSED DEVELOPMENT

5.5.1 Proposed Interconnector Overview

131 As noted previously, the proposed interconnector consists of two separate but related and complementary developments, one in Northern Ireland and the other in Ireland. The final design can be broken up as follows:

132 The SONI element of the proposed interconnector (i.e. Towers 1–102) comprising:

- The construction and operation of a new 275 kV / 400 kV (source) substation at Turleenan townland, north-east of Moy, County Tyrone;
- The construction and operation of two 275 kV terminal towers to enable connection of the Turleenan substation to NIE's existing 275 kV OHL and the removal of one existing 275 kV tower; and
- The construction and operation of a single circuit 400 kV overhead transmission line supported by 102 towers for a distance of 34.1km from the source substation (at Turleenan) to the border where it will tie into the future ESB network. The OHL will continue on in the Republic of Ireland with all further towers being promoted by EirGrid for placement within that jurisdiction. Because of the meandering nature of the border, the OHL will oversail a portion of land within the Northern Ireland townland of Crossbane for a short distance of 0.2km.

133 The EirGrid element of the proposed interconnector comprising:

- The proposed development in the CMSA comprises a single circuit 400 kV overhead transmission circuit supported by 134 towers (Tower 103 to Tower 236) extending generally southwards from a point along the jurisdictional border with Northern Ireland (in the townlands of Doohat or Crossreagh, County Armagh, and Lemgare, County Monaghan) to the townland of Clonturkan, County Cavan for a distance of approximately 46km. It includes lands traversed by the conductor from the jurisdictional border to Tower 103 and from Tower 103 to Tower 236 inclusive and lands traversed by the conductor strung from Tower 236 to Tower 237 (the first tower on the MSA section of the proposed development).[75]

- MSA – New and Existing 400 kV Line: The proposed development in the MSA comprises a new single circuit 400 kV overhead transmission circuit supported by 165 new towers (Tower 237 to Tower 401) extending for a distance of approximately 54.5km from Tower 237 in the townland of Clonturkan, County Cavan to Tower 402 (an existing double circuit tower on the Oldstreet to Woodland 400 kV transmission line) in the townland of Bogganstown (ED Culmullin), County Meath.

  It also includes the addition of a new 400 kV circuit for some 2.85km along the currently unused (northern) side of the existing double circuit 400 kV overhead transmission line (the Oldstreet to Woodland 400 kV transmission line) extending eastwards from Tower 402 in the townland of Bogganstown (ED Culmullin), County Meath to Tower 410 and the Woodland Substation in the townland of Woodland, County Meath.

5.6 THE PROPOSED DEVELOPMENT

134 The line design for that portion of the proposed interconnector located in Ireland is described in detail in **Chapter 6** of this volume of the EIS. The description is intended to illustrate the rationale for the direction, deviations and other relevant characteristics of the line design i.e. the micro consideration of alternatives in the line design process.

135 The consideration of other alternatives was also factored into the final line design for the proposed development. Those of relevance are briefly summarised below.

- The MSA preferred line design also includes 2.85km of the new circuit supported on existing 400 kV double circuit structures. One side is currently in use supporting the existing Oldstreet to Woodland 400 kV circuit; the other side is spare and available for the proposed development. From an environmental perspective, it was considered that using the unused side of these double circuit towers has a much lower potential impact compared to a new line route into / out of Woodland Substation.

- The MSA preferred line design also includes an associated extension to the existing Woodland Substation. The proposed extension will take place entirely within the existing ESB property boundary and will involve work to an area of approximately

[75] Between Tower 106 and Tower 107 the proposed transmission line crosses the jurisdictional border with Northern Ireland at two points - from the townland of Lemgare, County Monaghan into the townland of Crossbane, County Armagh and back into the townland of Lemgare, County Monaghan. This results in a section of the span between Tower 106 and Tower 107 oversailing Northern Ireland. The oversail section forms part of the SONI proposal.

5,440sq.m. (0.544ha) including the area to accommodate the proposed electrical equipment and the extension to the existing 2.6m high palisade fence. The overall area of the substation within the proposed fence line will however only be extended by approximately 2,307sq.m. (0.231ha) as the majority of the works are accommodated with the existing fence line. In this regard, in the previous application for planning approval a short section of underground cable was proposed at the approach to Woodland Substation and to connect into Bay E3. However, following ongoing review of the preferred line design as published in the *Preferred Project Solution Report* (July 2013) it is now proposed to connect into Bay E10 thus avoiding the need for an underground cable section within the substation. The specific works are detailed in **Chapter 6** of this volume of the EIS.

5.7 CONCLUSIONS ON ROUTE ALTERNATIVES

136 The route alignment of the proposed development has been subject to an extensive and careful examination of alternatives as part of an iterative project development process, from the broadest study area for the project down to localised alternatives for line routing. As this chapter has demonstrated, the mitigation of environmental impacts by design has been a fundamental aspect of EirGrid's line design process, and the proposed line design is considered to represent the best overall option amongst the main alternatives considered through the route development process.

6 DESCRIPTION OF DEVELOPMENT – TRANSMISSION CIRCUIT AND SUBSTATION WORKS

6.1 INTRODUCTION

1 This chapter provides a description, on a section by section basis, of the entire line route for the proposed development – that is, that portion of the proposed interconnector extending from the jurisdictional border with Northern Ireland to, and including within, Woodland 400 kV Substation, County Meath. The proposed line route is described using townlands and tower numbers as a guideline (refer to **Section 6.2** and **Figures 6.1** to **6.21**). This chapter also provides an overview of the project elements, including the overhead line (OHL) design, the towers and works to the existing Woodland Substation.

2 The principal construction works proposed as part of the development are set out in **Chapter 7** of this volume of the EIS. In this regard, associated and ancillary works and other considerations for the purpose of this EIS includes:

- A temporary construction material storage yard at Monaltyduff and Monaltybane, Carrickmacross, County Monaghan comprising *inter alia* associated site works, new site entrance onto the L4700 Local Road, and 2.6m high boundary palisade fencing; and
- All associated and ancillary development (including permanent and temporary construction and excavation works).

3 **Chapter 7** of this volume of the EIS also describes the construction techniques and equipment which will be used on the proposed development.

6.2 DESCRIPTION OF LINE ROUTE

4 As described in **Chapter 5** of this volume of the EIS, for ease of reference and local identification, the proposed transmission circuit is presented in two sections. These are the Cavan Monaghan Study Area (CMSA) and the Meath Study Area (MSA).

5 The proposed line route is described on a section by section basis using townlands and tower numbers. Each section is described in the text and supported by a corresponding figure. This figure is intended to illustrate where the line changes direction within that particular section - accordingly only angle towers are identified. The line route is also illustrated on a series of A1 aerial maps (contained in **Volume 3B Figures,** of the EIS). These detailed maps show the

location of all towers (intermediate, angle and transposition) in addition to many of the constraints which the proposed line seeks to avoid.

6.2.1 CMSA – New 400 kV Line

6 The proposed development in the CMSA comprises a single circuit 400 kV overhead transmission circuit supported by 134 towers (Tower 103 to Tower 236) extending generally southwards from a point at the jurisdictional border with Northern Ireland (in the townlands of Doohat or Crossreagh, County Armagh, and Lemgare, County Monaghan) to the townland of Clonturkan, County Cavan for a distance of approximately 46km. It includes lands traversed by the conductor from the jurisdictional border to Tower 103 and from Tower 103 to Tower 236 inclusive and lands traversed by the conductor strung from Tower 236 to Tower 237 (the first tower on the MSA section of the proposed development).[76]

7 The border crossing detail is illustrated in **Figure 6.1**. Tower 102 is located in Northern Ireland in the townland of Doohat or Crossreagh in County Armagh and the alignment travels along the lower contours of the landscape in a south-easterly direction in the townland of Lemgare, County Monaghan.

8 There is a slight deviation to the line route at Tower 105 in the townland of Lemgare in County Monaghan. From this location the alignment oversails the jurisdictional border in the townland of Crossbane, County Armagh in order to avoid an existing house.

[76] Between Tower 106 and Tower 107 and the proposed transmission line crosses the jurisdictional border with Northern Ireland at two points - from the townland of Lemgare, County Monaghan into the townland of Crossbane, County Armagh and back into the townland of Lemgare, County Monaghan. This results in a section of the span between Tower 106 and Tower 107 oversailing Northern Ireland. The oversail section forms part of the SONI proposal.

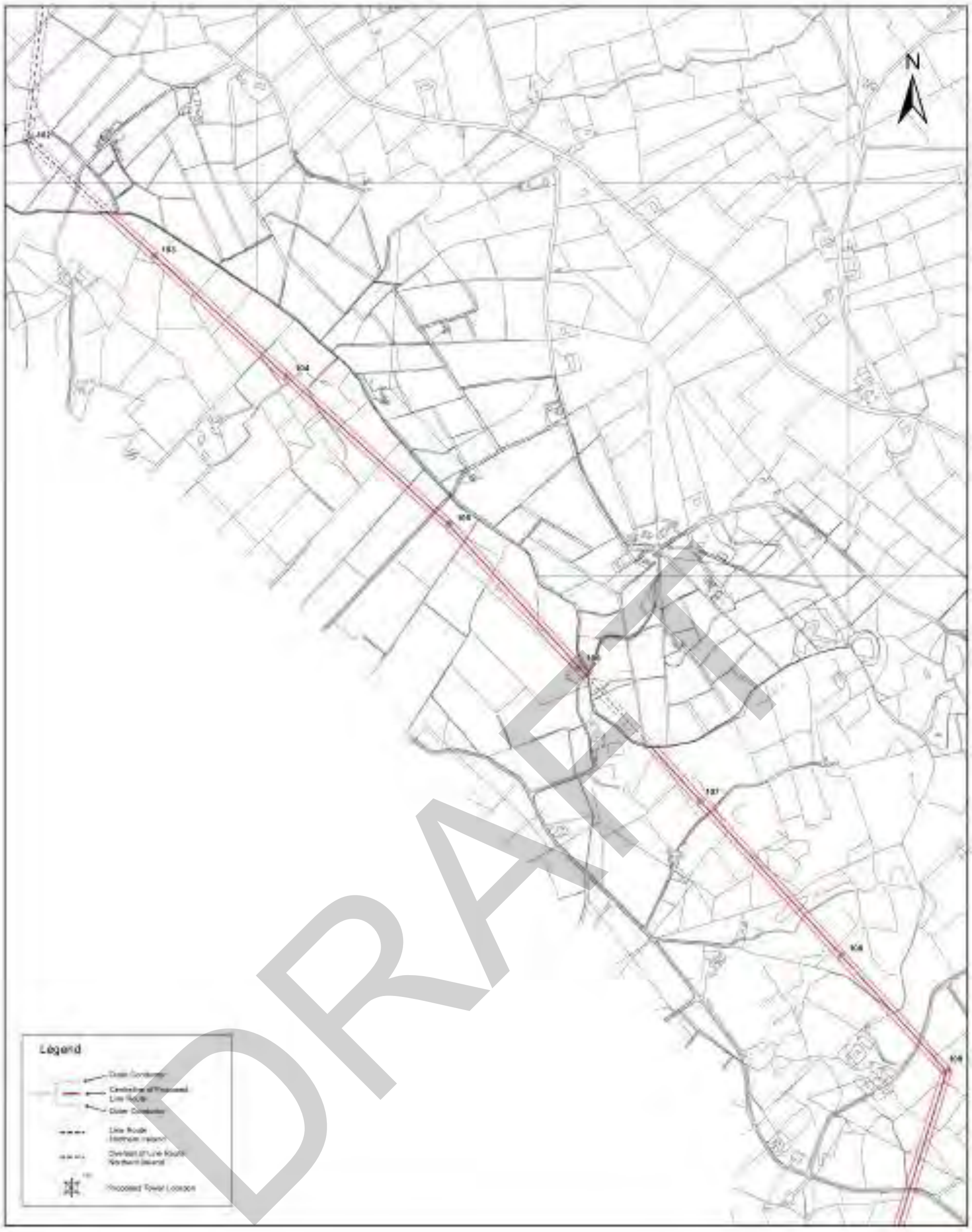


Figure 6.1: Border Detail

9 The CMSA section of the overall circuit is presented in **Figure 6.2**.

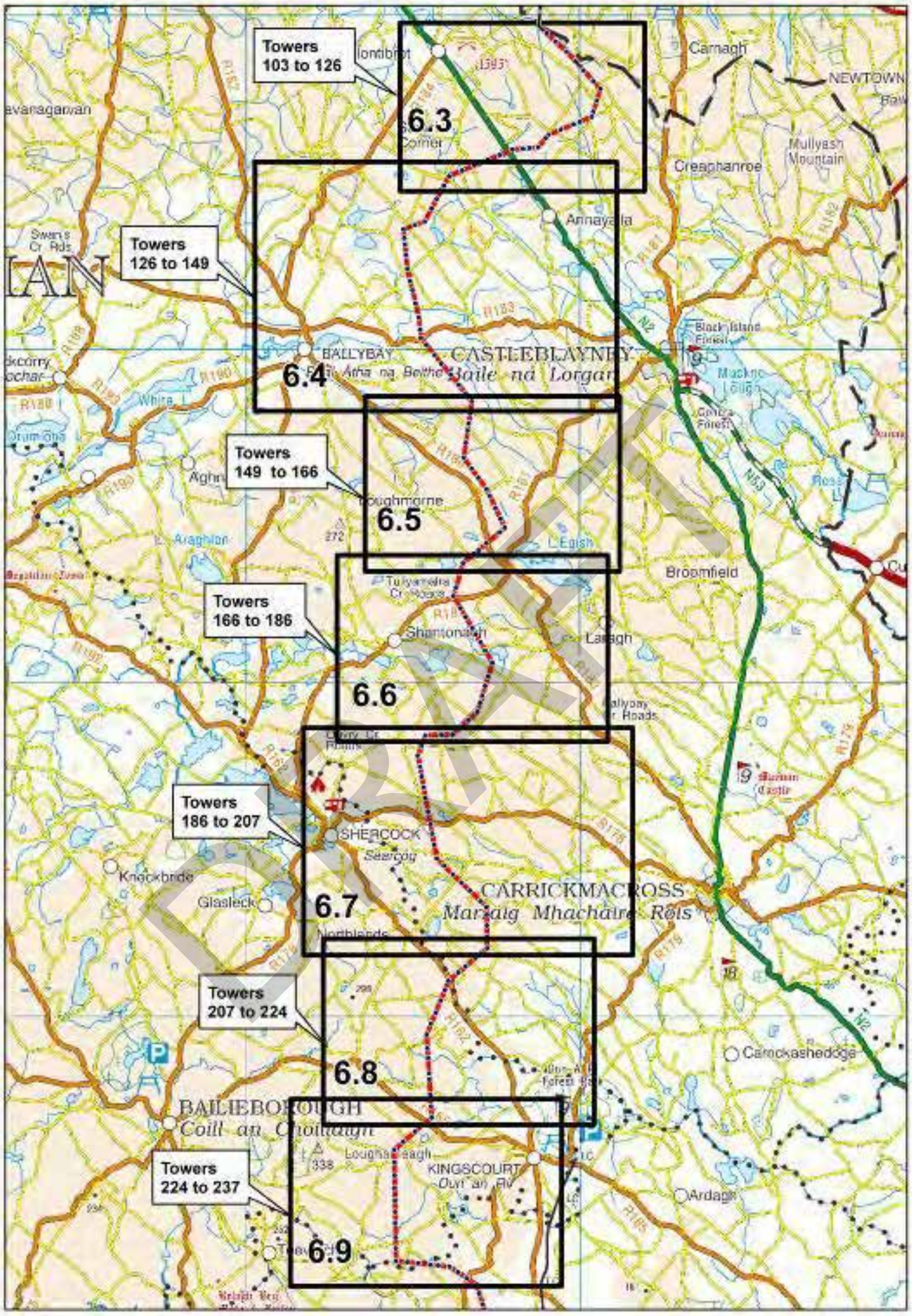


Figure 6.2: CMSA Section of Transmission Circuit

Lemgare to Cornamucklagh North Towers 103 to 126

Figure 6.3: Towers 103 to 126

10 As mentioned above Tower 102 is located in Northern Ireland in the townland of Doohat or Crossreagh in County Armagh and the alignment travels along the lower contours of the landscape in a south-easterly direction in the townland of Lemgare, County Monaghan. Again, as referred to above there is a slight deviation to the line route at Tower 105 in the townland of Lemgare. From this location the alignment oversails the jurisdictional border in the townland of Crossbane, County Armagh in order to avoid an existing house. The alignment in the aforementioned section is routed in a valley which straddles the two jurisdictions.

11 At Tower 109, in the townland of Lisdrumgormly, County Monaghan, the line route deviates in a more south-westerly direction crossing a minor road on its way. At Tower 112, in the townland of Annaglogh, County Monaghan, the line route diverts further to the south-west to avoid Tasson Lough to the south. Between towers 116 and 121, the line route ‗dog-legs‘ to the south in order to avoid the Cashel Bog complex. Straight 118 to 121 was chosen as the preferred location for the transposition alignment as it can be facilitated here without incurring any additional impact on the environment (over and above that which would occur if a standard configuration was proposed here) and there is also limited housing in the immediate area (see **Section 5.4.2.2**). Thereafter, the alignment reverts to a south-westerly direction and traverses

to Tower 126, in the townland of Cornamucklagh North, County Monaghan, in order to avoid, both ribbon development extending from Cremartin, as well as the general site of the battle of Clontibret to the north.

Cornamucklagh North to Drumguillew Lower Towers 126 to 149

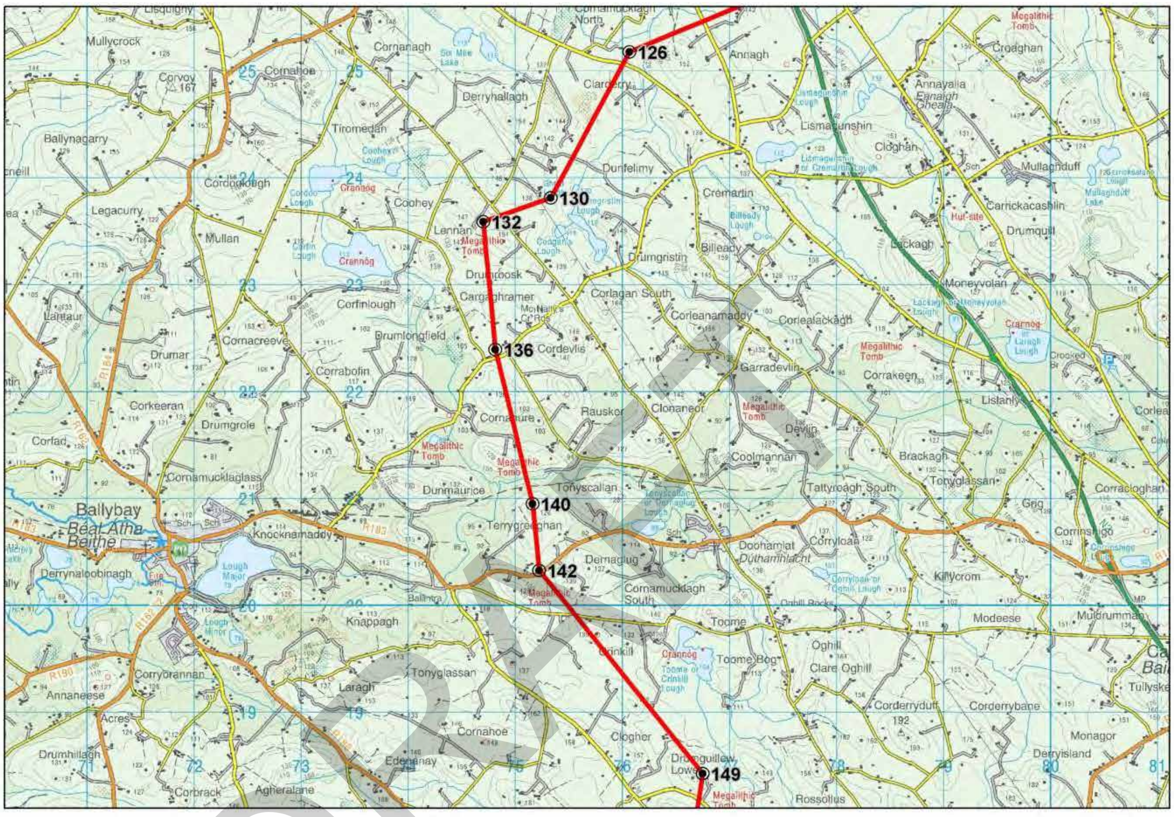


Figure 6.4: Towers 126 to 149

12 From Tower 126, in the townland of Cornamucklagh North to Tower 130, in the townland of Drumroosk the alignment travels in a south-westerly direction in order to avoid cutover bog at Clarderry and Derryhallagh (Monaghan By). The alignment is also routed in this location so as to avoid a drumlin at Derryhallagh and the lakes to the west and south of the line route. At Tower 130, the alignment turns further to the south-west, and crosses the existing Lisdrum-Louth 110 kV line. At Tower 132 in the townland of Drumroosk, the alignment turns in a southerly direction to meet up with Tower 136 in the townland of Cornanure (Monaghan By). Once again, thereafter, the alignment deviates to the south-east and again slightly deviates south at Tower 140 in the townland of Terrygreeghan in order to facilitate a house planning permission in the townland of Terrygreeghan. At Tower 142, also in the townland of Terrygreeghan, the alignment deviates south-east and traverses the main R183 Castleblayney–Ballybay road, approximately 1.5km west of Doohamlet. The alignment is routed in this area in order to avoid the villages of Doohamlet and Ballybay, and to avoid close proximity to the

church at Ballintra. The alignment minimises the number of road crossings within the area, and is located at what is considered to be an appropriate distance from Lough Major, which is located to the east of Ballybay. The alignment then traverses a local road in a south-easterly direction to Tower 149 in the townland of Drumguillew Lower.

13 The alignment between Tower 142 and Tower 149 traverses a valley and avoids a ridge line which follows the direction of the road to the west of the line route. The alignment route within this section avoids the wetland complex at Crinkill, as well as some fragments of mixed woodland located either side of the route.

Drumguillew Lower to Aghmakerr Towers 149 to 166

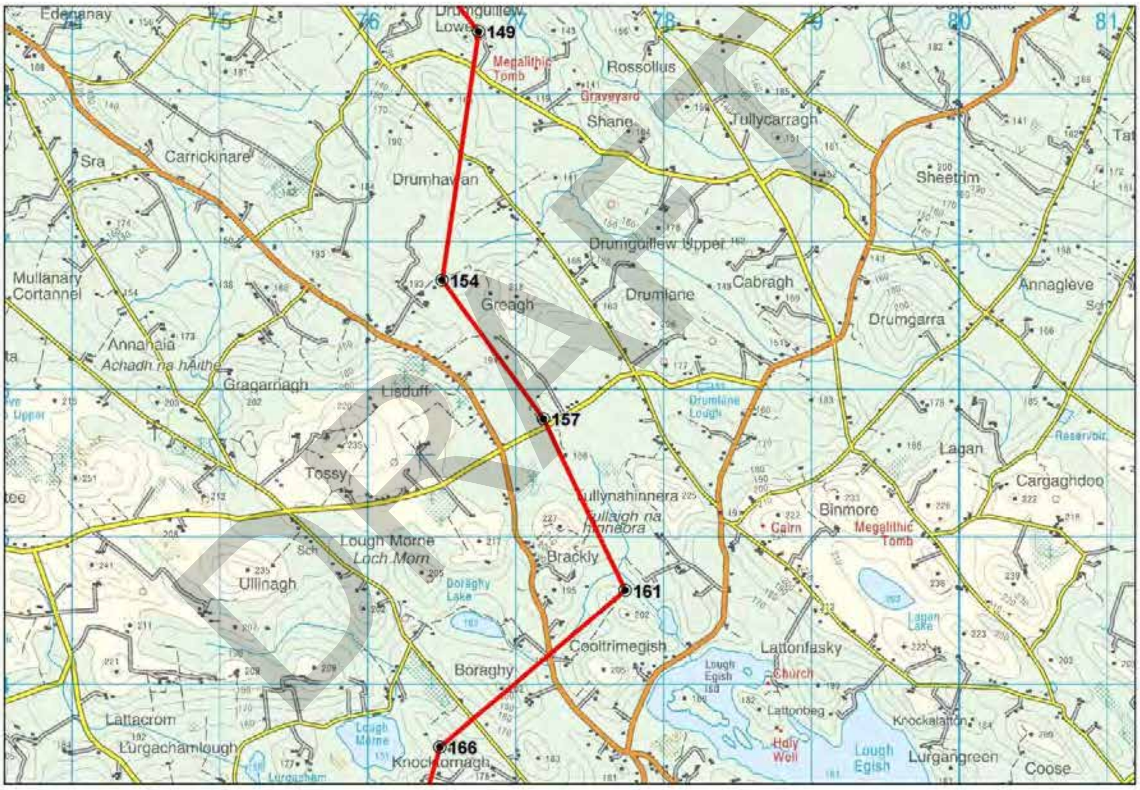


Figure 6.5: Towers 149 to 166

14 At Tower 149 in the townland of Drumguillew Lower, the alignment follows in a southerly direction, crossing two minor roads. The alignment in this section is routed to avoid ribbon development that occurs along a minor road to the east of line straight 149 to 154. The alignment maintains a distance from Drumhowan GAA pitch and a megalithic tomb located to the east of the line route. At Tower 154, in the townland of Greagh (Cremorne By), the alignment deviates in a south-easterly direction, crossing a minor road where ribbon development occurs. The alignment deviates slightly at Tower 157, in the townland of Greagh (Cremorne By) and joins up with Tower 161 in the townland of Cooltrimegish, in order to avoid

cutover bog in the townland of Brackly (Cremorne By). The line in this section is also routed so as to avoid ribbon development which occurs on the main R180 from Lough Egish, and also to avoid the scenic route north of Lough Egish. The line route follows this alignment in order to avoid high ground at Lisduff, Tossy and Brackly (Cremorne By). At Tower 161 in the townland of Cooltrimegish, the alignment route turns in a south-westerly direction to cross the R180 Carrickmacross–Ballybay road and a minor road, thereby avoiding ribbon development, and continues to Tower 166 in the townland of Aghmakerr.

Aghmakerr to Sreenty Towers 166 to 186

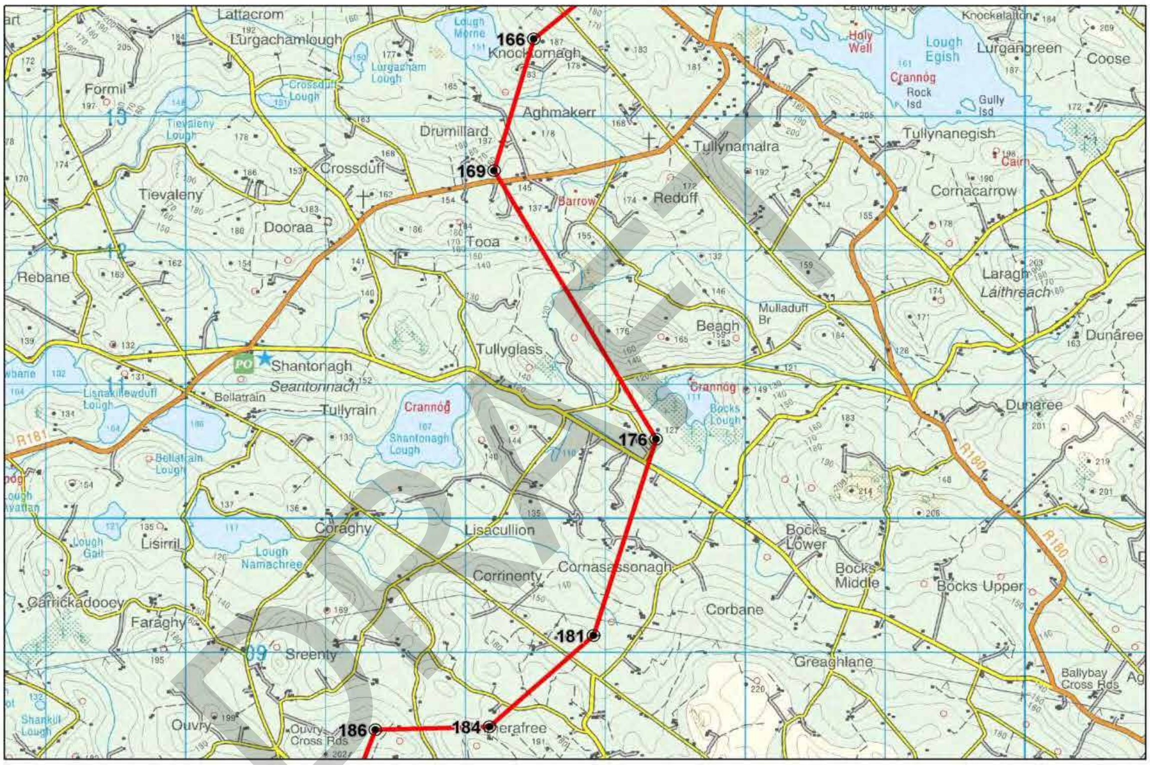


Figure 6.6: Towers 166 to 186

15 At Tower 166 in the townland of Aghmakerr, the alignment turns south-west (crossing a minor road) and then deviates south-east at Tower 169 in the townland of Drumillard (Cremorne By) in order to cross the R181 Shercock to Lough Egish road. The alignment avoids the church at Lough Egish to the east and the houses located along the R181. The alignment continues through the townlands of Tullyglass and Tooa in order to avoid a scenic route located 1.5km to the east of Shantonagh. The alignment crosses a minor road within this section and is routed in order to avoid Shantonagh Lough, and the scenic route at Beagh and Bock‘s Lough.

16 At Tower 176, in the townland of Tullyglass the alignment turns south-west in order to avoid Bock's Lough, a wetland woodland complex of high local value. The alignment has been designed in this location in order to obtain an optimum crossing of the existing Louth–Rathrussan 110 kV line and to circumvent the lakes to the east and west of Shantonagh Lough. The line route crosses the existing 110 kV line in that location in order to avoid the ribbon development located along the minor road to the north-west. At Tower 181 in the townland of Corrinenty the line route turns south-west and then west at Tower 184 in the townland of Ummerafree to meet up with Tower 186 in the townland of Sreenty. The alignment crosses a number of minor roads in this section and is routed to avoid ribbon development to the south.

Sreenty to Scalkill Towers 186 to 207

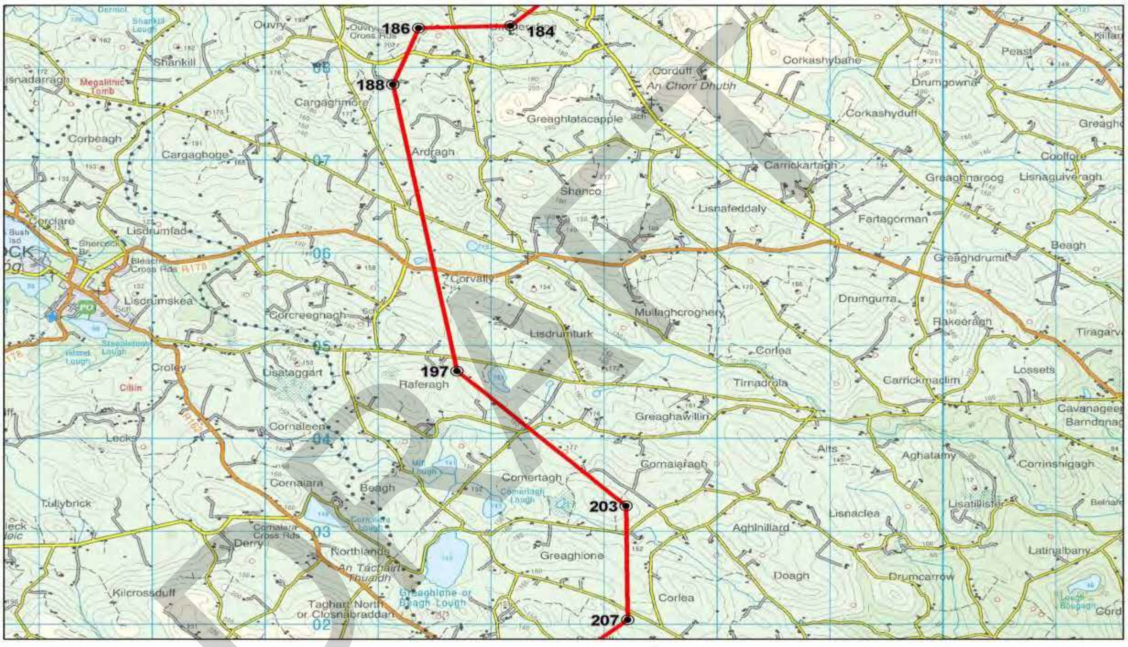


Figure 6.7: Towers 186 – 207

17 From Tower 186, in the townland of Sreenty the alignment crosses a minor road to Tower 188 in the townland of Ardragh and, thereafter, it traverses the countryside in a southerly direction crossing two minor roads and the R178 Shercock to Carrickmacross road 3km east of Shercock. The route is aligned in this direction in order to avoid Corduff and the high contours at Shanco (Farney By), and Greaghlatacapple and Corduff (Farney By) and to avoid established one-off housing.

18 At Tower 197, in the townland of Raferagh to Tower 203 in the townland of Doagh the line route turns south-east and crosses two minor roads, thus avoiding the cluster of one-off housing in the same townland to the east of the line route. The alignment is routed in this area so as to avoid the lakes to the east and west of the alignment. At Tower 203, the line route changes

direction to the south and crosses two minor roads before reaching Tower 207 in the townland of Scalkill.

Scalkill to Dingin Towers 207 to 224

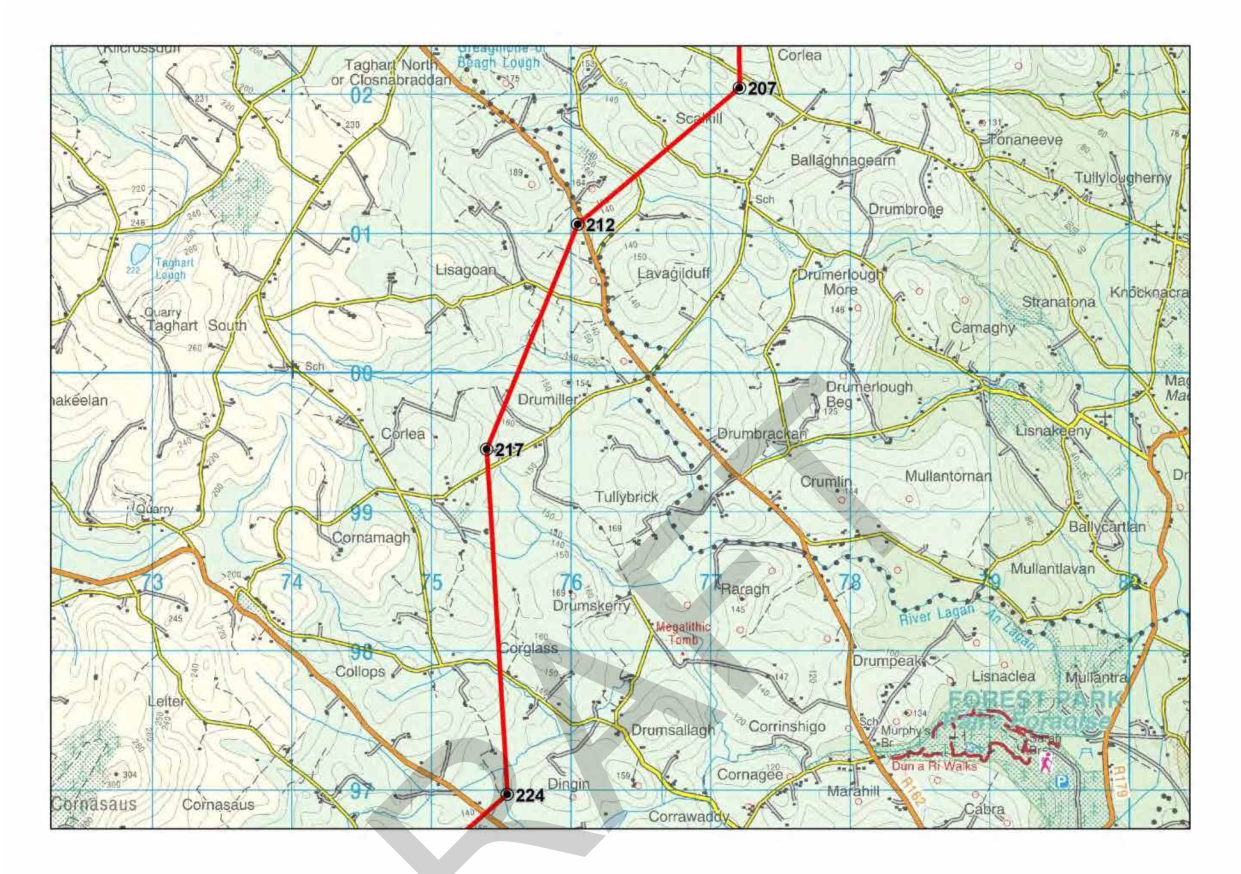


Figure 6.8: Towers 207 to 224

19 At Tower 207 in the townland of Scalkill, the alignment turns south-west and proceeds to Tower 212 in the townland of Lisagoan crossing on its path two minor roads and crossing the main R162 (Kingscourt–Shercock) road approximately 5.5km north-west of Kingscourt and the Cavan-Monaghan county boundary, in order to circumvent the lakes west of the line route located at Northlands. The line route is also at a distance (approximately 1.27km) from the wetland complex of Greaghlone Lough in this area. At Tower 212, in the townland of Lisagoan the line route crosses several minor roads, in order to avoid the ribbon development that emanates from the town of Kingscourt and the townland of Drumiller. At Tower 217, in the townland of Corlea (Clankee By), the alignment heads in a southerly direction and avoids the higher contours to the west at Cornamagh and the ribbon development on the lower slopes located to the west of the alignment and continues to Tower 224 in the townland of Dingin.

Dingin to Clonturkan Towers 224 to 237

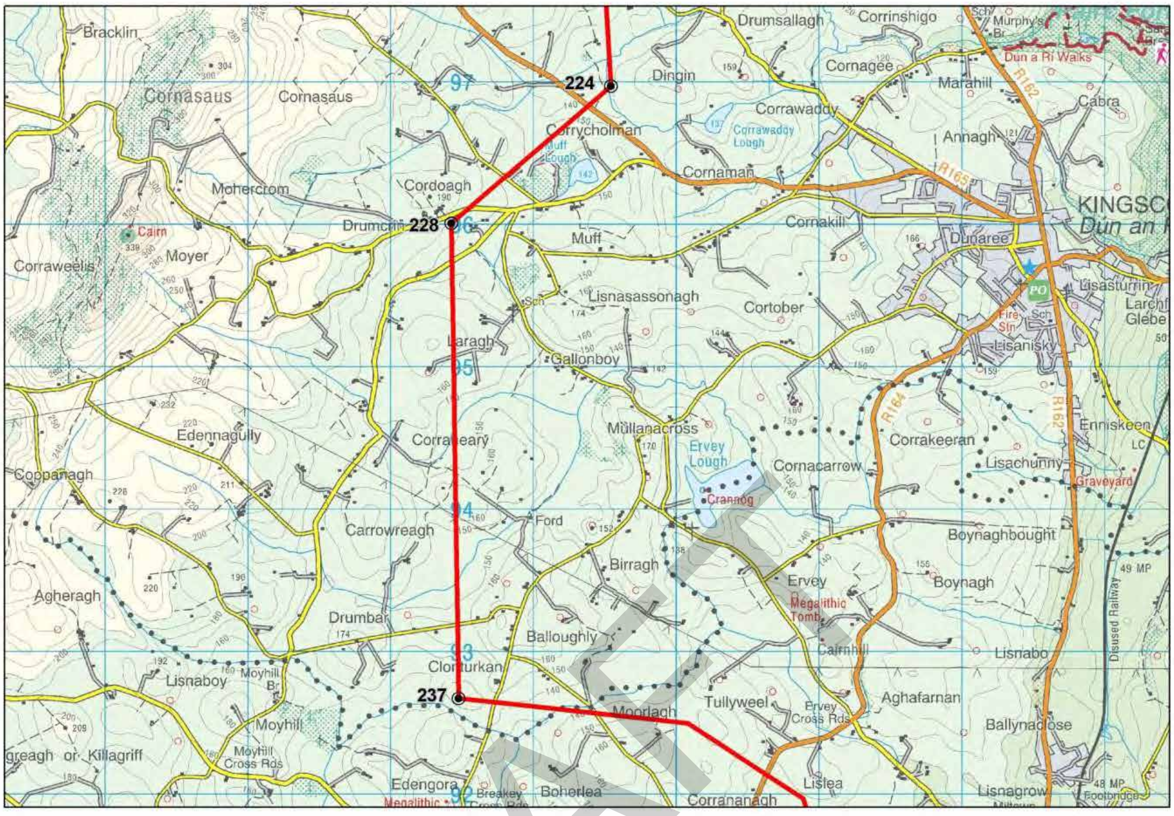


Figure 6.9: Towers 224 to 237

20 At Tower 224, in the townland of Dingin, the alignment traverses to the south-west to cross the R165 Kingscourt-Bailieborough road (approximately 3.2km west of Kingscourt), in order to avoid the ribbon development which extends from Kingscourt and to keep to the lower slopes of Lough-an-Lea, while maintaining a sufficient distance from Dún-an-Rí Forest Park. The alignment route crosses several minor roads and passes to the north of Muff Lough. At Tower 228 in the townland of Cordoagh (ED Enniskeen), the alignment proceeds in a southerly direction crossing some minor roads and avoiding Lough-an–Lea to the west and Ervey Lough to the east to Tower 237 in the townland of Clonturkan, County Cavan. The alignment crosses the existing Flagford–Louth 220 kV Line and follows this trajectory in order to avoid the ribbon development extending from Kingscourt.

6.2.2 MSA – New and Existing 400 kV Line

21 The proposed development in the MSA comprises a new single circuit 400 kV overhead transmission circuit supported by 165 new towers (Tower 237 to Tower 401) extending for a distance of approximately 54.5km from Tower 237 in the townland of Clonturkan, County Cavan

to Tower 402 (an existing double circuit tower on the Oldstreet to Woodland 400 kV transmission line) in the townland of Bogganstown (ED Culmullin), County Meath.

22 The line route has been chosen to minimise environmental impacts as detailed in **Chapter 5** of this volume of the EIS.

23 It also includes the addition of a new 400 kV circuit for some 2.85km along the currently unused (northern) side of the existing double circuit 400 kV overhead transmission line (the Oldstreet to Woodland 400 kV transmission line) extending eastwards from Tower 402 in the townland of Bogganstown (ED Culmullin), County Meath to Tower 410 and the Woodland Substation in the townland of Woodland, County Meath.

24 The MSA section of the overall circuit is presented in **Figure 6.10.** A more detailed section by section breakdown is provided below.

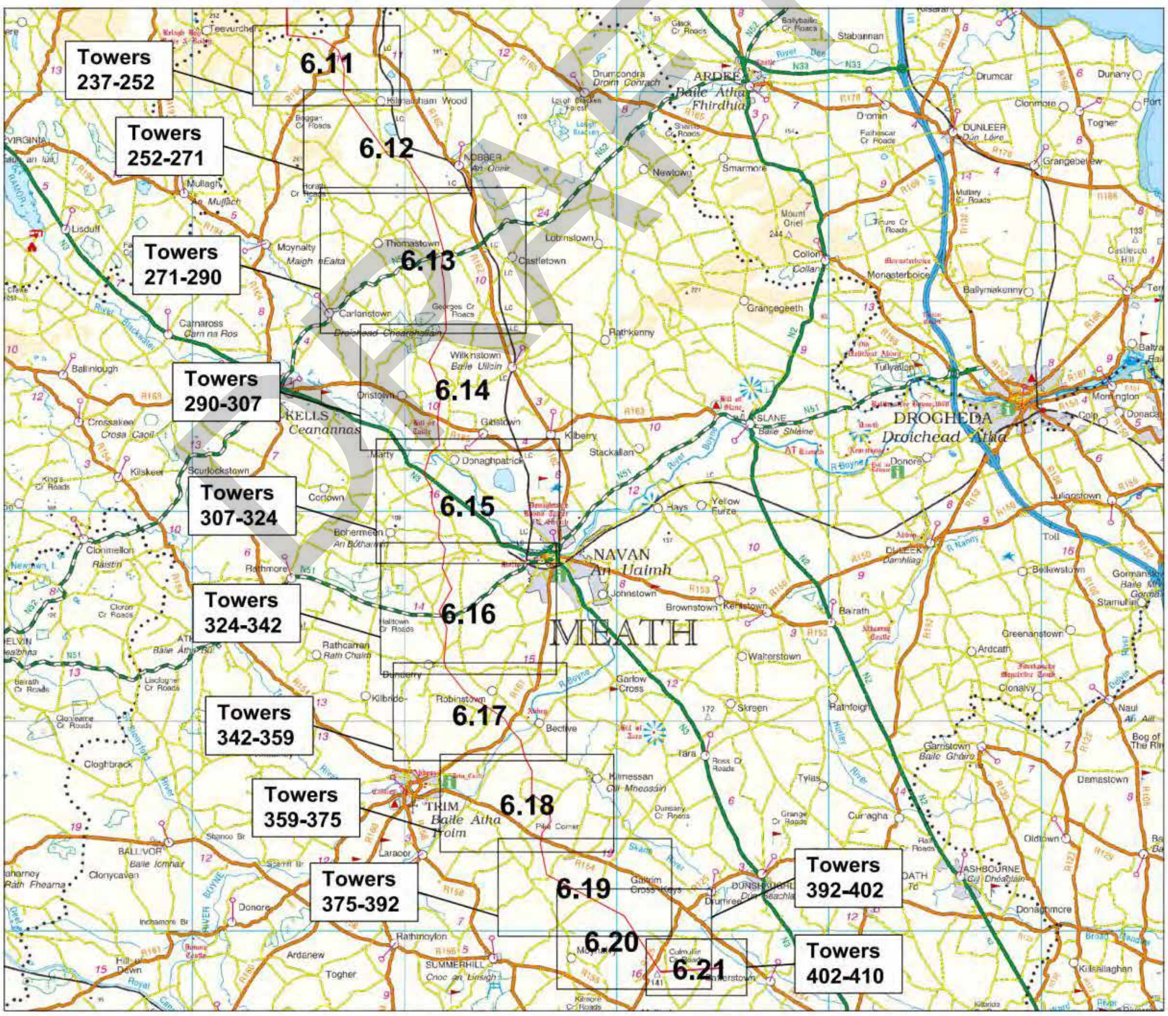


Figure 6.10: MSA Section of Circuit

Clonturkan to Shancor: Towers 237 to 252

Figure 6.11: Towers 237 to 252

25 From Tower 237 in the townland of Clonturkan, County Cavan, the line route proceeds in an easterly direction in the area of the boundary between counties Cavan and Meath, avoiding an ecologically sensitive area to the north, and a number of national monuments to the south. Between Tower 237 and Tower 242 in the townland of Tullyweel, the line route crosses two local roads. The line route turns south-east at Tower 242 avoiding viewpoint VP21 (as detailed in the *Meath County Development Plan* (CDP)). The line route then crosses the R164 Regional Road between Towers 244 and 245, before turning south at Tower 245 in the townland of Lislea to avoid the railway line to the east, a cluster of national monuments and Newcastle Lough (which has recorded Whooper swan activity). Between Towers 245 and 248, the line route travels south south-east crossing agricultural land and small sections of forestry. Between Towers 248 and 252 the route aligns south to ensure separation is maintained from the village of Kilmainhamwood, crossing two local roads (between Tower 249 and Tower 250 and between Tower 251 and Tower 252). The line route crosses Kilmainham River between Towers 251 and 252.

Shancor to Rahood: Towers 252 to 271

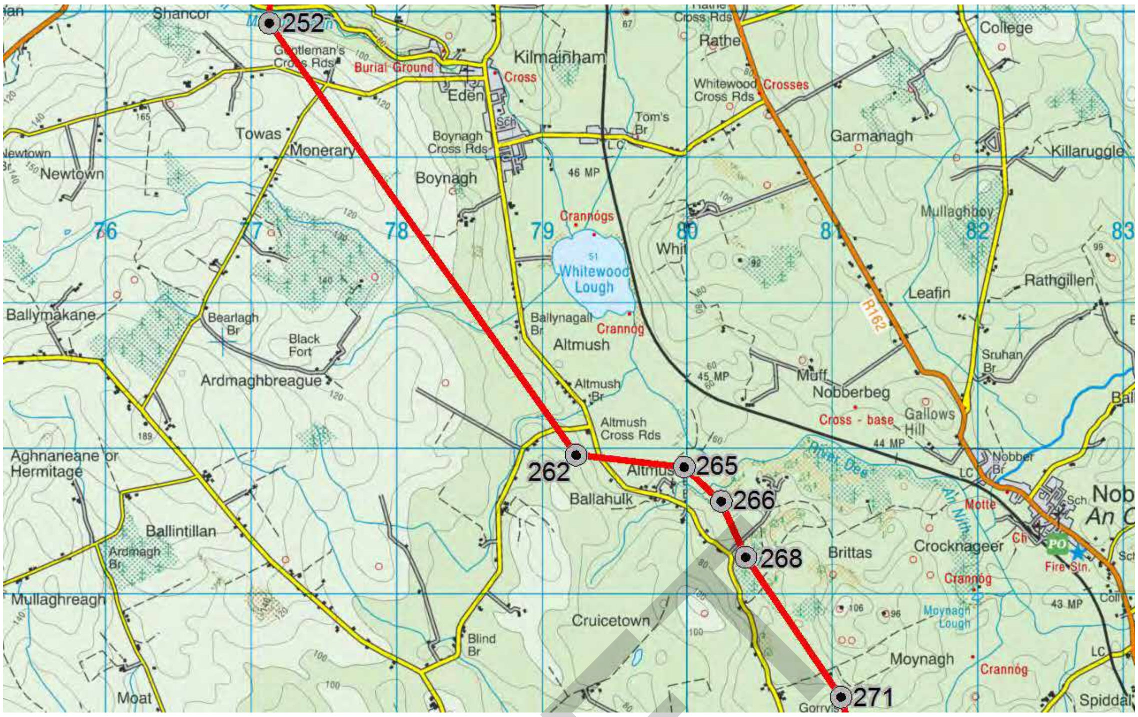


Figure 6.12: Towers 252 to 271

26 The line extends in a south-easterly direction between Tower 252 and Tower 262 in the townland of Cruicetown (ED Cruicetown). Between Towers 253 and 254, the line route crosses two local roads and continues to avoid the village of Kilmainhamwood which lies to the east. Between Towers 254 and 262, the line route crosses agricultural land avoiding a number of key viewpoints both to the west and east (VP18 and VP19 as designated in the Meath CDP). The line route is also routed along this path to avoid Whitewood Lough, several Crannógs and Whitewood House. Between Towers 260 and 262, the line route crosses the Altmush county geological site (towers are not located on the feature of interest within this geological site) and a local road.

27 The line route veers east at Tower 262 near the Altmush crossroads to avoid high ground and a number of viewpoints further south (VP16 and VP17). The line then continues in this direction until Tower 265 located in the townland of Altmush (ED Cruicetown). At Tower 265 the line route turns in a south-easterly direction crossing a tributary to the River Dee.

28 Between Towers 266 and 271, the line route takes a series of slight bends to minimise the impact on the Brittas Demesne while also avoiding high ground to the west and the village of Nobber and high ground to the east. The line route crosses at the edge of Brittas Demesne avoiding the core features of the demesne. The line route in this area also avoids Cruicestown Lough and Cruicestown Church and Graveyard (a National Monument) to the west; and a

designated landmark and viewpoint VP17 (as detailed in the Meath CDP) which are also located to the west of the line route.

Rahood to Dowdstown (ED Castletown): Towers 271 to 290

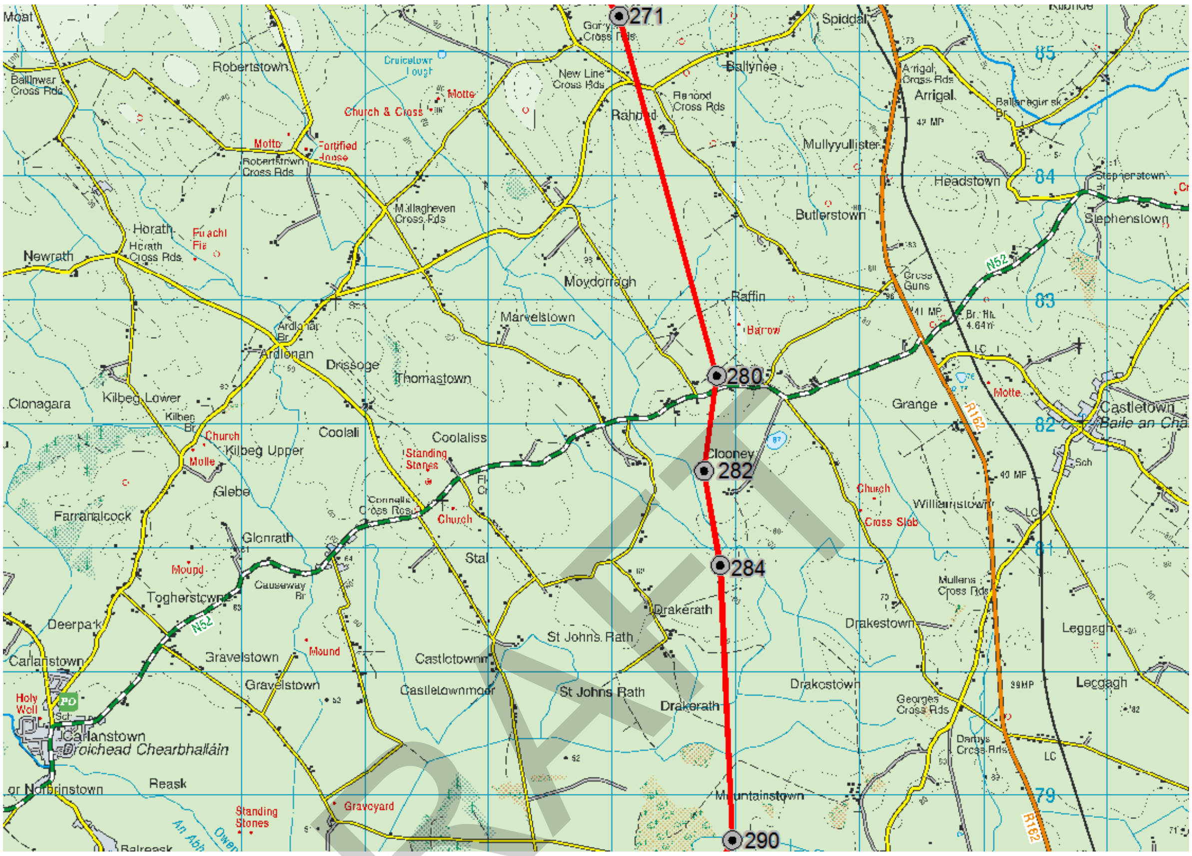


Figure 6.13: Towers 271 to 290

29 At Tower 271, situated in the townland of Rahood, the line route kinks slightly, travelling in a more southerly direction crossing agricultural land until reaching Tower 280 in the townland of Clooney. By making this slight alteration in direction, the line route bisects a gap between several houses clustered in the area. This section of the line route crosses a local road between Towers 272 and 273 and avoids a viewpoint to the west (VP16).

30 The line route deviates slightly at Tower 280 to avoid a farmyard to the west and a house to the east. It crosses the N52 to the west of Raffin Cross, and follows this route until arriving at Tower 282 in the townland of Clooney. The line route turns slightly east but continues generally south at Tower 282 until reaching Tower 284 in the townland of Drakerath where the route turns to an almost southerly direction and maintains this direction until reaching Tower 290. This section of the line route passes through the townlands of Drakerath and Mountainstown and is routed such that the line avoids the villages of Castletown, approximately 3km to the east, and Carlanstown, approximately 6km to the west, and an ecologically sensitive area to the west.

Dowdstown (ED Castletown) to Diméin Bhaile Ghib (Gibstown Demesne): Towers 290 to 307

Figure 6.14: Towers 290 to 307

31 The line route veers in a south-westerly direction between Towers 290 in the townland of Dowdstown (ED Castletown) and Tower 295 in the townland of Cluain an Ghaill (Clongill), crossing a local road between Towers 291 and 292 and avoiding a large ecologically sensitive area to the west.

32 To avoid the villages of Clongill and Wilkinstown to the east and Oristown to the west, the line route changes to a south-easterly direction at Tower 295 in the townland of Cluain an Ghaill (Clongill) and follows this direction until reaching Tower 299 in the townland of Baile Órthaí (Oristown). The line route crosses a local road between Towers 295 and 296 and a local road between Towers 298 and 299.

33 To minimise the length of line traversing Gibstown Demesne and to cross the R163 at a location where there is a gap in the housing along it, the line route changes direction at Tower 299 in the townland of Baile Órthaí (Oristown) to a south-westerly route until reaching Tower 303. The line route crosses the R163 Regional Road between Towers 302 and 303. Between Towers 303 and 307, the route follows an approximately southwards bearing, avoiding the village of Bhaile Ghib (Gibstown) to the east.

Diméin Bhaile Ghib (Gibstown Demesne) to Durhamstown: Towers 307 to 324

Figure 6.15 Towers 307 to 324

34 In order to avoid the village of Donaghpatrick, the line route veers south-west at Tower 307 and maintains this direction until Tower 309 in the townland of Tailtin (Teltown), crossing a local road between Tower 307 and 308, in order to minimise the crossings of the River Blackwater. At Tower 309, the line route turns to a south south-westerly direction in order to avoid Teltown Church and a site recorded on the Record of Protected Structures (RPS) to the west. The line continues in this direction until reaching Tower 312 in the townland of Castlemartin, having made a crossing of the River Blackwater between Towers 310 and 311, and the R147 between Tower 311 and Tower 312 approximately 600 metres west of Finnegans Cross Roads.

35 In order to find a suitable crossing point of the nearby local road, the line route then veers south-eastwards between Tower 312 in the townland of Castlemartin and Tower 314 in the townland of Tankardstown (ED Ardbraccan) crossing a local road between Tower 313 and 314. The line route aligns south between Towers 314 and 316 in the townland of Tankardstown crossing a dismantled railway between Towers 314 and 315.

36 To avoid housing and commercial premises in this area, the line route deviates to a south south-easterly direction at Tower 316, then changes direction at Tower 317 to an almost southerly direction and crossing a local road before reaching Tower 318 in the townland of Grange (ED Ardbraccan). Between Tower 318 and Tower 319, the line route turns south-east

to avoid several houses located to the south. The line route veers south at Tower 319 in order to avoid Ardbraccan Demesne to the east, crossing the M3 to the west of Navan and then continuing south until reaching Tower 322 in the townland of Durhamstown. The line route crosses a local road between Towers 321 and 322 and avoids the aforementioned houses which are situated along this local road. Between Tower 322 and 324 in the townland of Durhamstown, the line route veers to the south-east to avoid housing located to the south.

Durhamstown to Philpotstown (ED Bective): Towers 324 to 342

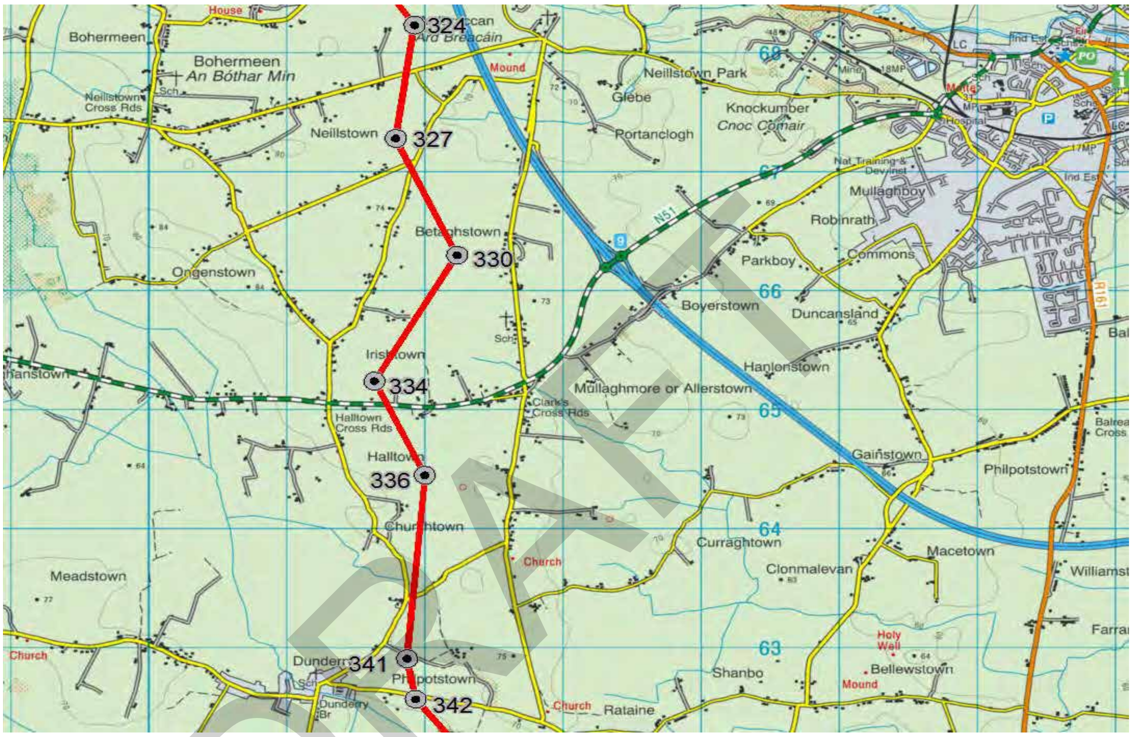


Figure 6.16: Towers 324 to 342

37 In order to avoid housing on the local road to the south, the line route turns to a south south-west direction at Tower 324 and maintains this direction until Tower 327 in the townland of Neillstown, (ED Ardbraccan), crossing a local road between Tower 325 and 326.

38 Between Towers 327 and 330, the line route veers south-east to avoid housing, crossing two local roads between Towers 327 and 328. The line route veers south-west between Tower 330 in the townland of Betaghstown (ED Ardbraccan) and Tower 334 in the townland of Irishtown (ED Ardbraccan), just north of the N51 near Halltown Crossroads.

39 The line route changes direction at Tower 334 to avoid housing along the N51 and a national monument to the south, following a south-easterly path until Tower 336 in the townland of Halltown. This section of the line route crosses the N51 approximately 3km to the west of the

town of Navan and avoids Jamestown Bog pNHA which is located approximately 3km to the west of the line route.

40 At Tower 336 the line route turns to a near southerly direction to avoid a national monument to the east, until Tower 341 in the townland of Philpotstown (ED Bective) crossing a local road between Towers 339 and 340. The line route then deviates slightly east between Towers 341 and 342 in the townland of Philpotstown (ED Bective), crossing a local road, avoiding Dunderry House and the village of Dunderry.

Philpotstown (ED Bective) to Trubley: Towers 342 to 359

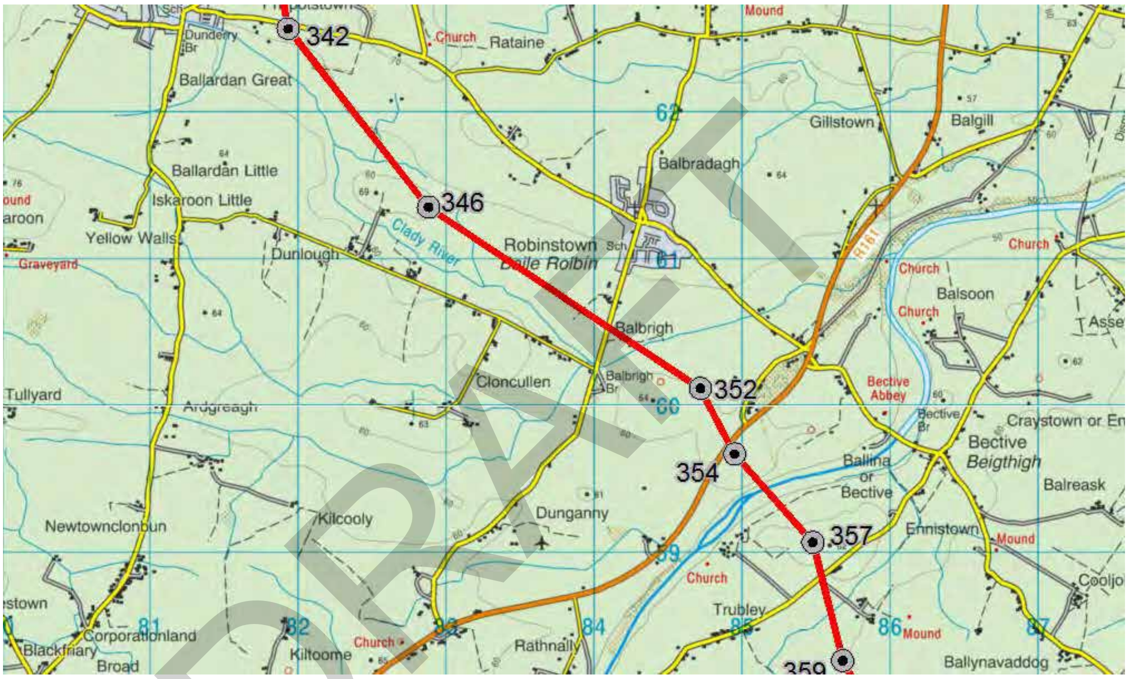


Figure 6.17: Towers 342 to 359

41 The line route follows a south-easterly direction between Tower 342 and Tower 346 in the townland of Dunlough running parallel to the eastern bank of the Clady River. A change in direction occurs at Tower 346 in order to avoid established one-off housing and Trim Airfield, resulting in the line route travelling in a more easterly direction until reaching Tower 352 in the townland of Balbrigh crossing a local road between Towers 349 and 350 and crossing the Clady River between Towers 350 and 351. In order to avoid VP86 (as detailed in the Meath Landscape Character Assessment), the line route follows a south south-easterly direction between Tower 352 and Tower 354 in the townland of Rathnally, crossing the R161 Regional Road between Towers 353 and 354. At Tower 354 the line route turns to a south-easterly heading and follows this direction until Tower 357 in the townland of Trubley, crossing the River Boyne, while avoiding the village of Bective and Bective Abbey to the east. To the west the line route also avoids Trim Airfield and the location of lands in respect of which a new planning

application for two houses has been granted in the townland of Trubley. Between Towers 357 and 359, the line route travels in a south south-easterly direction crossing a local road between Towers 357 and 358.

Trubley to Branganstown: Towers 359 to 375

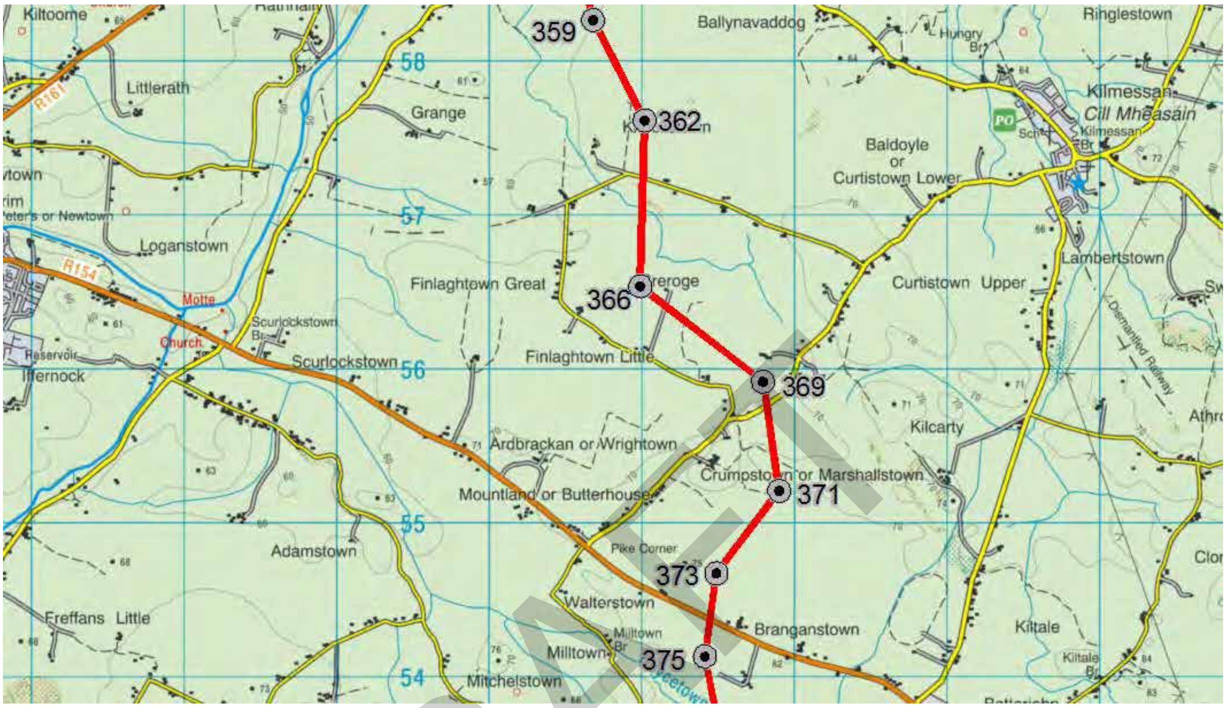


Figure 6.18: Towers 359 to 375

42 At Tower 359 the line route turns slightly east but maintains an overall south south-easterly direction until Tower 362 in the townland of Knockstown (Ed Kilcooly). At Tower 362 the line route aligns south until Tower 366 in the townland of Creroge, avoiding the village of Kilmessan to the east while also maintaining sufficient distance from the Hill of Tara to the east and the town of Trim to the west. The line route veers south-east at Tower 366 and travels in this direction until Tower 369. The line route follows a southerly direction between Towers 369 and 371 in the townland of Crumpstown or Marshallstown (ED Galtrim), crossing a local road which is a designated cycle route between Tower 369 and 370.

43 The line route turns south-west at Tower 371 in order to avoid housing on the R154 to the south, following this direction until Tower 373 in the townland of Branganstown. Between Towers 373 and 375, the line route follows a near southerly direction crossing the R154 Regional Road in the townland of Branganstown.

Branganstown to Culmullin: Towers 375 to 392

Figure 6.19: Towers 375 to 392

44 The line route travels in a south south-easterly direction between Tower 375 in the townland of Branganstown and Tower 380 in the townlands of Boycetown and Galtrim, turning slightly to avoid Galtrim Demesne. This section of the route crosses the Boycetown River between Towers 376 and Tower 377. Such that the impact on Galtrim Moraine is minimised, the line route veers south-east at Tower 380, following this direction until reaching Tower 392 (in the townland of Culmullin) crossing two local roads, Galtrim Moraine and the Derrypatrick River and passing close to Derrypatrick Bridge.

Culmullin to Bogganstown (ED Culmullin) Towers 392 to 402 (Existing Oldstreet to Woodland OHL Route)

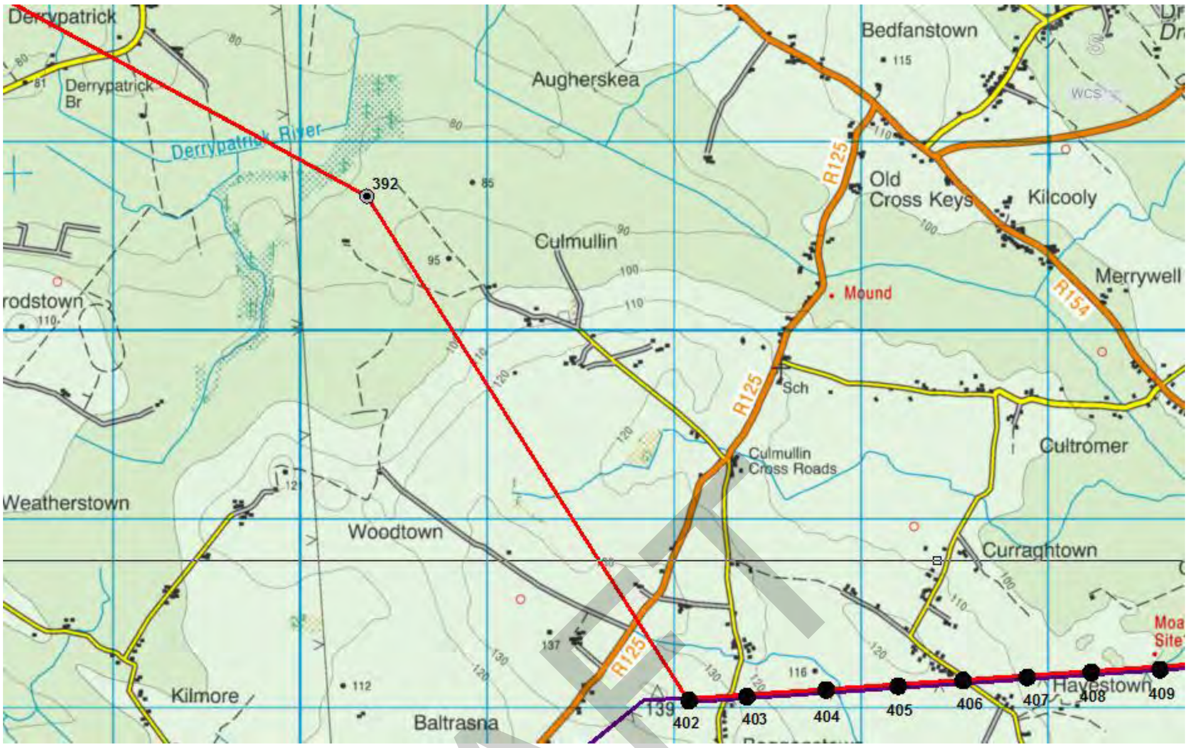


Figure 6.20: Towers 392 to 402

45 The line route deviates slightly at Tower 392 in Culmullin (ED Culmullin) such that it can tie into the existing line but maintains a south-easterly direction until reaching Tower 402 (an existing double circuit tower on the Oldstreet to Woodland circuit) in the townland of Bogganstown (ED Culmullin), crossing the R125 Regional Road approximately 1km south-west of Culmullin Crossroads. The line route in this area avoids ecologically sensitive areas to the east and west between Towers 397 and 399.

Bogganstown (ED Culmullin) to Woodland - Towers 402 to 410 (Existing Oldstreet to Woodland OHL Route)

Figure 6.21: Towers 402 to 410

46 This portion of the proposed line route comprises the addition of a new 400 kV circuit for some 2.85km along the currently unused (northern) side of the existing double circuit 400 kV overhead transmission line (the Oldstreet to Woodland 400 kV transmission line).

47 From Tower 402 the line route follows an easterly direction on the existing double circuit structures of the Oldstreet to Woodland 400 kV circuit, crossing two local roads before connecting to an end mast (Tower 410) adjacent to the existing Woodland Substation in the townland of Woodland, County Meath. The end mast is where the existing circuit connects into the substation bay - Bay E10 (see **Section 6.3.3**).

6.3 OVERHEAD LINE ELEMENTS

48 An OHL is made up of a number of elements, the design and approach to which is a primary consideration to the line design process. These elements are:

- Towers and associated foundations; and
- Conductors & shieldwires (wires) and associated hardware (including insulators and fittings).

6.3.1 Towers and Associated Foundations

49 Towers are one of the most significant components of OHL. There are three types of tower typically used for OHL transmission developments. These are detailed below:

- **Intermediate or suspension towers** are used on straight sections of an alignment. Electricity conductors hang on, or are suspended from, the cross arms of these towers resulting in these towers being somewhat taller and slimmer than angle towers and typically requiring smaller foundations.

- **Angle / tension towers** are so-called because the electricity conductors pull off the crossarms (i.e. connecting to the towers under tension). This requires the angle tower to have a greater mechanical strength than the intermediate tower. These towers are used at points when the OHL changes direction, where the line terminates, such as at substations (for example Tower 410 on the existing Oldstreet to Woodland OHL) or in order to break a long linear span. Angle towers use heavier steel members and can also be shorter than comparable intermediate towers (while still maintaining the same clearance between the ground and the electricity conductor). This gives the towers the appearance of being ‗stockier' than the intermediate tower. Due to the required increase in mechanical strength, angle towers will also typically have much larger foundations than intermediate towers.

- **Transposition towers** change the physical position of the conductors on a transmission line (known as phases) while maintaining electrical phase separation and clearance. Transposition phases can be important over long linear lengths as it balances the electrical impedance[77] between phases of a circuit. As noted in **Chapter 5** of this volume of the EIS, analysis by EirGrid shows that the operating performance of the proposed interconnector will benefit from a single point of transposition. Transposition is the practice of transposing or rearranging the spatial arrangement of the three electricity wires or conductors that make up the three-phase circuit. The transposition takes place over four structures (the transposition alignment) as illustrated in **Chapter 5** (**Figure 5.19**), of this volume of the EIS.

[77]Electrical impedance is a measure of the opposition that a circuit presents to the passage of the electrical current as the length of the circuit increases.

50 Tower foundations (per tower leg) typically range from 2m to 3.5m in depth to the invert level of the foundation and anywhere from 2 x 2 metres squared to 9 x 9 metres squared, in plan area depending on tower type. However, the type and size of the foundations will ultimately depend on the type of tower, ground conditions and terrain. Further detail relating to foundation types and their installation is outlined in **Chapter 7** of this volume of the EIS.

6.3.2 Conductors and Associated Infrastructure

51 Relevant conductor and associated infrastructure components include:

- **Conductors** are the wires that carry the electricity and comprise a number of conducting aluminium wires around a high strength core consisting of steel wire (see **Figure 6.22**). Each phase typically consists of a number of single conductors forming a conductor bundle. Generally, the higher the voltage level, the higher the number of conductors in the bundle.

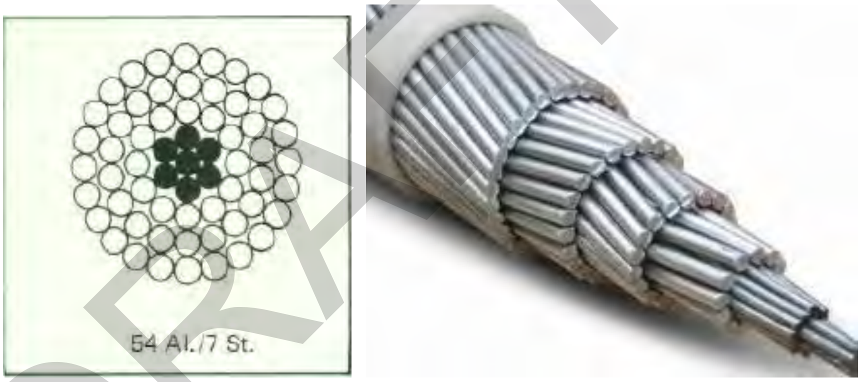


Figure 6.22: Diagrammatic and Actual Cross Section of a Typical Conductor (ACSR)

- To achieve the required power capacity of the proposed interconnector, it will be necessary to install a pair of conductors per phase (known as a twin bundle – see **Figure 6.23**). These conductors will be separated by spacers at regular intervals. The distance of the conductors from the ground is determined not only by the lateral clearance away from the line but also by the height of the conductor overhead. For the proposed 400 kV OHL, the minimum conductor height above ground has been designed to 9m.

Figure 6.23: Twin Bundle Configuration

- **Earth / ground wire or shield wire and optical fibres (OPGW)** are installed above the live conductors at the top of the tower to minimise the likelihood of direct lightning strikes to the conductors. Shield wires are also conductors but serve a different purpose to live conductors. Should lightning strike the line it will in all likelihood strike a shield wire rather than a live conductor (as they are installed above the live conductor). This will not necessarily prevent the line from tripping out but it will protect the line from being damaged by very quickly dissipating the energy in the lightning strike away from the line and into the ground. In such circumstances, if the line did trip out it can be restored automatically in less than a second. Shield wires may include optical fibres used in respect of controlling the power system and communication.

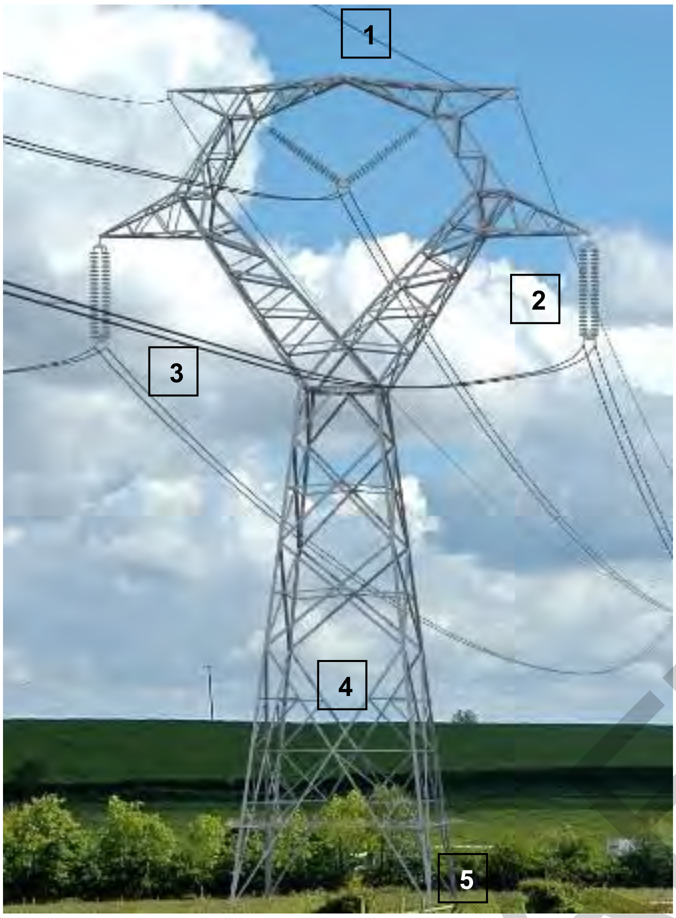
- **Insulators** support the conductors and have to withstand both normal operating voltage and surges as a result of switching and lightning strikes. For transmission lines these tend to be suspended below the structure and comprise a number of glass or composite discs, the number of which increases for the higher voltages. The proposed insulator for the proposed development is the composite type (see **Figure 6.24**). The advantages of this modern design include: slimline appearance; lighter weight; more repellent to airborne pollutants (resulting in a reduction in the noise or ‗crackle' that can emanate from high voltage OHLs during periods of high humidity); and silicon rubber insulator sheds which are less susceptible to damage. **Chapters 9** of **Volumes 3C** and **3D** of the EIS consider the issue of corona noise in greater detail.

Figure 6.24: Typical Composite Insulator

6.3.2.1 Proposed Tower Design for the New 400 kV OHL

52 As addressed at **Chapter 4** of this volume of the EIS, it is intended to use the ‗C-IVI-1 hot rolled' (IVI) lattice steel tower design for the proposed development. The IVI design raises the centre phase to increase the apparent height while reducing the width of the tower thereby ensuring a more slender proportion to the structure. The tower's overall shape comprises a diamond located at the top of a relatively narrow body. Located on either side of the diamond shape are two cross supporting arms, the two outer phasing arrangements. In both front and side elevation the tower forms a symmetrical structure comprised of a typical steel lattice framework.

53 The general arrangement for the IVI tower design (including conductors and associated infrastructure) is illustrated in **Figure 6.25.** The IVI tower is designed to accommodate two shield wires connected to the extremities of the upper most cross arm.



1. Earthed Shield wires

2. Insulators

3. Conductors

4. Tower

5. Concrete foundation for each tower footing

Figure 6.25: General Arrangement of a C-IVI-1 (IVI) Tower

54 The three different tower types (i.e. intermediate, angle and transposition) for the proposed development are illustrated in **Figures 6.26, 6.27** and **6.28**, and described below.

55 Three types of angle tower are required: a 30 degree angle tower, a 60 degree angle tower, and a 90 degree angle tower. The lower arms vary to allow for the appropriate tension angle on the line. The use of each type of tower is determined by technical requirements at each location along the route. Detail on which type of tower is used in each location is contained in **Tables 6.1** and **6.2.**

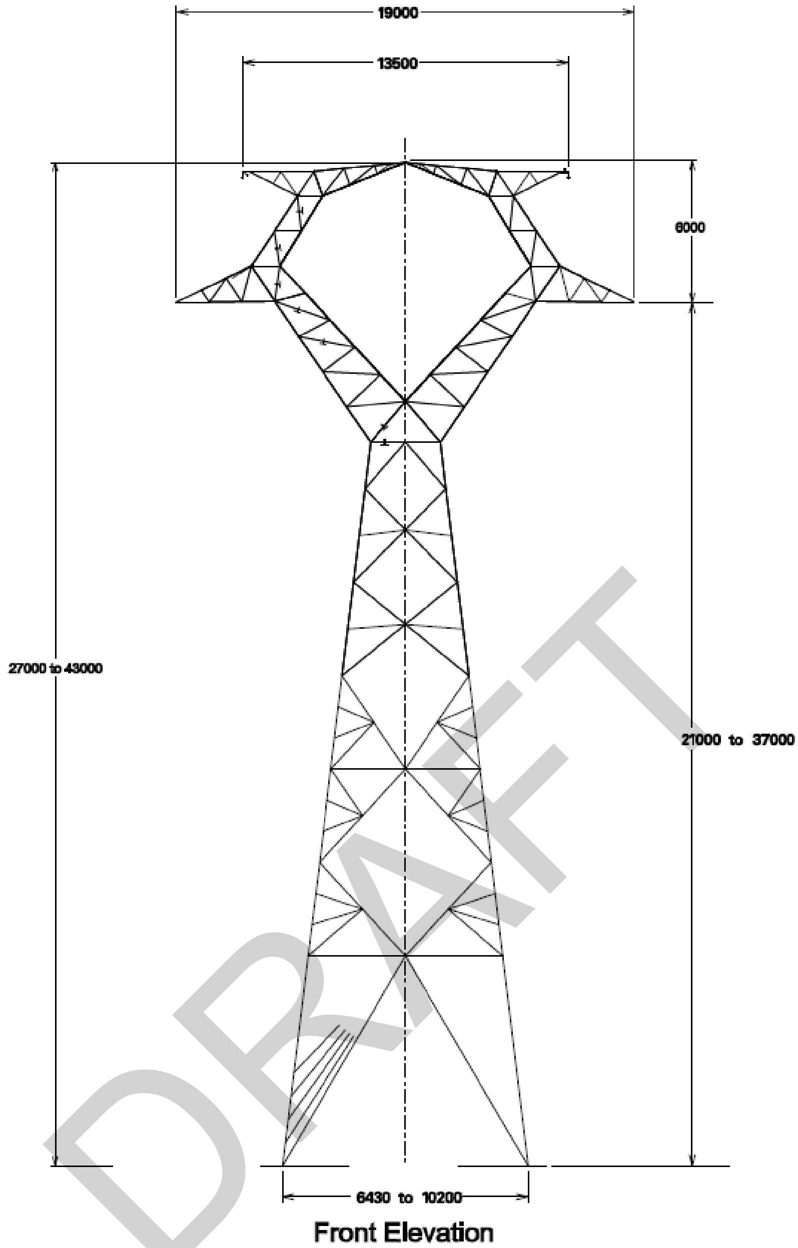


Figure 6.26: Proposed 400 kV Intermediate C-IVI-1 Lattice Tower

(Not to be scaled - for illustrative purposes only)

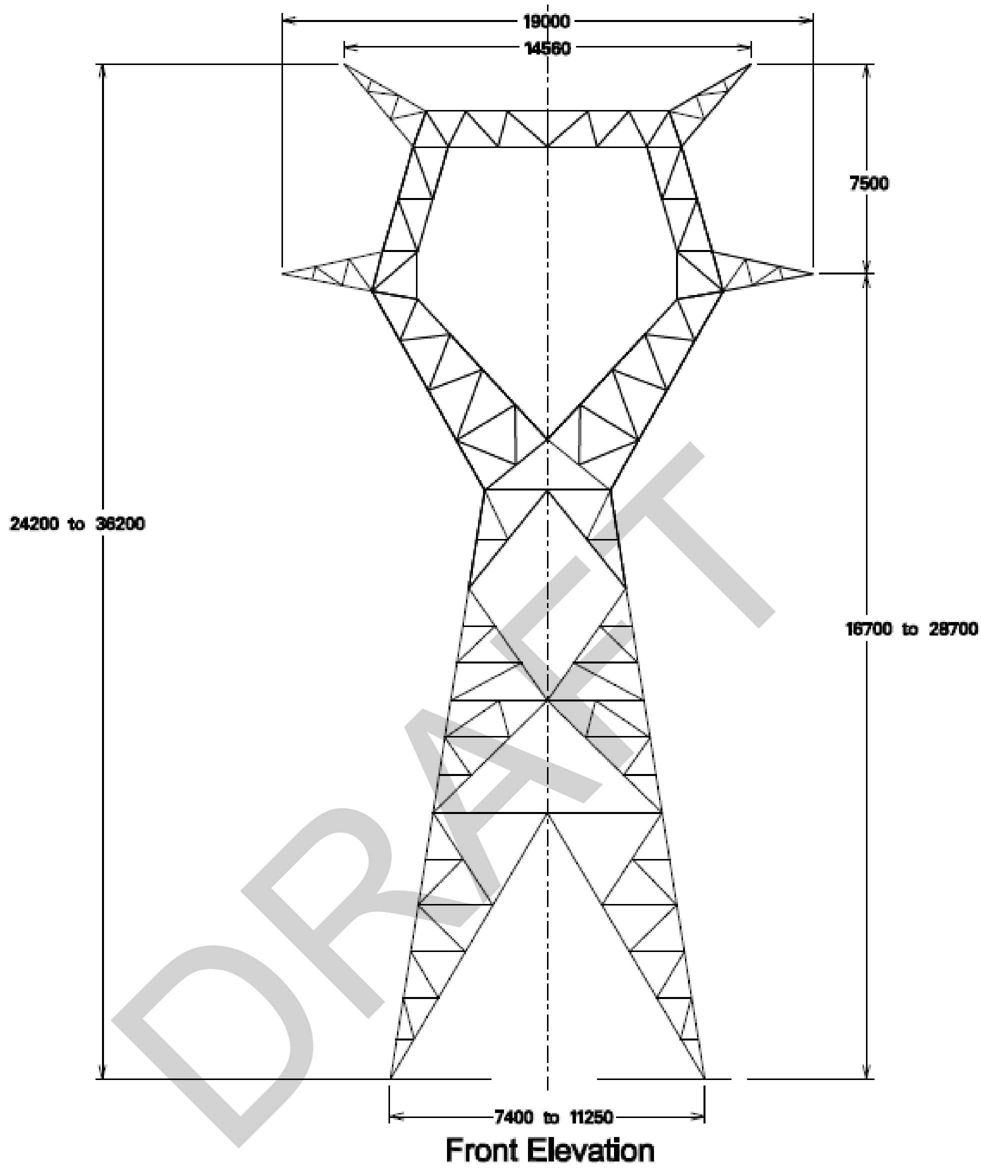


Figure 6.27: Proposed 400 kV Angle C-IVI-1 Lattice Tower

(Not to be scaled - for illustrative purposes only)

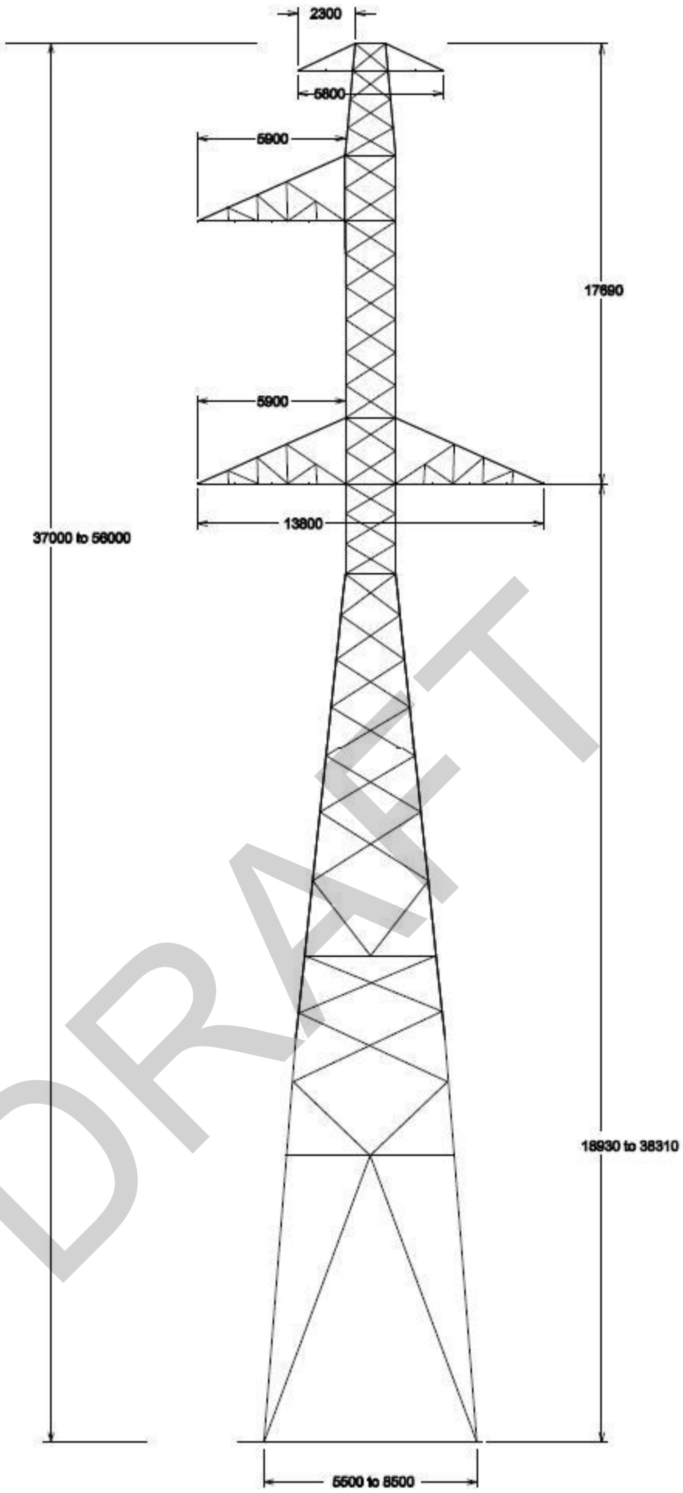


Figure 6.28: Proposed 400 kV Transposition Tower

(Not to be scaled - for illustrative purposes only)

6.3.2.2 Proposed Tower Types and Heights for the New 400 kV Circuit

56 The spacing, type, and angle tower and the height of the towers for the new 400 kV transmission circuit vary depending on technical requirements which relate primarily to topography. Spacing between the proposed towers averages at approximately 340m.

57 Tower heights will range from approximately 26m to 43m. Towers are measured above ground level at the centre point of the tower to a height at the centre point of the tallest point of the tower. For the 400 kV towers the tallest points are the earthed shieldwires (refer to **Figure 6.25**). Small variances in measurement will naturally arise with uneven ground conditions.

58 A list of towers, their locations and heights is included in **Table 6.1** and **Table 6.2**. The planning drawings (see **Volume 1B** of the application documentation) which accompany the application also provide the detail of each tower height.

Table 6.1: Tower Heights for the New 400 kV Line (CMSA Section)

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
103	Intermediate	31	128.382	363
104	Intermediate	42	131.138	445
105	Angle	33.2	131.32	395
106	Intermediate	37	138.878	184
107	Intermediate	38	151.774	425
108	Intermediate	34	187.501	319
109	Angle	28.2	187.673	364
110	Intermediate	32	173.487	358
111	Intermediate	32	179.418	156
112	Angle	26.2	176.529	391
113	Intermediate	43	139.46	195
114	Intermediate	39	155.49	407
115	Intermediate	39	149.31	409
116	Angle	29.2	147.375	127
117	Intermediate	28	153.949	358
118	Angle	36.2	152.905	250

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
119	Transposition	38.5	148.858	200
120	Transposition	38.5	140.249	315
121	Angle	36.2	143.983	425
122	Intermediate	39	125.166	384
123	Intermediate	40	136.91	427
124	Intermediate	42	133.515	402
125	Intermediate	32	135.514	426
126	Angle	36.2	121.59	328
127	Intermediate	31	140.994	450
128	Intermediate	38	130.41	327
129	Intermediate	40	133.988	445
130	Angle	34.2	126.876	308
131	Intermediate	43	137.811	363
132	Angle	36.2	136.422	276
133	Intermediate	43	138.198	194
134	Intermediate	34	128.907	310
135	Intermediate	41	111.933	420
136	Angle	35.2	102.375	368
137	Intermediate	33	121.76	289
138	Intermediate	41	98.333	402
139	Intermediate	27	117.431	426
140	Angle	36.2	109.298	375
141	Intermediate	40	119.691	249
142	Angle	36.2	100.163	259
143	Intermediate	36	105.57	393
144	Intermediate	39	125.309	328
145	Intermediate	42	113.318	445
146	Intermediate	41	118.929	385
147	Intermediate	38	113.964	345

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
148	Intermediate	38	121.324	284
149	Angle	36.2	135.826	355
150	Intermediate	43	135.48	310
151	Intermediate	36	149.465	222
152	Intermediate	43	150.179	363
153	Intermediate	42	168.48	454
154	Angle	33.2	181.204	410
155	Intermediate	40	190.564	336
156	Intermediate	31	187.798	416
157	Angle	36.2	186.254	225
158	Intermediate	33	187.557	409
159	Intermediate	38	189.034	362
160	Intermediate	33	185.387	290
161	Angle	36.2	179.321	222
162	Intermediate	43	177.894	498
163	Intermediate	42	163.714	316
164	Intermediate	28	195.584	164
165	Intermediate	43	177.559	439
166	Angle	27.2	179.935	290
167	Intermediate	32	178.56	469
168	Intermediate	42	163.971	266
169	Angle	29.2	153.828	418
170	Intermediate	36	140.096	304
171	Intermediate	34	148.876	398
172	Intermediate	39	127.718	199
173	Intermediate	39	146.921	286
174	Intermediate	39	143.818	279
175	Intermediate	34	132.28	428
176	Angle	35.2	119.15	433

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
177	Intermediate	32	141.273	289
178	Intermediate	38	132.103	312
179	Intermediate	35	153.955	220
180	Intermediate	31	140.654	279
181	Angle	31.2	148.917	373
182	Intermediate	39	164.983	301
183	Intermediate	36	178.928	336
184	Angle	36.2	165.884	328
185	Intermediate	41	181.474	486
186	Angle	36.2	181.396	336
187	Intermediate	40	161.299	313
188	Angle	27.2	178.133	344
189	Intermediate	38	178.499	284
190	Intermediate	37	173.579	347
191	Intermediate	32	150.426	304
192	Intermediate	39	134.067	426
193	Intermediate	32	144.11	396
194	Intermediate	42	137.575	272
195	Intermediate	42	137.762	348
196	Intermediate	36	151.978	417
197	Angle	29.2	172.837	294
198	Intermediate	43	171.87	390
199	Intermediate	38	161.508	341
200	Intermediate	43	160.516	353
201	Intermediate	40	170.176	449
202	Intermediate	34	153.698	257
203	Angle	26.2	158.822	230
204	Intermediate	27	150.818	321
205	Intermediate	37	151.149	343

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
206	Intermediate	43	158.196	334
207	Angle	33.2	151.682	252
208	Intermediate	27	162.87	208
209	Intermediate	39	143.773	393
210	Intermediate	38	153.23	276
211	Intermediate	42	148.535	389
212	Angle	34.2	138.384	293
213	Intermediate	30	157.303	343
214	Intermediate	32	154.284	393
215	Intermediate	40	141.58	362
216	Intermediate	35	166.193	350
217	Angle	31.2	160.41	409
218	Intermediate	38	147.095	289
219	Intermediate	40	147.838	459
220	Intermediate	34	167.76	193
221	Intermediate	41	154.889	451
222	Intermediate	32	155.456	353
223	Intermediate	36	134.444	333
224	Angle	29.2	132.796	360
225	Intermediate	38	147.678	297
226	Intermediate	39	145.163	462
227	Intermediate	42	153.882	357
228	Angle	31.2	157.718	383
229	Intermediate	43	146.953	385
230	Intermediate	37	169.852	380
231	Intermediate	39	154.782	381
232	Intermediate	42	140.254	333
233	Intermediate	43	158.882	344
234	Intermediate	43	146.693	432

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
235	Intermediate	41	142.488	315
236	Intermediate	31	157.944	385 to MSA 237

Table 6.2: Tower Heights for the New 400 kV Line (MSA Section)

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
237	Angle	29.2	150.768	337
238	Intermediate	39	140.313	328
239	Intermediate	42	129.238	367
240	Intermediate	34	140.956	244
241	Intermediate	37	148.451	339
242	Angle	33.2	141.196	296
243	Intermediate	35	145.053	315
244	Intermediate	39	123.755	356
245	Angle	29.2	115.706	274
246	Intermediate	39	114.966	348
247	Intermediate	35	126.996	288
248	Angle	36.2	125.267	269
249	Intermediate	34	123.782	199
250	Intermediate	35	122.463	389
251	Intermediate	39	103.063	322
252	Angle	33.2	99.032	341
253	Intermediate	35	129.810	375
254	Intermediate	43	133.689	337
255	Intermediate	35	132.547	367
256	Intermediate	39	124.059	423
257	Intermediate	38	114.052	418
258	Intermediate	35	92.387	386
259	Intermediate	35	78.658	440

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
260	Intermediate	27	88.423	306
261	Intermediate	39	73.671	250
262	Angle	29.2	77.522	298
263	Intermediate	42	51.032	205
264	Intermediate	35	53.498	243
265	Angle	29.2	57.993	347
266	Angle	33.2	55.951	208
267	Intermediate	31	65.600	211
268	Angle	36.2	60.022	415
269	Intermediate	43	59.484	370
270	Intermediate	35	66.841	381
271	Angle	29.2	78.587	235
272	Intermediate	36	75.471	395
273	Intermediate	39	87.438	305
274	Intermediate	31	101.458	417
275	Intermediate	31	90.826	365
276	Intermediate	35	84.071	381
277	Intermediate	35	74.453	368
278	Intermediate	31	75.480	229
279	Intermediate	39	71.233	349
280	Angle	31.2	72.061	399
281	Intermediate	39	67.030	343
282	Angle	31.2	60.027	370
283	Intermediate	43	59.921	404
284	Angle	34.2	58.302	437
285	Intermediate	36	66.591	446
286	Intermediate	43	52.697	362
287	Intermediate	35	51.123	261
288	Intermediate	32	53.058	354

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
289	Intermediate	39	54.710	360
290	Angle	33.2	53.353	259
291	Intermediate	35	54.410	366
292	Intermediate	43	54.145	412
293	Intermediate	37	56.022	306
294	Intermediate	34	55.210	397
295	Angle	36.2	52.306	315
296	Intermediate	40	52.713	448
297	Intermediate	40	51.550	370
298	Intermediate	43	58.001	363
299	Angle	36.2	61.446	340
300	Intermediate	33	61.971	280
301	Intermediate	35	64.217	382
302	Intermediate	43	72.448	317
303	Angle	29.2	80.394	395
304	Intermediate	39	71.560	335
305	Intermediate	31	65.808	268
306	Intermediate	31	63.059	286
307	Angle	33.2	56.224	267
308	Intermediate	39	44.355	285
309	Angle	33.2	40.411	379
310	Intermediate	39	41.441	404
311	Intermediate	39	45.850	300
312	Angle	33.2	52.123	367
313	Intermediate	42	50.323	456
314	Angle	33.2	51.124	286
315	Intermediate	31	52.378	300
316	Angle	29.2	55.807	334
317	Angle	33.2	60.376	308

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
318	Angle	33.2	61.969	314
319	Angle	29.2	63.010	305
320	Intermediate	35	62.114	274
321	Intermediate	35	63.897	316
322	Angle	29.2	68.197	259
323	Intermediate	35	71.144	299
324	Angle	29.2	68.988	344
325	Intermediate	35	69.219	296
326	Intermediate	39	70.411	323
327	Angle	29.2	74.135	308
328	Intermediate	43	70.607	413
329	Intermediate	39	74.166	357
330	Angle	29.2	74.331	269
331	Intermediate	35	73.416	397
332	Intermediate	39	72.656	344
333	Intermediate	33	74.453	207
334	Angle	30.2	77.661	400
335	Intermediate	40	74.548	471
336	Angle	36.2	71.599	275
337	Intermediate	37	72.113	224
338	Intermediate	35	70.694	326
339	Intermediate	36	67.930	368
340	Intermediate	36	66.005	355
341	Angle	33.2	63.460	347
342	Angle	34.2	60.915	424
343	Intermediate	43	59.551	422
344	Intermediate	35	60.453	398
345	Intermediate	39	58.358	297
346	Angle	33.2	59.490	390

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
347	Intermediate	39	55.969	337
348	Intermediate	39	56.500	367
349	Intermediate	40	55.278	395
350	Intermediate	43	54.938	399
351	Intermediate	35	56.033	326
352	Angle	29.2	57.682	213
353	Intermediate	31	57.500	290
354	Angle	33.2	59.766	232
355	Intermediate	35	57.673	287
356	Intermediate	35	56.305	280
357	Angle	33.2	60.131	405
358	Intermediate	39	55.538	425
359	Angle	36.2	59.699	190
360	Intermediate	35	62.273	318
361	Intermediate	31	64.628	226
362	Angle	29.2	63.250	211
363	Intermediate	35	62.659	335
364	Intermediate	35	61.375	258
365	Intermediate	31	62.500	274
366	Angle	29.2	63.632	342
367	Intermediate	35	66.017	345
368	Intermediate	31	68.510	330
369	Angle	29.2	65.692	350
370	Intermediate	35	73.042	367
371	Angle	29.2	71.543	340
372	Intermediate	35	70.599	335
373	Angle	29.2	75.032	262
374	Intermediate	31	76.725	283
375	Angle	29.2	72.549	242

Tower Number	Type of Tower	Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
376	Intermediate	32	70.210	388
377	Intermediate	31	73.998	297
378	Intermediate	31	75.001	355
379	Intermediate	35	72.950	193
380	Angle	33.2	74.792	351
381	Intermediate	35	80.331	416
382	Intermediate	37	71.491	330
383	Intermediate	39	72.850	396
384	Intermediate	35	73.003	265
385	Intermediate	31	76.580	353
386	Intermediate	35	73.171	230
387	Intermediate	39	74.237	412
388	Intermediate	36	83.867	415
389	Intermediate	39	78.143	335
390	Intermediate	43	75.915	297
391	Intermediate	43	76.098	354
392	Angle	29.2	82.614	248
393	Intermediate	31	87.649	281
394	Intermediate	31	89.383	362
395	Intermediate	39	97.796	366
396	Intermediate	31	122.050	249
397	Intermediate	31	126.749	278
398	Intermediate	35	122.323	413
399	Intermediate	43	124.205	376
400	Intermediate	39	131.624	322
401	Angle	35.2	130.131	278

59 The line width of the proposed 400 kV IVI tower is approximately 19m (see **Figures 6.26, 6.27** and **6.29**). This is measured from outer conductor to outer conductor.

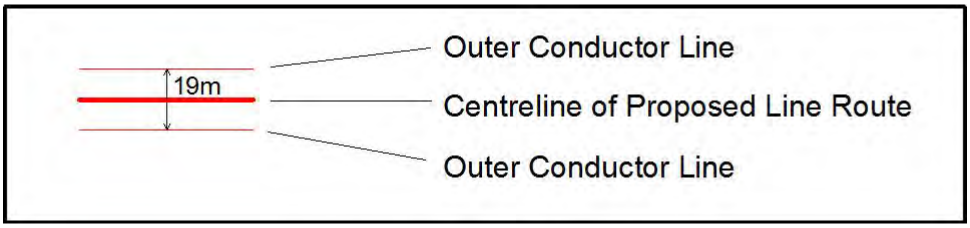


Figure 6.29: Line Width Measurement

6.3.2.3 Towers along the Existing 400 kV Line

60 The proposed development also includes approximately 2.85km of the new circuit supported on existing 400 kV double circuit towers. One side of these towers is currently in use supporting the existing Oldstreet to Woodland 400 kV circuit; the other side is spare and available for the proposed development. The existing tower height details are provided in **Table 6.3**, and one of the intermediate towers is illustrated in **Figure 6.30**.

Table 6.3: Tower Heights for the Existing Oldstreet to Woodland Line

Existing Tower Number	Existing Type of Tower	Existing Tower Height (m)	Elevation (mAOD)	Overhead Line Span to next Tower (m)
402	Double Circuit	52.5	138.640	312
403	Double Circuit	60.8	125.937	419
404	Double Circuit	60.8	115.218	389
405	Double Circuit	56.8	113.939	352
406	Double Circuit	56.8	120.726	342
407	Double Circuit	56.8	108.967	340
408	Double Circuit	57.8	100.846	372
409	Double Circuit	56.8	102.607	254
410	Double Circuit	52.5	97.638	68m to substation

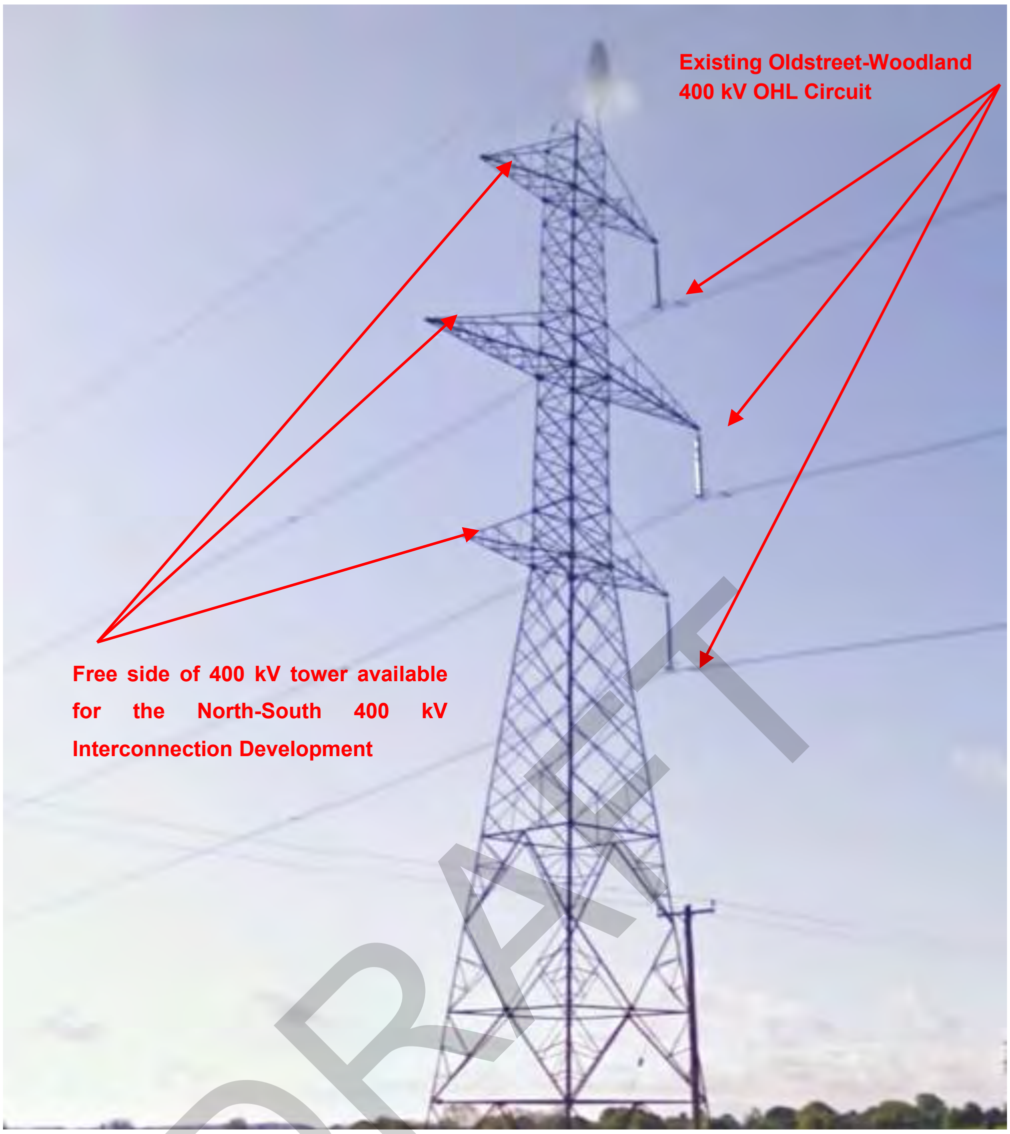


Figure 6.30: Existing 400 kV Double Circuit Tower near Woodland Substation

61 The proposed works and construction activities associated with utilising the free side of the existing Oldstreet-Woodland 400 kV OHL for a distance of 2.85km are described in **Chapter 7** of this volume of the EIS.

6.3.2.4 Tower Material

62 The towers are made from galvanised steel and are grey in colour. The towers may be (re) painted matt grey at intervals throughout the life of the towers as protection against corrosion.

6.3.2.5 Fixing of Tower Positions

63 The line design for the proposed development identifies fixed tower structure positions for the new transmission circuit. This provides clarity to landowners and other interested parties on the location of the OHL and associated infrastructure relative to particular landholdings, nearby dwellings, buildings, other structures and considerations such as environmental constraints. Accordingly, EirGrid is not seeking any approval for ‗micro-siting‘ (small deviations from the locations) of structures proposed in the application.

6.3.3 Works to Existing OHL and Works within the Substation Site

64 An extension of the existing Woodland Substation is necessary to allow the connection of the new 400 kV circuit. The existing substation has a total size of approximately 7.7ha, located within ESB‘s overall landholding in this area of approximately 27.2ha. The proposed works will take place on a site of approximately 0.544ha within and immediately adjacent to the substation and include:

- A western extension of the existing compound (approximately 0.231ha). The approximate location of the works is identified on **Figure 6.31**;
- Erection of a gantry structure to allow the OHL entry into Bay E10 at the north western corner of the substation (18m high to insulator chain connection; 28m to Franklin tip / lightning rod height);
- Erection of 2 No. new gantry structures located each side of the existing corridor (18m high to insulator chain connection; 28m to Franklin tip height);
- An extension to the existing 400 kV busbar to accommodate new 400 kV bay at location E10;
- New 400 kV line bay including the provision of the following electrical equipment;
    - Installation of 1 No. Circuit Breaker (7.398m high);
    - Installation of 3 No. Current Transformers (8.175m high);
    - Installation of 3 No. Inductive Voltage Transformers (8.175m high);
    - Installation of 3 No. Three pole Disconnectors with Earth Connections (7.67m high);
    - Installation of 6 No. Pantograph Disconnecting Switch with Earthing switch (13.70m high);

- Installation of 3 No. Surge Arresters (8.70m high);
- Installation of 6 No. Support Insulator Bars (13.70m high); and
- Installation of 5 No. Support Insulators (13.70m high).

- Extension of the existing substation palisade fencing (2.6m high) to accommodate the works;
- Installation of 1 No. Lightning monopole to protect Bay E10 (28m to Franklin tip / lightning rod height); and
- Construction of additional land drains to connect to the existing drainage network via a proposed new surface water manhole.

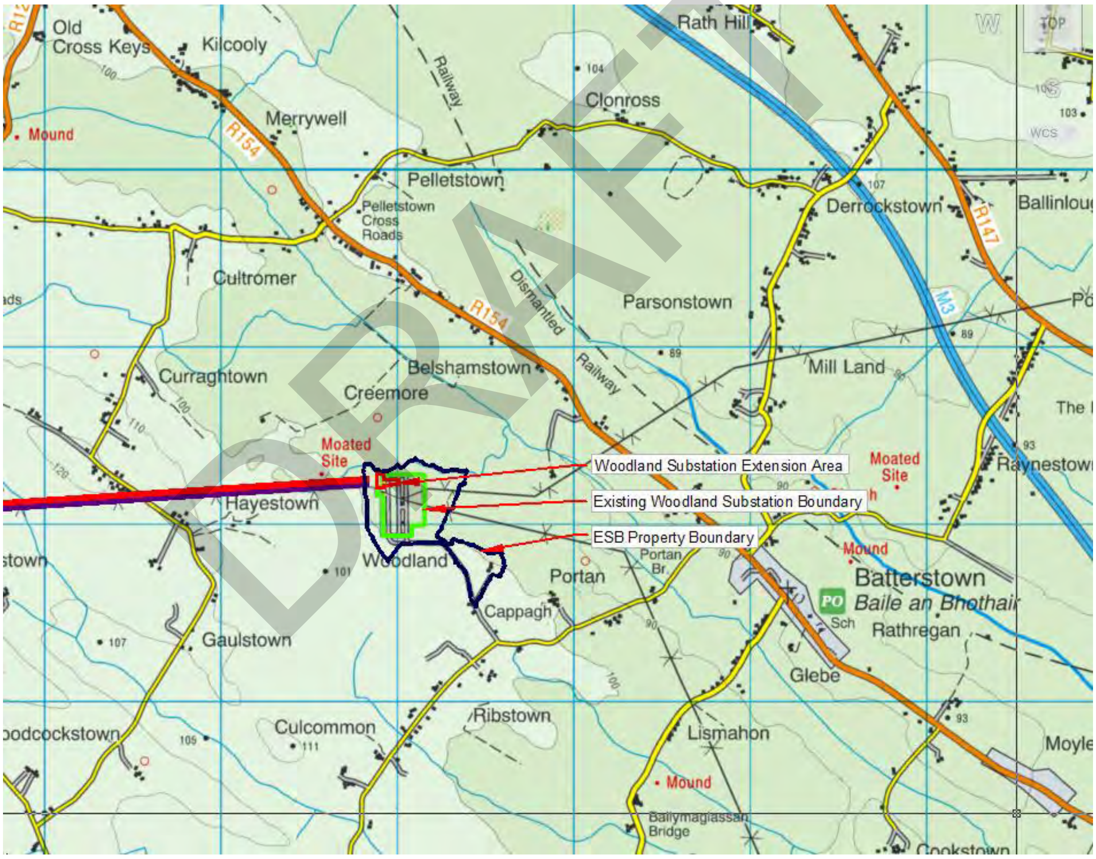


Figure 6.31: Location of Works to Woodland Substation (in red)

6.4 OPERATIONAL ACTIVITIES

6.4.1 Overhead Lines

65 Following construction, the transmission line will be subject to an annual survey (helicopter patrol) and a planned maintenance survey (climbing patrol) every five years or so. Emergency maintenance patrols may also be required following severe storms. As a result of these patrols, faults may be identified on the line, meaning that certain remedial work may be required on the line. This may include the replacement of worn or damaged hardware, damaged insulators or conductors. Access to lands will be required on these occasions and shall occur in accordance with the relevant ESB / IFA Code of Practice and relevant statutory provisions.

66 It is the responsibility of ESB to keep trees and high hedges cut, to ensure a requisite level of electrical clearance to the line and more particularly to avoid any possible danger to people. The amount of cutting will normally be sufficient for a few years growth; however, care is taken to minimise impacts and potential damage to shelter belts.

67 Further detail on the maintenance of the OHL and towers is provided in **Chapter 7** of this volume of the EIS.

6.4.2 Woodland 400 kV Substation

68 The operation of the Woodland 400 kV Substation will be similar to that currently occurring – the proposed development will essentially comprise a new bay within the existing substation. Woodland Substation is normally unmanned with the equipment operated by remote control. Visits to site by operational staff will generally be confined to weekly visits for routine plant inspection. Access for maintenance, which may require the use of a truck, will normally be limited to once per annum.

7 CONSTRUCTION

7.1 INTRODUCTION

1 The purpose of this chapter is to describe the construction of the proposed development. It outlines the associated construction methodology and activities along the specific route alignment as described in **Chapter 6** of this volume of the Environmental Impact Statement (EIS).

2 The ESB and any contractors employed during the construction phase of the project will be obliged to comply with all the commitments set out in this EIS, in addition to any conditions which may be attached by An Bord Pleanála (the Board) to any planning approval that may be granted.

3 This chapter has been prepared and should be read, in conjunction with the following chapters of the EIS:

- **Chapter 4** Consideration of Alternatives – Technology, of this volume of the EIS;
- **Chapter 5** Consideration of Alternatives – Routing, of this volume of the EIS;
- **Chapter 6** Description of Development – of this volume of the EIS; and
- Chapter 13 Material Assets – Traffic, **Volumes 3C** and **3D** of the EIS.

7.2 CONSTRUCTION METHODOLOGY

4 The purpose of this section is to outline the construction methods which will be implemented on the proposed development.

5 Following receipt of consent for the proposed development and prior to commencement of works, the contractor(s) which will be appointed by the Electricity Supply Board (ESB) and will prepare a detailed *Construction and Environmental Management Plan* (CEMP). An outline CEMP is included as, **Appendix 7.1, Volume 3B Appendices,** of the EIS for information. The detailed CEMP can only be completed post-consent as it will include method statements and work programmes that provide more detailed phasing of work based on the methodologies described in this chapter, and the mitigation measures contained in this EIS (see **Chapter 11** for further details), all of which must first be approved by An Bord Pleanála as part of any statutory consent. The appointed contractor(s) will develop a series of detailed plans for the construction of the existing substation elements, the erection of the towers and the stringing of the line. The construction and environmental plans will detail the temporary vehicular access to tower sites and identify archaeological and ecological sensitive sites (identified in the EIS - see 1:5,000 aerial drawings included in **Volume 3B Figures,** of

the EIS) and mitigation measures. Again, these plans will be required to incorporate the material elements of the mitigation measures outlined in the Summary of Mitigation Measures or Schedule of Commitments (see **Chapter 11** of this volume of the EIS).

6 The detailed contents of the CEMP produced by the contractor(s) will be agreed with ESB and subsequently with local and other appropriate authorities. ESB will employ a team to monitor the construction phase of the project and ensure works are being carried out by the appointed contractor in accordance with the CEMP and agreed method statement, safety procedures, pollution control etc.

7 It should be noted that while the construction methodology described in this EIS is based on experience in similar electricity transmission infrastructure projects, it considers the particular characteristics of the receiving environment in respect of this proposed development. Any issues specific to this project, for example the project specific mitigation measures contained in the EIS, or any planning conditions attached to any approval which the Board may decide to grant, will be incorporated fully into the appointed contractors' scope of works and careful supervision and management will be carried out to ensure full compliance.

7.3 (ANCILLARY) WORKS FOR CONSTRUCTION OF OVERHEAD LINES

8 The following is a description of the temporary works required for the construction of the proposed development.

7.3.1 Construction Material Storage Yard

9 The construction yard for the overhead line (OHL) elements of the project is proposed to be located in the townlands of Monaltyduff and Monaltybane, Carrickmacross, County Monaghan. The compound, of approximately 1.42ha, is located immediately adjacent to the southern side of the N2 National Primary Road, with access thereto and therefrom via a local road (L4700) – see Planning Drawing MT-009-002 included in **Volume 1B** of the application documentation. This location ensures appropriate accessibility to all parts of the alignment of the proposed transmission line.

10 The compound has a history of such use, being a former construction yard facility associated with the construction of the N2 National Primary Road. It will provide for the secure storage of all materials associated with the construction of the proposed development, as well as staff car parking, temporary site offices and welfare facilities (comprising Portaloos - no foul drainage will occur on the site).

11 The proposed use of the site as a construction material storage facility will require a new site entrance off the L4700 at a central location along the southern boundary of the site. Internal access within the compound will occur by means of an approximately 4m wide road laid out in hardcore material (such material will be laid throughout the site). Other site development proposed to occur within the site includes the laying of interceptor traps in a demarcated area for refuelling, and other necessary and appropriate site drainage works. The site will be bounded by a 2.6m high palisade fence. A 2m tall continuous fence with gaps will be affixed to three sides of the boundary fence to reduce noise levels.

12 Given the temporary nature of the compound to facilitate construction of the proposed development, all materials and works on the site will be removed following completion of construction. The site will be restored to its former condition prior to its use as a storage compound associated with the proposed development.

13 Individual members for each tower section are identified from a pick list in the main steelyard. These identified section members are picked out from the main storage bails and brought to the top of the yard near the main gate using a teleporter where they are stored in individual bundles as tower sections for each individual tower. Bundles of tower sections are loaded onto the truck or tractor and trailer using the teleporter, secured and carried to their relevant tower sites locations.

14 As outlined above, if the tractor and trailer are being used the steel will be delivered to the areas surrounding the base of the tower. If a lorry is being used due to distance from steel yard, this will be unloaded close to final tower site location destination onto a tractor and trailer using the hi-ab on the lorry. The tractor and trailer will then complete delivery to each tower site location.

7.3.2 Stringing Areas including Crossings over Public Roads

15 Stringing of OHLs refers to the installation of the phase carrying conductors and shieldwires on the supporting towers. The conductor is kept clear of all obstacles along the straight by applying sufficient tension. During the stringing operation for safety reasons the conductor will be kept clear of roads / railway crossings and transmission or distribution lines. These obstacles along a straight have to be guarded (see **Figure 7.1**).

Figure 7.1: Typical Guarding Arrangements in Overhead Line Construction

7.3.3 400 kV Overhead Line Construction

16 OHL construction is undertaken effectively on a long linear alignment with isolated areas of activity which are limited in size. While a 400 kV OHL is a major infrastructural project, the machinery and equipment required to construct such a line is relatively modest and generally similar in size to machinery utilised for normal farming activities, or construction of a domestic dwelling.

17 The construction of the 400 kV OHL will be undertaken by ESB. ESB may use external contractors who carry out transmission line construction on its behalf. The OHL construction will be split into two distinct contracts, namely foundation installation and tower erection and stringing. EirGrid shall appoint a Client Engineer for this stage of the development. The Client Engineer shall monitor and inspect the detailed designs, plant, material, and works including scheduling to ensure they meet the requirements of its functional specification, designs and transmission standards.

18 The construction techniques carried out will fully comply with all health and safety requirements. In general the construction phase can be broken down into the following parts:

- Verify that all planning and environmental conditions have been satisfied;
- Carry out pre-construction site investigations including access review and ground conditions to confirm the conditions as predicted;
- Delineation of any on-site working area (e.g. erection of temporary fencing to mark out for health and safety purposes the construction works area);
- Setting out of tower foundations (tower foundation areas are marked out on the ground using timber pegs to guide the excavator when digging to remove soil);

- Site preparation works including minor civil works such as removal of fences and erection of temporary fencing;
- Installation of tower foundations;
- Erection of tower; and
- Stringing of conductors and commissioning.

19 The proposed 400 kV line will consist of galvanised steel lattice towers of varying heights at intermediate and angle locations. The construction methodology will be similar to that used on the existing 400 kV lines previously constructed in Ireland and currently being constructed throughout Europe and internationally. **Figure 6.25** in **Chapter 6** of this volume of the EIS shows the proposed tower arrangement.

20 In wet areas bog-mats, or aluminium tracking may be required in order to access sites without causing excessive damage (see **Section 7.3.4.1.3** for further details on the types of access proposed for this development). The proposed temporary access routes have been considered by the environmental consultants in their appraisal of the proposed development (refer to **Volumes 3C** and **3D** of this EIS). Prior to construction, notices and schedules, as well as maps confirming the position of towers, will be issued to all landowners. EirGrid representatives will meet with landowners to confirm the exact position of the towers on the ground and deal with any other queries the landowner may have following the issuing of the Notice. Construction may commence at this stage.

7.3.4 Construction Programme

21 The construction period for the proposed linear development is anticipated to be approximately three years from the commencement of the site works. However construction at any one tower location is of short duration.

22 The construction of the OHL will be undertaken in five general stages, according to the following sequence, on a rolling programme of estimated durations:

- Stage 1 – Preparatory Site Work (1 – 7 days);
- Stage 2 – Tower Foundations; standard installation (3 – 6 days), pilling installation (5 – 10 days);
- Stage 3 – Tower Assembly and Erection (3 – 4 days);
- Stage 4 – Conductor / Insulator Installation (7 days); and

- Stage 5 – Reinstatement of Land (1 – 5 days).

23 The construction methods carried out by ESB and its contractors will fully comply with all relevant health and safety requirements. The principal OHL construction methods are outlined in this section, as detailed below, and are based on ESB's long and successful OHL construction experience, both in Ireland and internationally.

24 The ground conditions encountered will vary along the proposed OHL route and hence the construction techniques and machinery / equipment required may vary to accommodate this.

25 Access to the tower location sites will be during hours of daylight for all construction stages (see **Figure 7.2** for typical construction stage sequence). It is not anticipated that construction works will be carried out on Sundays, Bank Holidays or that any construction works will be carried out in hours of darkness.

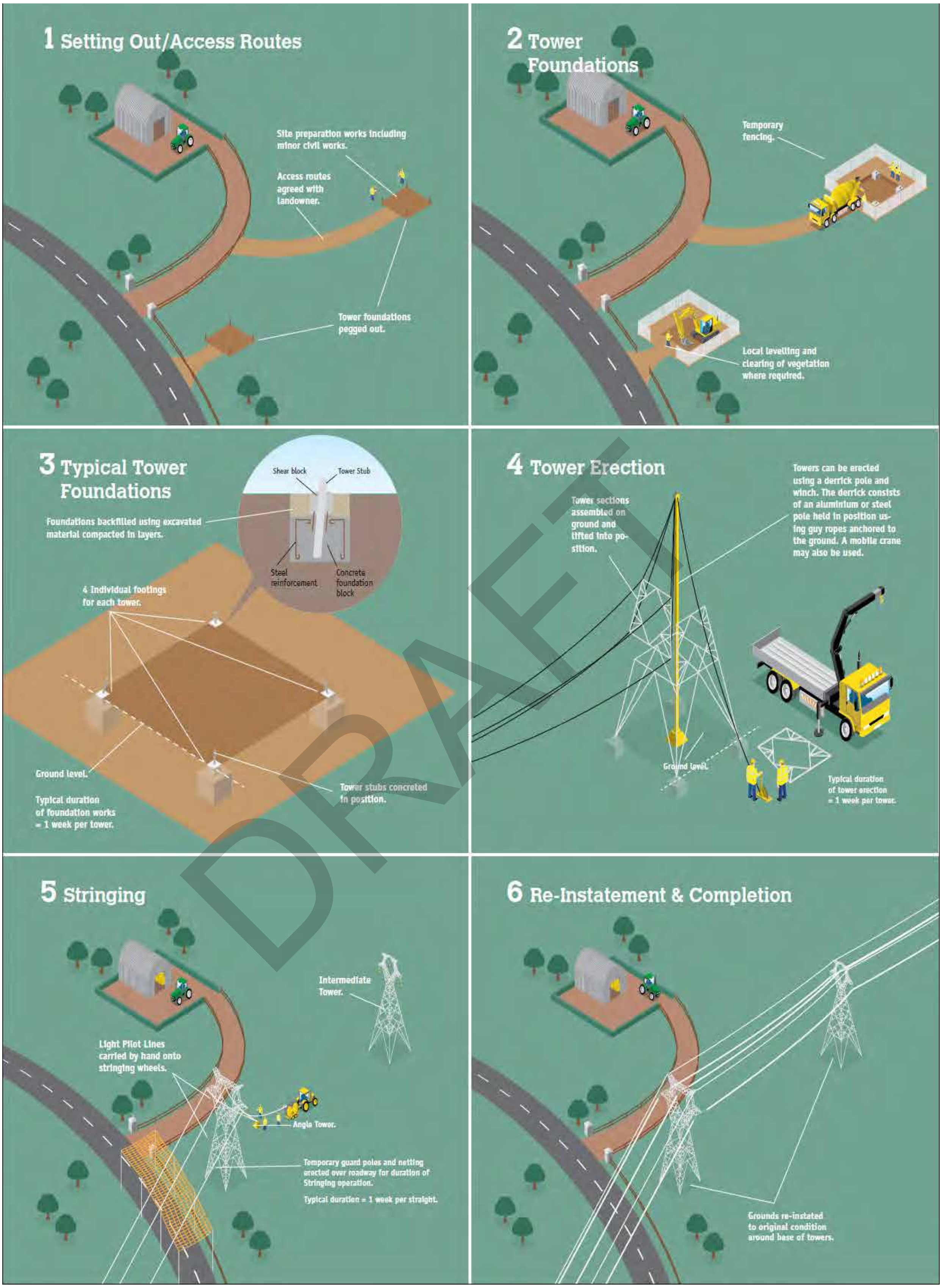


Figure 7.2: Typical Construction Works

(Source: *Landowner Information Brochure* (July 2013) for illustrative purposes only)

7.3.4.1 Stage 1 - Preparatory Site Work

7.3.4.1.1 Pre-Construction works

26 Pre-construction surveys will be undertaken immediately prior to the construction phase, including ground investigations, to confirm the ground conditions which have been predicted in this EIS.

27 Prior to commencing any works, discussions will take place between the appointed landowner agents and landowners to ensure awareness of the specific works that will take place pursuant to the proposed development. All landowners will be contacted prior to access being required on their lands and a date of commencement for the works will be provided to the landowner before any work begins. The detailed design of access routes and construction methodology based on condition of land at the time of construction will be agreed and recorded with the landowner prior to the commencement of works.

7.3.4.1.2 Site Enabling Works including Guarding and Services

28 Site preparation works for OHL construction includes laying of temporary access tracks to the tower positions (refer to **Section 7.3.4.1.3** for further detail) and may include minor civil works around the tower location including *inter alia*:

- Clearing the site (e.g. removal of fences, cutting back of trees and vegetation etc.): All vegetation adjacent to the conductors which has the potential to fall onto the conductors will be cut or trimmed to ensure safety clearances. This will form part of the ongoing maintenance of the proposed OHL. This is standard practice and is done for all existing OHLs. Less trimming will be required further from the conductors as there will be less potential for falling vegetation onto the OHL. The trimming regime will involve a scalloping or profiling effect which will minimise the effect on vegetation. It is assumed that an area adjacent to the line and up to 30m from the position below the conductors (on either side) will be required to be examined for falling hazards. The level of trimming required will be directly related to the distance from the OHL and the height of the vegetation – i.e. the further from the OHL, the less vegetation that is required to be trimmed. There would be a loss of localised vegetation to the tower sites including tree, shrub and hedge removal to allow for the construction of towers for supporting the OHLs. Vegetation will be reinstated. Temporary access routes to the towers may also result in loss of localised vegetation; again this vegetation will be reinstated. As part of the EIS an assessment has been carried out to identify the positions and quantities of vegetation clearance due to this development (refer to Chapter 6, **Volumes 3C** and **3D** of the EIS, for further detail). ESB will employ the services of a forester and / or tree surgeon during construction to remove vegetation which has been identified as being in violation of required clearance for the development.

- Levelling of the tower foundation area: The towers are designed such that a difference in ground level can be accommodated from one side of the tower to the other, hence minimising the quantity of local disturbance. Where the gradient between two legs is greater than 1m, the tower will be installed with a leg extension. The towers as per design do not increase in height. Gradients at the proposed tower locations greater than 1m have been accounted for in the design, by the selection of the appropriate leg extensions to match the gradient. Depending on the particular gradient at each location, the tower may require a single leg extension, or it is possible to add an extension to any number of the four tower legs to overcome a gradient. Where the gradient is less than 1m, and the impact is moderate, consideration will be given to levelling the site foundation area. Prior to construction a site survey will be conducted at each tower location to confirm the requirement for leg extensions and / or site levelling.

- Diversion of field drains: Where existing drainage is present at the location of a tower foundation, typically this drainage will be removed from the tower foundation construction area. New drainage trenches will be dug to pass the tower foundations on one or as many sides of the foundations as required, or alternatively a number of drains can be replaced by a larger single drain inserted, which bisects the tower foundation.

- Delineation of any on-site working area (e.g. erection of temporary fencing etc.).

- Diversion of any existing utilities (e.g. underground water pipes, cables etc.).

- Erection of temporary guarding positions: Where the conductor is to be strung over roads and electricity lines, protective structures will be erected prior to the commencement of stringing. These structures will be in the form of guard poles. For transmission line crossings a catenary stringing method will be used as an alternative to erecting large guarding arrangements, (see **section 7.3.4.4.1** for details). The protective structures will be positioned both sides of a crossing and will be temporary in nature, for the duration of the stringing operation. They will help to ensure that the stringing operation does not interfere with road users or disrupt the supply of electricity (See 1:5,000 aerial drawings **Volume 3B Figures** of the EIS).

7.3.4.1.3 Access Routes

29 Temporary access routes capable of accommodating construction plant, construction materials and personnel are required for the construction of each tower, installation of the conductor and the setting up of guarding locations (see 1:5,000 aerial drawings **Volume 3B Figures** of the EIS).

30 There are three locations along the proposed route where vehicular access is typically required for the construction of OHL:

- **Access to tower sites:** Temporary access routes will be used to gain access to the working areas from the public road network. The proposed access routes will be selected to minimise disruption to agricultural land by using existing routes and access points as far as possible.

- **Access to stringing locations:** Generally access for the stringing equipment (see **Figure 7.11**) is directly from the nearby proposed angle tower to the stringing location, where the two points are in the same fields and there are no obstructions. Where obstructions (e.g. a hedgerow) occur between these points, an alternative access route has been chosen.

- **Access to guarding locations:** The guarding locations will be accessed by 4x4 vehicle and excavator with two trips, one for erection, and one for disassembly.

31 Access routes to tower sites enable the deployment of excavators or piling rigs together with foundation materials (shuttering, concrete, steel re-enforcement, piles), and for the removal of excess spoil. For tower erection, approximately 10 tonnes for an intermediate tower to 32.5 tonnes for an angle tower of steelwork will be delivered to each tower location site and erected using a gin / derrick pole.

32 As noted previously, appropriate route and site selection is the most effective method of avoiding or minimising the environmental effects of development.

33 The first part of the identification process is to develop some general principles to guide the decisions about identifying potentially suitable temporary access routes to construct the proposed development. The general guidelines are set out below:

- Access routes could be up to 4m in width. The width of routes and any associated works would be minimised where possible and where safety and design are not compromised;

- Defining the route of temporary access to work sites (on private lands) will seek to:
  - Minimise disturbance to current land use and farm / land management practices, where possible;
  - Avoid sensitive areas where possible (e.g. cSAC / pNHA / NHA / SPAs);
  - Cause least disturbance to and minimise impacts to natural heritage interests (including watercourses);

- o Cause least disturbance to and minimise impacts to cultural heritage interests;
- o Minimise intrusion to and disturbance of the surrounding area and local communities;
- o Maximise use of existing farm entrances, farm tracks, roads and bridges, where possible. The use of private accesses to residential properties should be avoided wherever possible for safety and amenity reasons;
- o Minimise the amount of new temporary entrances, and access tracks / roads, where possible; and
- o Take appropriate precautions to protect animal welfare and crop fertility by avoiding the spreading of diseases and noxious and invasive plants between farms.

- Prior to commencement of construction, a project traffic management plan will be produced and implemented which will be subject to revision in conjunction with local authorities. (Refer to Chapter 13, **Volumes 3C** and **3D,** of the EIS for further details on construction traffic).

34 Based on the above guidelines, temporary access routes for the proposed development have been identified in this EIS (See 1:5,000 aerial drawings in **Volume 3B Figures** of the EIS).

35 Temporary access tracks tend only to be laid where there may be poor ground conditions, a sensitive receptor or sensitive land use (see **Figures 7.3** and **7.4**). While the terrain of the proposed development is generally undulating with favourable ground conditions likely to be encountered for a vast majority of the proposed route, construction techniques and machinery / equipment may vary to accommodate localised ground conditions along specific parts of the route and / or as a result of weather conditions during the construction period. For the purposes of this appraisal, all temporary access routes have been assessed based on very wet weather conditions, expansive construction techniques with heavy machinery / equipment.

36 Details of alternative types of temporary access route for wet conditions relative to land use, condition and having regard to specific environmental conditions are set out below. It is noted that these are not mutually exclusive in all cases and that a particular temporary access route may incorporate different track types along its length.

- **Type 1**

  Good quality land (i.e. in areas of very dry pasture): In general, the laying of temporary tracks is not required. Using tracked machinery (low ground pressure vehicles where possible) usually means that access to tower sites can be achieved with relative ease using existing roadways where available and the crossing of fields.

- **Type 2**

  Relatively dry / peat land or very sensitive areas: Where a defined track is required, temporary rubber matting or aluminium road panels would be used to distribute the weight evenly. Low ground pressure vehicles would also be used where possible.

Figure 7.3: Temporary Aluminium and Rubber Panel Tracks

- **Type 3**

  Very poor, soft, wet boggy and / or undulating land with unfavourable ground conditions: In such conditions roads with stone or wooden sleepers may need to be constructed. This involves the excavation of the topsoil and storage of this to one side of the track. A geotextile reinforcement would be placed on the subsoil surface and stone placed on top and compacted to form the track.

Figure 7.4: Temporary Stone Road and Wooden Sleepers

37 Based on the assessment criteria set out in paragraph 35, the vast majority of access routes identified in **Volume 3B Figures** will be Type 1. The access routes or part of the routes to the following tower locations and associated ancillary works have been identified as Type 2 which potentially require temporary rubber matting or aluminium tracks: Towers 103, 104, 106, 116, 117, 119, 120, 123, 126, 130, 168, 180, 181, 182, 202, 222, 223, 229, 232 in the CMSA; and Towers 269, 279, 287, 292, 379 in the MSA. It is not envisaged that Type 3, roads constructed with stone or wooden sleepers will be required at any of the proposed tower locations, stringing areas or guarding locations.

7.3.4.1.4 Duration of Access Route Works

38 The duration of access routes construction and preparation where necessary is typically very short with one day being the norm for 0.5km temporary access route. For a very long route, greater than 1km, two working days may be required. In cases where access tracks have been installed over wet or boggy accesses, they may need to remain in place until the full construction period has elapsed.

7.3.4.2 Stage 2 – Tower Foundations

7.3.4.2.1 Setting Out and Excavation of Tower Foundations

39 The average duration of foundation works for a ‗Base Construction Crew' of 4 - 6 workers is six days for an angle tower, four days for an intermediate tower and 10 days for piled / rock anchor foundations.

40 Excavations are set out specifically for the type of tower (e.g. angle, intermediate or transposition) and the type of foundation required for each specific site (depending on ground conditions). As noted in **Section 7.3.4.2.3** tower foundations typically range from 2m to 3.5m in depth to the invert level of the foundation and anywhere from 2 x 2 metres squared to 9 x 9 metres squared in plan area depending on tower type. Each of the four corners of the tower stubs (i.e. lower part of the tower leg) will be separately anchored below ground in a block of concrete. The standard ESB practice is to use a concrete pipe in the foundation holes which is as an integral part of the foundation.

7.3.4.2.2 Installation of 400 kV Steel Tower Foundations

41 The foundation of the tower is the means by which the loads are transmitted from the tower into the surrounding soil. The foundation is designed to withstand the maximum uplift, compression, transverse shear, and, longitudinal shear loads imposed by the tower as derived from the tower design. The foundation will be sufficiently stable to prevent any movement of the tower under

the maximum load conditions. The foundations will be excavated using a rubber tyre or tracked excavator. Depending on the location a wheeled or tracked dumper may deliver the ready-mix concrete to the excavation site. For the range of foundations to be used in this project see planning drawing Numbers MT-007-001, MT-007-002, and MT-007-003.

Figure 7.5: Typical Excavator and Dumper used in OHL Foundation Installation

42 The standard ESB foundation practice is to have four individual footings for each tower leg. The tower will be set out and pegged prior to foundation excavation. In some cases this will require excavation of existing hedges and / or drains to allow clear pegging of each individual leg footing for excavation. All such removals are restored upon completion of foundation works. A maximum size footing may be required (see **7.3.4.2.3** foundation sizes) in the case of weak soils, pile foundations may be required in the case of deep bog and reduced footing size foundations may be required in the case of rock being encountered at shallow depths (no deep bog is expected based on the soils and geology review of the tower sites).

43 All tower sites will be checked for underground services such as cables, water pipes etc. as part of normal pre-construction verification. If field drains are encountered these will be diverted and all diversions identified and discussed with the landowner.

44 In areas of poor ground and high water table, it may be necessary to use sheet piles supported by hydraulic frame(s) to prevent collapse of the sides and also to prevent the excavation becoming too large. In this case the requirement for a concrete pipe (which is normally used in tower foundations) is removed. During any dewatering activities a standard water filtration system will be utilised to control the amount of sediment in surface water runoff (see Chapter 7, **Volumes 3C** and **3D,** for further details).

45 When each leg is excavated the formation levels (depths) are checked by the on-site engineer. Once the levels have been achieved the concrete pipes (if used) are lowered into position. Once in position and all water is pumped from the excavation, concrete is poured outside the concrete ring. When this concrete has set a paving slab is set within the concrete pipe to provide a stable base on which the tower stubs will rest.

46 A setting template (see **Figure 7.6**) is used to set and hold the tower stubs in position while the concrete is being poured and cured. Any water in the excavation is pumped out prior to any concrete being poured into the foundation. Concrete trucks will be brought as close as possible to the excavation to pour directly into the excavation. In the event of this not being possible concrete will be transported in six tonne dumpers fitted with concrete chutes.

47 After the concrete is poured the remaining part of the foundation, the shear block or neck is shuttered. Once the shuttering is complete the concrete may be poured and the foundation completed. The tower foundations are backfilled one leg at a time usually with the soil material already excavated. The backfill is placed and compacted in layers.

48 In locations where the soil investigation shows that the ground conditions do not conform to the bearing and / or ground conditions catered for by the range of generic pad and chimney foundations, either a piled, or rock augured site specific foundation will be required. It will be the engineering preference to use an excavator with an attachable hydraulic hammer to install the piles. This will remove the requirement for any larger plant.

49 The use of piled or rock anchor foundations may require the drilling or ‗auguring‘ of several holes for each leg of the tower. In the case of piled foundations there will be two options. The holes are drilled and then reinforced with steel and concreted or grouted, or the contractor will use precast concrete piles and drive these into the ground. The piles form a stable base at ground level, upon which a typical foundation will be installed. In the case of rock foundation, a site specific rock anchor foundation will be designed. Rock anchors of a specified length are drilled and grouted into the bedrock. The quantity of concrete used will be no greater than the worst case quantity for that of a generic ‗pad‘ and ‗chimney‘ foundation for the particular tower location.

50 Once the tower base is completed and fully cured it is ready to receive the tower body. When the base construction crew leave site they will ensure to remove all surplus materials from the site including all unused excavated fill.

Figure 7.6: Photograph of Setting Template being prepared for Final Concreting

7.3.4.2.3 Foundation Size

51 The foundation size for each tower leg used on the 400 kV transmission system range from approximately 3.8m x 3.8m x 3.5m to 8.8m x 8.8m x 3.5m for a single circuit 400 kV angle tower, 2.2m x 2.2m x 2.5m to 3.7m x 3.7m x 2.5m for a single circuit 400 kV intermediate tower (refer to Drawings MT-007-001, MT-007-002 and MT-007-003, submitted with the planning application, for foundation details). It is likely that the large majority of tower foundations will be constructed using the generic foundation types within the minimum to maximum ranges. A number of towers are considered to be in locations where poor ground conditions may be encountered, specifically tower numbers, 104, 105, 106, 117, 119, 120, 122, 163, 187, 269, 279, 287, 292 and 379. The tower locations may require a piled or rock anchor foundation (as described in **Section 7.3.4.2.2**). Piled and / or rock anchor foundations will not exceed the maximum foundation plan sizes as listed above.

7.3.4.2.4 Working Area

52 The working area for construction of a 400 kV tower will extend to 30 x 30m all around the footprint of the base of the tower.

7.3.4.2.5 Construction Equipment Required for Foundation Installation Stage

53 The equipment required for the foundation installation stage of construction includes the following:

- 4 x 4 vehicle;
- Concrete vibrator;
- Water pump;
- Wheeled dumper or track dumper (6 to 8 tonnes);
- Timber or other shuttering boxes;
- 360˚ tracked excavator (13 tonnes normally, 22 tonnes for rock breaker);
- Transit van;
- Road sweeper;
- Chains and other small tools; and
- Concrete delivered by supplier to closest convenient point (38 tonnes gross).

7.3.4.2.6 Duration of Foundation Works

54 The average duration (continuous days) of foundation works is as follows:

- Angle / intermediate tower 4 - 6 days
- Piled / rock anchor foundation 10 days
- Crew size 4 to 6 workers

7.3.4.3 Stage 3 – Tower Assembly and Erection

7.3.4.3.1 Erection of Tower Body

55 The most common methods of constructing a transmission line of this nature is by using a ‗derrick pole‘ or a mobile crane. Both methodologies are outlined below.

7.3.4.3.2 Derrick Pole Methodology

56 The tower can be erected using a derrick / gin pole and tractor. The derrick pole is a very simple and straight forward way to build the tower where small sections of steel are lifted into place using the derrick and a winch. As illustrated in **Figure 7.7** the derrick pole consists of either a solid or lattice aluminium or steel pole which is held in position using guy ropes anchored to the ground.

Figure 7.7: Derrick Pole at Tower Base

Figure 7.8: Lower Part of the Tower Head being dropped into Position

7.3.4.3.3 Construction Equipment Required for Tower Erection Works by Derrick Pole

57 The equipment required for the tower erection stage by derrick pole of construction includes the following:

- 4 x 4 vehicle;
- Winch Tractor and trailer;
- Derrick pole;
- Teleporter;
- Transit van; and
- Chains and other small tools.

7.3.4.3.4 Duration of Tower Erection Works

58 The average duration (continuous days) of tower building works is as follows:

- Angle tower 4 days
- Intermediate / transposition tower 3 days
- Crew size 7 workers

7.3.4.3.5 Mobile Crane Methodology

59 Mobile cranes can also be used to construct steel towers, however due to cost and access issues they are generally restricted to sites which provide optimal construction conditions. End towers in or close to a substation site are good examples of where use of a mobile crane can present advantages. Crane size and weight is generally dependent upon the properties of the tower in question, with the tower erection procedure completed in separate sections due to the weight of the differing components. Tower sections are assembled on the ground and lifted into place.

Figure 7.9: Tower Erection by Mobile Crane

7.3.4.3.6 Construction Equipment Required for Tower Erection Works by Mobile Crane

60 The equipment required for the tower erection stage by construction using a mobile crane includes the following:

- 4 x 4 vehicle;
- All terrain mobile crane;
- Tractor and trailer;
- Teleporter;
- Transit van; and
- Chains and other small tools.

7.3.4.3.7 Duration of Tower Erection Works

61 The average duration (continuous days) of tower building works is as follows:

- Angle tower 4 days
- Intermediate / transposition tower 3 days
- Crew size 7 workers

7.3.4.4 Stage 4 – Conductor / Insulator Installation

7.3.4.4.1 Stringing of Overhead Lines

62 Stringing of OHLs refers to the installation of phase conductors and shieldwires on the transmission line supporting towers. The conductor is kept clear of all obstacles along the straight by applying sufficient tension. Certain obstacles along a straight have to be guarded such as road / railway crossings and other transmission or distribution lines. See generic layout in **Figure 7.10**.

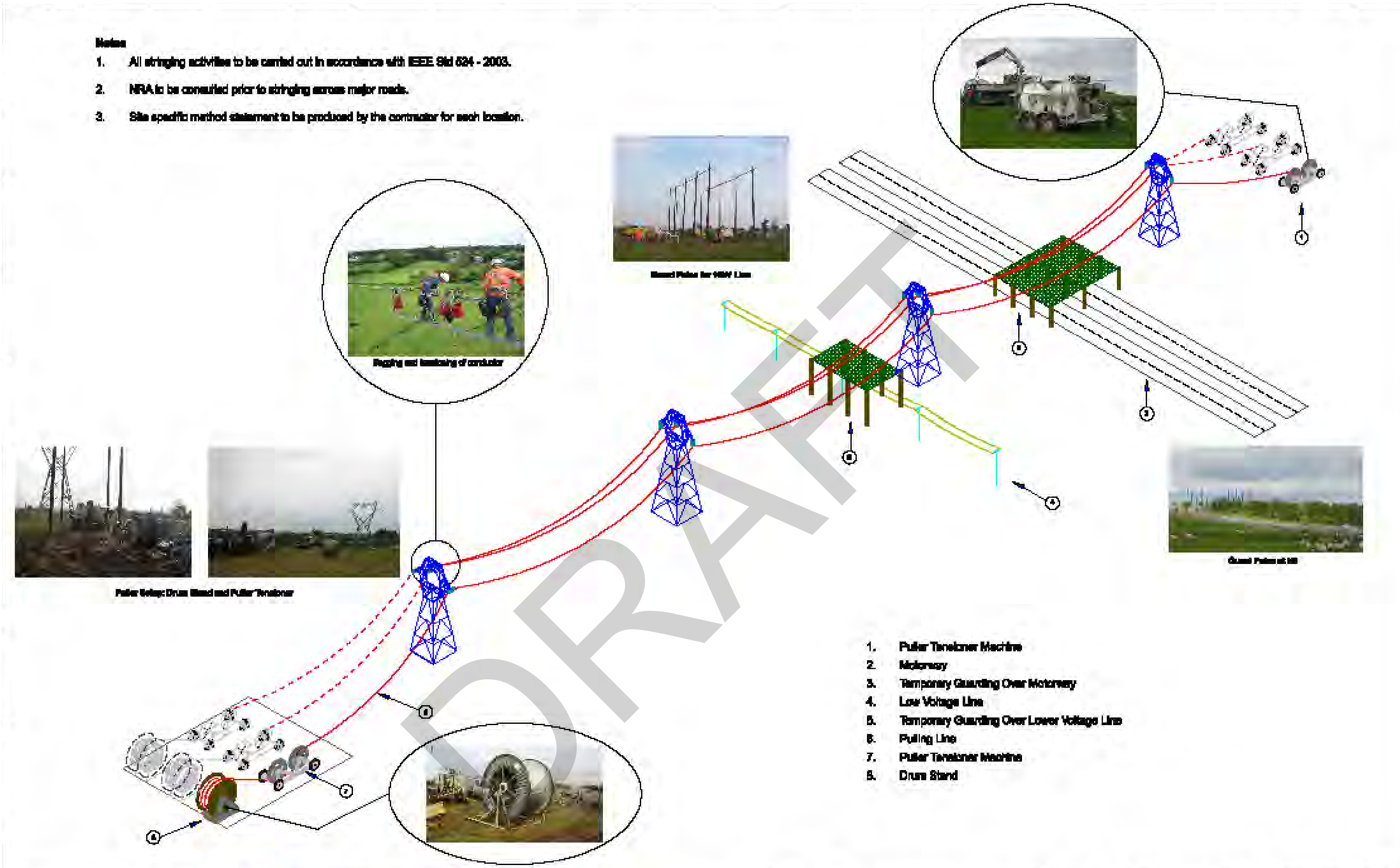


Figure 7.10: Generic Tension Stringing Layout

63 This stringing method involves the pulling of a light pilot line (nylon rope) which is normally carried by hand into the stringing wheels. This in turn is used to pull a heavier pilot line (steel rope) which is subsequently used to pull in the conductors from the drum stands using specifically designed ‗puller – tensioner' machines (see **Figure 7.11**). The main advantages with this method are (a) the conductor is protected from surface damage and (b) major obstacles such as road and rail crossings can be completed without the need for major disruption. The temporary working area utilised for the stringing equipment are generally 20m x 20m.

Figure 7.11: Puller – Tensioner Machine

64 Once the conductor has been pulled into position, one end of the straight is terminated on the appropriate tension fittings and insulator assemblies. The free end of the straight is then placed in temporary clamps called ‗come-alongs' which take the conductor tension. The conductor is then cut from the puller-tensioner and the conductor is sagged using a chain hoist. This stringing method will be used to string the conductors for the proposed development including the approximate 2.85km section on the existing double circuit structures near Woodland Substation. In the case of a small number of alignments where major road and / or existing transmission line crossings occur and in order to avoid having to construct large guarding structures it is proposed to use the catenary stringing method as outlined below.

65 The catenary support system is a secondary support used in OHL stringing where an additional safety factor is required over and above those used in normal tension stringing. Catenary support systems are typically used where motorways are crossed with movement of vehicles unhindered. In addition where an outage cannot be obtained the catenary support system can be used for crossing over live transmission and distribution lines. The catenary support system essentially consists of a high strength, low elasticity rope, which is deployed to the pilot wire, carried or hurled across the obstacle and connected to the conductor with rollers at spacing determined to provide adequate working clearances to the conflict below. The system in deployment is illustrated in **Figure 7.12** where the rope is pulled along by a robot over the conflicting span with double wheel rollers connected at a distance specified by the designer.

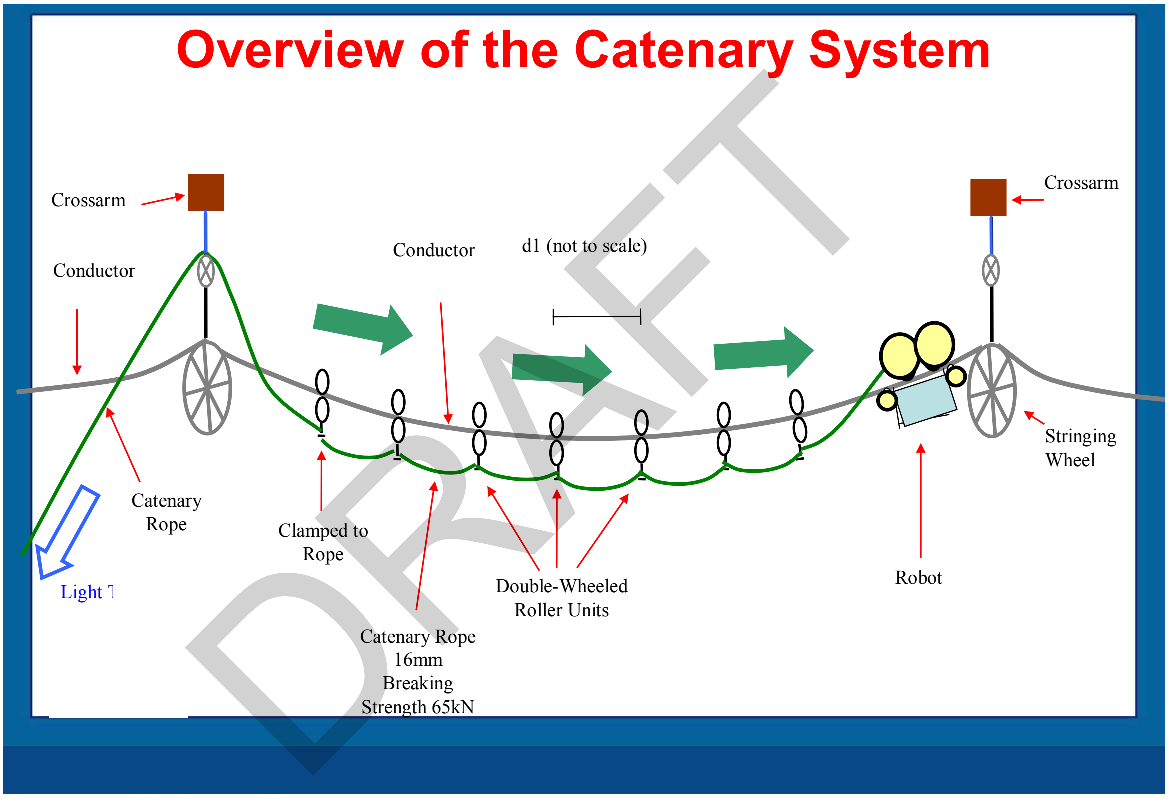


Figure 7.12: Typical Catenary Arrangement

66 When the rope and rollers are fully deployed and tied off either to a tower or to ground anchors, tension is then applied to the rope to flip it over the pilot wire. The rope is now supporting the conductor (see **Figure 7.13**).

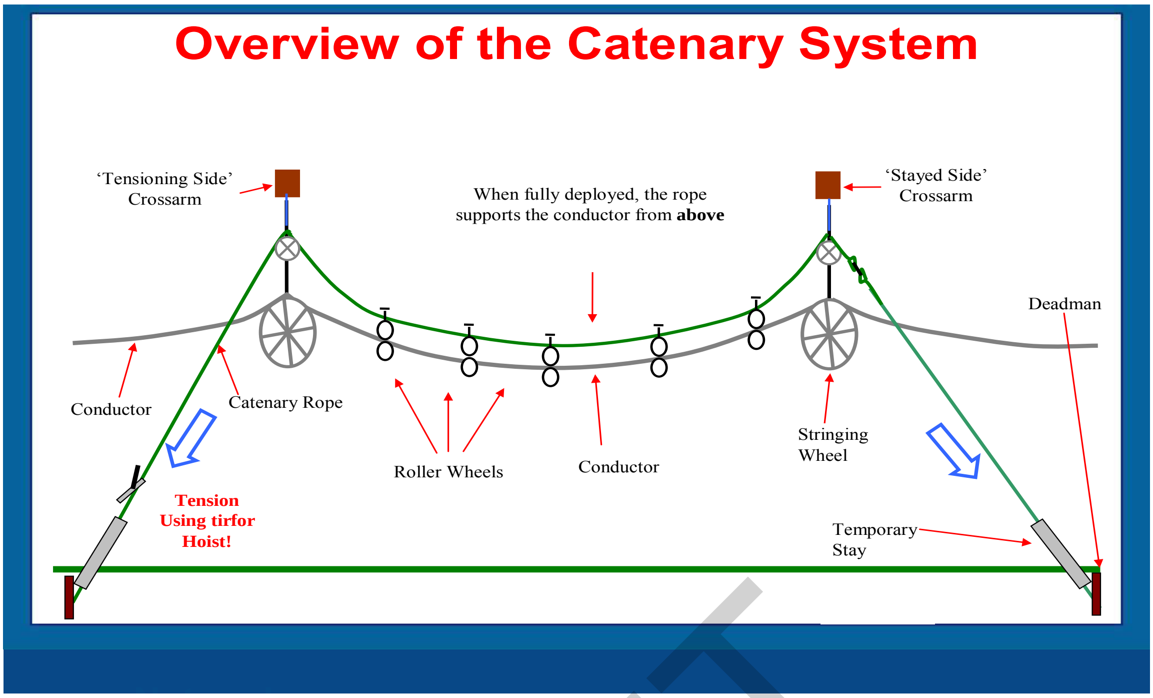


Figure 7.13: Catenary Arrangement when Flipped for Conductor Support

67 Essentially the catenary support system is a secondary support system. Should the conductor break during stringing the conductor would only fall by 1 wheel spacing. Therefore the spacing of the rollers will dictate how far the conductor can infringe into the safety zone for the conflict in question.

Figure 7.14: Typical Stringing Equipment

7.3.4.4.2 Construction Equipment Required for Stringing Stage

68 The equipment required for the stringing stage of construction includes the following:

- 4 x 4 vehicles;
- Puller - tensioner X 2;
- Teleporter X 2;
- Drum stands X 2;
- Drum carriers X 2;
- Stringing wheels;
- Conductor drums;
- Compressor & head;
- Transit vans;
- Road sweeper;
- Chains and other small tools; and
- Conflict guardings.

7.3.4.4.3 Duration of Stringing Works

69 The average duration of stringing works is typically one week per straight. This figure is similar for all straights regardless of length as the most time consuming aspect is the movement and setup of stringing equipment. Stringing crews are typically quite large and could have as many as 15 workers.

7.3.4.5 Stage 5 - Reinstatement of Land

70 Once all works are complete, the access route and the construction areas around the OHL towers are reinstated as close as possible to their original condition. Generally this work is carried out by a specialised agricultural contractor and is carried out in accordance with the relevant *ESB / IFA Code of Practice for Survey, Construction and Maintenance of OHL in relation to the rights of Landowners* and in consultation with the individual landowner.

7.3.5 Substation Works

71 The extension of the existing Woodland 400 kV substation is necessary to allow the connection of the new Turleenan 400 kV line bay. The works are described in **Section 6.3.3**. The approximate location of the works is identified on **Figure 6.31**, **Chapter 6** of this volume of the EIS. The proposed extension will take place entirely within the existing ESB lands and will involve works to an area of approximately 5,440sq.m. (0.544ha) including the area to accommodate the proposed electrical equipment and the extension of the existing palisade fence.

72 The proposed works associated with extending / modifying the existing Woodland Substation will consist of, but not limited to, the following elements:

- Site preparation works, including the removal of part of the existing fence, site clearance and earthworks;
- Installation of the new 2.6m high palisade fence;
- Excavation of trenches and laying of ducts for electrical cables, communication cables, lighting, etc.;
- Excavation of trenches and laying of pipework for connection to the existing surface water drainage network;
- Foundations works for the installation of equipment, structures and monopole;
- Installation of miscellaneous outdoor electrical equipment including support structures, gantries and bases and associated cabling and wiring;
- Stringing of OHL conductors;
- Installation of lightning conductor equipment; and
- Completion of external finishes.

73 The following machinery will be necessary to carry out all the construction works above:

- Concrete truck;
- Mobile crane;
- Pulling and tension devices for overhead conductors;

- Excavator;
- Dumper truck; and
- Bulldozer.

74 The proposed substation extension will take place entirely within the existing ESB lands. Excavation works will be undertaken to lower the ground level and install foundations to a maximum of 3.5m. Excess soils / subsoils will be disposed of at licensed / permitted waste management facilities. It is estimated that approximately 3,500m^3 (equivalent to approximately 7,350 tonnes) of material will be removed off site as a result of these works at the proposed substation.

75 Throughout the construction of the proposed development the client, designers, project supervisors, contractors, and workers will be required to comply with all applicable health and safety legislation and practice specific to works within an existing substation.

7.3.6 Traffic Management

76 Traffic Signs Manual issued by the Department of Transport provides details of the traffic signs which may be used on roads in Ireland, including their layout and symbols, the circumstances in which each sign may be used and rules for positioning them. Chapter 8 *Temporary Traffic Measures and Signs for Roadworks* of the 2008 Traffic Signs Manual will be used on this project. (Refer to Chapter 13, **Volumes 3C** and **3D** of the EIS for further details on construction traffic).

7.3.7 Working Hours

77 Site development and building works will generally be carried out during normal working hours. In exceptional circumstances works may be required outside of these hours.

7.3.8 Waste Management

78 Similar to any infrastructure project, there will be excavated material during the construction of the proposed towers. At the depths below ground at which tower foundation bases are installed, various types of soil, gravelly soil, and rock will be excavated. All topsoil excavated in the construction of tower foundations will be reinstated where possible. Where practical and appropriate, excavated subsoil will be used for associated construction and landscaping purposes. All surplus waste arising during the construction phase will be managed and disposed of in a licensed landfill, this ensures the provisions of the *Waste Management Act*

1996 (as amended) and subsequent amendments and regulations and any of the relevant local authorities Waste Management Plans. A Construction Waste Management Plan will be implemented to minimise waste and ensure correct handling and disposal of construction waste streams in accordance with the *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects,* Department of the Environment, July 2006 (see Chapter 12**, Volumes 3C** and **3D** of the EIS).

7.3.9 Commercial Forestry and Hedging

7.3.9.1 Commercial Forestry

79 The proposed development crosses commercial forestry. The normal corridor widths centred on the line to be left clear of trees for 400 kV lines is a maximum 74 metres.

7.3.9.2 Hedgerow

80 Hedgerows need to be managed under electricity lines. All trees should be outside their falling distance from any part of any OHL support.

7.3.10 Construction Environmental Management Plan

81 For infrastructural projects of this nature, it will be a requirement of the construction contractor to prepare a *Construction and Environmental Management Plan* (CEMP) in the event that planning approval is granted. For similar projects where planning approval has been granted, a condition has been attached in relation to preparing a CEMP. An outline CEMP is provided in **Appendix 7.1, Volume 3B Appendices,** of the EIS.

7.3.11 Maintenance

82 The design life for all the units of the proposed development is 50 to 80 years.

83 During this lifespan there will be on-going maintenance on the different units. The maintenance on the OHL will require access through third-party lands from time to time. The following section describes the expected maintenance requirements for the OHLs over the lifetime of the project.

7.3.11.1 Overhead Lines Maintenance

Overhead Line Patrolling

84 Helicopter patrols of OHLs are carried out once a year. These patrols will be advertised in advance.

Tree and Hedge Cutting to Maintain Clearances

85 Foot patrols of OHLs are carried out every five years. The landowners will be contacted in advance. ESB contractors will identify vegetation which has grown within the electrical clearance envelopes. Vegetation adjacent to the conductors which has the potential to fall onto the conductors and / or vegetation directly underneath the electricity line which has grown with close proximity will be cut or trimmed to ensure safety clearances. This maintenance activity will form part of the ongoing maintenance of the electricity line.

Towers

86 After approximately 35 to 40 years‘ service, tower painting of all steel towers will take place in order to get additional 15 to 20 years of steel corrosion prevention.

Insulator and Earthwire Hardware

87 It is estimated that 25% earthwire hardware replacement and less than 5% insulator replacement on the 400 kV line will be required after 30 years.

Foundation

88 No foundation maintenance work is generally required.

Conductor

89 No conductor maintenance work is generally required.

7.3.12 Decommissioning

90 The proposed development will become a permanent part of the transmission infrastructure. The expected lifespan of the development is in the region of 50 to 80 years. This will be achieved by routine maintenance and replacement of hardware as required. There are no plans for the decommissioning of the overhead line or existing substation. In the event that part of, or the entire proposed infrastructure is to be decommissioned, all towers, equipment and material to be decommissioned will be removed off site and the land reinstated.

7.4 HEALTH & SAFETY

7.4.1 Design & Construction

91 During the design and throughout the construction of the proposed development the client, designers, project supervisors, contractors, and workers will be required to comply with all applicable Health and Safety legislation and practice.

92 ESB has policies, procedures and systems, which will be in place, in the unlikely event of an accident or emergency incident occurring during the construction of the proposed development.

8 ELECTRIC MAGNETIC FIELDS (EMF)

8.1 INTRODUCTION

1 Electric power is transmitted throughout the country of Ireland over an extensive electrical network that includes over 6,500km of high-voltage transmission lines from generation facilities to networks of medium and low voltage distribution lines.

2 This chapter describes the electric and magnetic fields (EMF) associated with the operation of the proposed development and focuses on topics referenced in public submissions. It describes the characteristics and background levels of EMF found in the everyday environment, and the projected effect of the new transmission circuit on EMF levels under and around the line.

3 The data and methods used to calculate levels of EMF from an existing transmission circuit (the part of the existing Oldstreet-Woodland 400 kV line installed on double circuit towers) and the proposed north-south transmission circuit are described. The EMF calculations for the various aspects of this project are provided in greater detail in **Section 8.7** Technical Calculations.

4 This chapter also discusses the criteria applied within Ireland and elsewhere in the European Union (EU) to assess the potential for any significant health or environmental impacts. The scientific weight-of-evidence process by which health and scientific agencies review and assess research is described and the conclusions of reviews by national and international agencies are summarised. Discussion of known effects from high-level short term exposures, and compliance of the proposed development with the guidelines that are established to prevent such effects are also discussed. To respond to questions from the public, a review of recent scientific research relating to EMF exposures to humans, animals, and plants whose exposures generally fall below these exposure criteria limits is provided. Notwithstanding the absence of any conclusions from health and scientific agencies that exposures to EMF at levels associated with the proposed project are harmful, a consideration of precautionary actions that address the concerns of some stakeholders including landowners and nearby residents is discussed and EirGrid‘s response to these recommendations is noted.

5 Except for limited segments of the proposed route, the EMF calculations presented in this section describe the expected levels of EMF associated with the operation of the proposed transmission line for almost the entire route between the existing substation in Woodland, County Meath and the new terminal substation proposed in Turleenan, County Tyrone. More detailed information in respect to EMF levels in the vicinity of the remaining short sections of the alignment are set out in **Section 8.7** as well as in Chapter 5, **Volume 3C** of the EIS, in relation to the few spans of the transposition alignment in the Cavan Monaghan Study Area (CMSA)

and Chapter 5, **Volume 3D** of the EIS, in relation to the levels associated with the last 2.85km of the route that connects to the Woodland Substation in the Meath Study Area (MSA) on double-circuit towers.

8.2 OVERVIEW OF ELECTRIC AND MAGNETIC FIELDS

6 In our modern environment, people are surrounded by both natural and manmade sources of EMF. Natural sources include, for example, the earth's static magnetic field, which has been used for navigation for hundreds of years, and the electric fields present in the atmosphere due to air turbulence, which can increase to very high levels resulting in lightning during thunderstorms. Electricity is also an integral part of life, as brain and nerve functioning and movement of muscles and the heart are all the result of electric impulses. Various manmade sources include, for example, the electricity we use in our homes and radio waves used for communications purposes.

7 Electricity produces two types of fields—electric fields and magnetic fields. Electric fields are created by voltage potentials or differences in voltage between two locations or objects. The unit of measurement for electric field strength is volt per meter (V/m). The greater the potential between two points the higher the resulting electric fields. Higher electric field levels are expressed in kilovolts per meter (kV/m); where 1kV/m is equal to 1,000V/m. Typical electric field levels at ground level in fair weather are around 100V/m.

8 Magnetic fields are created by the flow of electric current (i.e. by the flow of electrical charges). Magnetic field strength is expressed by flux density and measured in units of Tesla (T). Levels of magnetic fields common in our environments are expressed in microtesla (µT); where 100,000µT is equal to 1T. The earth's magnetic field is approximately 50µT in Ireland. In some parts of the world, magnetic fields are expressed in units of milligauss (mG); where 10mG is equal to 1µT.

9 A common feature of electric and magnetic fields is that they both diminish quickly with distance from the source. One main distinction is that electric fields are effectively blocked by conducting objects—trees, shrubbery, fences, buildings, even the human body—while magnetic fields are not effectively blocked by conducting objects.

8.2.1 Electromagnetic Spectrum

10 Electromagnetic energy is characterised by frequency (i.e. the number of times electromagnetic energy changes direction and completes a full cycle per second). Frequency is expressed in hertz (Hz) or multiples of Hz, such as kilohertz (kHz), megahertz (MHz), or gigahertz (GHz). A related characteristic of electromagnetic energy is its wavelength, which is inversely associated

with frequency. Low frequency energy has a long wavelength, while high frequency energy has a short wavelength. The frequency and wavelength of electromagnetic energy are key factors in its interaction with objects and living things. The coupling of an electromagnetic field to an object is greatest when the wavelength of the field is similar to the size of the object. The electromagnetic spectrum includes frequencies from 0Hz (static fields associated with direct current (DC)) and the extremely low frequencies (ELF) of 3-300Hz[78] at the lower end, through radio waves and microwaves (frequencies in the several hundred kHz to MHz and GHz) and visible light, up to X-rays and gamma rays with frequencies of billions of Hz. The energy level of electromagnetic fields is dependent on the frequency and wavelength of the fields. High frequency fields have high energy and are able to ionise atoms, that is, they are able to dislodge electrons from their path around their atomic nucleus, potentially causing damage in living cells. Frequencies in the radio wave and microwave range (which is used, for example, in microwave ovens) may be able, at very high levels, to result in tissue heating. On the other hand, lower frequency fields, such as ELF EMF, have very little energy and have no ionizing or tissue heating effects.

11 On the electromagnetic spectrum, electric and magnetic fields associated with the power system are in the ELF range. Electricity, which is a source of electric and magnetic fields, is transmitted in the power system in Ireland primarily as alternating current (AC) at a frequency of 50Hz with a wavelength of approximately 6,000km. These ELF fields do not couple well to organisms because of their long wavelength. As a contextual reference, a radiofrequency field at a frequency of 800MHz, has a wavelength of 37cm, more similar to the diameter of the human body, which allows for more efficient coupling. At sufficiently high intensities, radio frequency energy in the very high frequency range can heat tissue, while ultraviolet light and higher frequency energy can damage cells directly. Electromagnetic energy with a low frequency and long wavelength, such as ELF EMF, needs to be considered separately from energy at these higher frequencies and shorter wavelengths when evaluating the potential health effects of interactions with living things.

8.2.2 ELF EMF Sources and Exposure Considerations

12 All components of the AC electric power system in Ireland and the rest of Europe that generate and transmit electricity, such as generating stations, substations, transmission and distribution lines, and domestic wiring, produce 50Hz ELF EMF. In addition, anything that uses electricity in our homes, schools, and workplaces (for example, household appliances, power tools, and

[78] The primary source of ELF fields in most environments is AC electricity supplied by the electric power system.

various types of electric equipment) is also a source of ELF EMF. Both electric and magnetic fields diminish quickly from the source. Electric fields are produced due to voltage potential between two points, even when there is no flow of electricity. For example, electric fields are present when an electric appliance is plugged in, even if it is not turned on. Magnetic fields are produced due to the flow of current; for example, an appliance needs to be turned on to produce a magnetic field. Electric fields are easily shielded or blocked by conductive objects, such as trees and other vegetation, and building materials. Consequently, indoor exposure to electric fields is largely dependent on indoor sources. Magnetic fields are not effectively shielded by conductive objects; therefore, even indoor exposure may be influenced by both indoor and outdoor sources. Magnetic fields are also easier to measure in practice. These are among the reasons that most of the EMF health research over the past 30 years has focused on magnetic fields rather than electric fields. In 2007, the World Health Organisation (WHO) concluded "*Following a standard health risk assessment process, the Task Group concluded that there are no substantive health issues related to ELF electric fields at levels generally encountered by members of the public*" (WHO, 2007a).

8.2.2.1 Background Levels

13 Electricity increasingly has become part of daily life over the past 100 years and modern life could not be imagined without it. Sources of common exposure are the wiring in homes and buildings, electrical appliances and equipment used in the home or in work environments, the transmission lines that carry electricity from generating stations to substations, and the distribution lines that deliver power locally.

14 Distribution lines have a lower voltage and carry less current, but are more common and can be a greater source of ELF EMF because of their closer proximity to homes than transmission lines. The equipment within substations is not a common source of exposure because EMF levels drop off quickly with distance, so the exposure levels at the fence lines around substations, generally, are at background levels (i.e. the levels typically measured at distances from all sources in one‘s environment). The dominant sources near substations are the power lines that connect to them.

15 There are no surveys of background levels of magnetic fields that have been conducted in Ireland, but several have been conducted in the United Kingdom. Since the power grid and household characteristics are similar to that of Ireland, the information is useful to evaluate typical background levels. The Health Protection Agency (HPA) estimates background magnetic field levels in the United Kingdom are between 0.01μT and 0.2μT. An evaluation of three studies in which spot measurements were recorded in 684 homes in Great Britain, computed a geometric mean magnetic field level of 0.038μT (Swanson and Kaune, 1999).

Based on limited data, they calculated that personal exposure of most persons is approximately 40% higher than these spot measurements, which is consistent with the HPA's determination.

8.2.2.2 Exposure from Appliances

16 The strongest sources of magnetic fields encountered indoors are electrical appliances, power tools, and other electrical equipment. While the intensity of these fields may diminish with distance from the source more rapidly than fields from transmission lines, they are nonetheless a very important contributor to a person's overall background magnetic field because of the proximity and frequency of use. Preece et al. (1999) sampled magnetic field levels of a variety of common appliances in 50 homes in the United Kingdom. Measurements were taken at a distance of 50cm using a procedure that best characterised exposure in normal use (see **Table 8.1**). In a separate analysis, Mezei et al. (2001) showed that domestic appliances may be substantial contributors to personal magnetic field exposures, particularly at higher exposure levels.

Table 8.1: Average Magnetic Field Level from Appliances Measured at 50cm

Appliance	Magnetic Field (µT)
Clock radio	0.05
Dishwasher	0.82
Electric shower	0.48
Microwave	1.65
Washing machine	1.00
Vacuum cleaner	0.78

Source: Preece et al., 1999, p. 73

8.2.2.3 Transmission and Distribution Lines

17 In outdoor environments, among the most common sources of magnetic fields are distribution and transmission lines. Since the intensity of magnetic fields diminishes quickly with distance from the source, however, the contribution to indoor magnetic field levels from transmission lines is usually not extensive or common as they are typically situated farther from buildings than distribution lines and other lower voltage sources. Magnetic field levels from transmission and distribution lines depend on the amount of current carried at any one time and the various engineering and design characteristics of the lines. In an AC transmission system, the amount of current (load) depends on customer demand, so magnetic field levels are commonly reported

at average load and peak load. Generally, peak load operates about 1% of the time and is about twice the level of average load (NIEHS, 2002).

18 Transformers and other equipment within substations are sources of magnetic fields, but, as mentioned above, they have little or no impact on exposure of the general public because experience indicates that EMF levels from substations –*attenuate sharply with distance and will often be reduced to a general ambient level at the substation security fencing. The exception is where transmission and distribution lines enter the substation”* (IEEE Std. 1127-1998). A survey conducted by the National Radiological Protection Board[79] in 2004 of representative local substations in the United Kingdom supports this conclusion (HPA, 2004). Magnetic field levels at enclosure boundaries overall were 1.1μT, while at distances of 5m to 10m outside the substation fence, the magnetic field was not detectable above between 0.02μT and 0.05μT. Consistent with the finding of the Institute of Electrical and Electronics Engineers (IEEE), along the path of cables entering the substation, the magnetic field was measured at 1μT. The National Grid in the United Kingdom conducted a similar survey of suburban substations. Magnetic field levels of 1.9μT diminished by more than half at 1.3m. In the vicinity of nearby housing at about 5m, the fields could not be distinguished from other background sources (HPA, 2004).

8.2.2.4 Personal Exposure

19 Each person‘s exposure to magnetic fields is determined by the environments where they spend time, the sources encountered in those environments, and the duration of exposure. Personal exposure during any given period may be characterised in several ways. For example, one can use measures of central tendency, such as mean and median; measures of peak exposures, such as the maximum levels, or fraction of time spent above certain exposure levels; or rate of change metrics, indicating how field levels fluctuate over time. Each of these exposure metrics are specific to the time period they represent, may change over time, and may rank the same individuals in different orders. Since it is not known which of these exposure metrics, if any, exerts any potential influence on biological processes and health, research studies most commonly describe and evaluate time-weighted average (TWA) exposures.

[79] The National Radiological Protection Board was merged into the Health Protection Agency of Great Britain in 2005 and the Health Protection Agency has since been folded into Public Health England in 2013.

20 Numerous exposure assessment methods have been developed to estimate personal exposure to magnetic fields. These methods include calculated historical fields based on transmission line characteristics near the subject‘s residence; wearing personal exposure meters by the study subjects; short term stationary, so called, spot measurements; wire code categories; residential distance to transmission facilities; and job-exposure matrices. The methods that use surrogates of actual magnetic field measurements—calculated historical fields, wire code categories, distance, and job exposure matrices—are commonly used in epidemiology studies of magnetic field exposure and health because participation of individuals is not required and data are easy and inexpensive to collect. These methods, however, are indirect and do not take into account all sources of exposure. In addition, it is often unclear whether the study subjects were actually exposed at the levels estimated.

21 Monitoring a person‘s personal exposure levels with a recording magnetic field meter is more accurate, but this type of measurement is often utilised for a short period (24 or 48 hours). This method will capture all magnetic field exposure from all sources while the meter is worn, but does not take into account short- or long term variations a person experiences from day to day or year to year, so may not fully represent past exposure (WHO, 2007b). This is especially problematic in studies of childhood diseases, when the children‘s exposure may be measured after disease development, long after the time period when the exposure may potentially be etiologically relevant.

22 Brief encounters with high magnetic field levels, such as while walking under a transmission line, in front of the refrigerator at home, or at a grocery store next to a freezer, would not significantly alter a person‘s TWA exposure because such a small amount of time is spent at these locations. On the other hand, an appliance such as a clock-radio on the nightstand in a bedroom, which produces a relatively weak magnetic field, may contribute more to a person‘s TWA exposure because of the many hours spent in bed. A failure to distinguish between spot measurements of magnetic fields at one location at one point in time and long term exposure from many sources over time is a common source of confusion when assessing environmental exposure levels (Bailey and Wagner, 2008).

8.3 ELECTRIC AND MAGNETIC FIELDS (EMF) FROM THE PROPOSED DEVELOPMENT

23 The portion of the proposed interconnector occurring within Ireland (referred to as the North-South 400 kV Interconnection Development – ‗the proposed development‘) has been evaluated as one project, however, for the purposes of presenting the information in this EIS, it has been subdivided into two sections, the CMSA (**Volume 3C** of the EIS) and the MSA (**Volume 3D** of the EIS). For a full understanding of the development being proposed by EirGrid all volumes of this EIS and the Consolidated Environmental Statement (ES) should be read.

24 In addition to being addressed in this chapter of the EIS, EMF is addressed in Chapter 5, **Volumes 3C** and **3D** of the EIS. In the ES prepared by NIE, EMF is addressed in Chapter 7, **Volume 2** of the ES. A map of the proposed interconnector, highlighting the CMSA and MSA in Ireland, as well as the portion in Northern Ireland, is shown in **Figure 8.1**. Also highlighted in this figure are the proposed Turleenan Substation in County Tyrone and the existing Woodland Substation in County Meath.

25 The EMF from the proposed transmission development is determined by the particular configuration and tower-type used in different portions of the route rather than by reference to a particular study area. The discussion of the EMF from the proposed transmission line therefore is divided into these separate transmission line tower cases. Over the vast majority of the project route, the proposed transmission line will be supported on intermediate lattice towers, as shown in **Figure 8.2**. In short portions elsewhere along the route, the transmission line is proposed to be built in two additional configurations: Double-Circuit Lattice Towers in the MSA portion of the route and Single-Circuit Transposition Towers in the CMSA portion of the route. These configurations are discussed further in **Section 8.7** as well as in Chapter 5 of **Volumes 3C** and **3D** of the EIS, respectively.

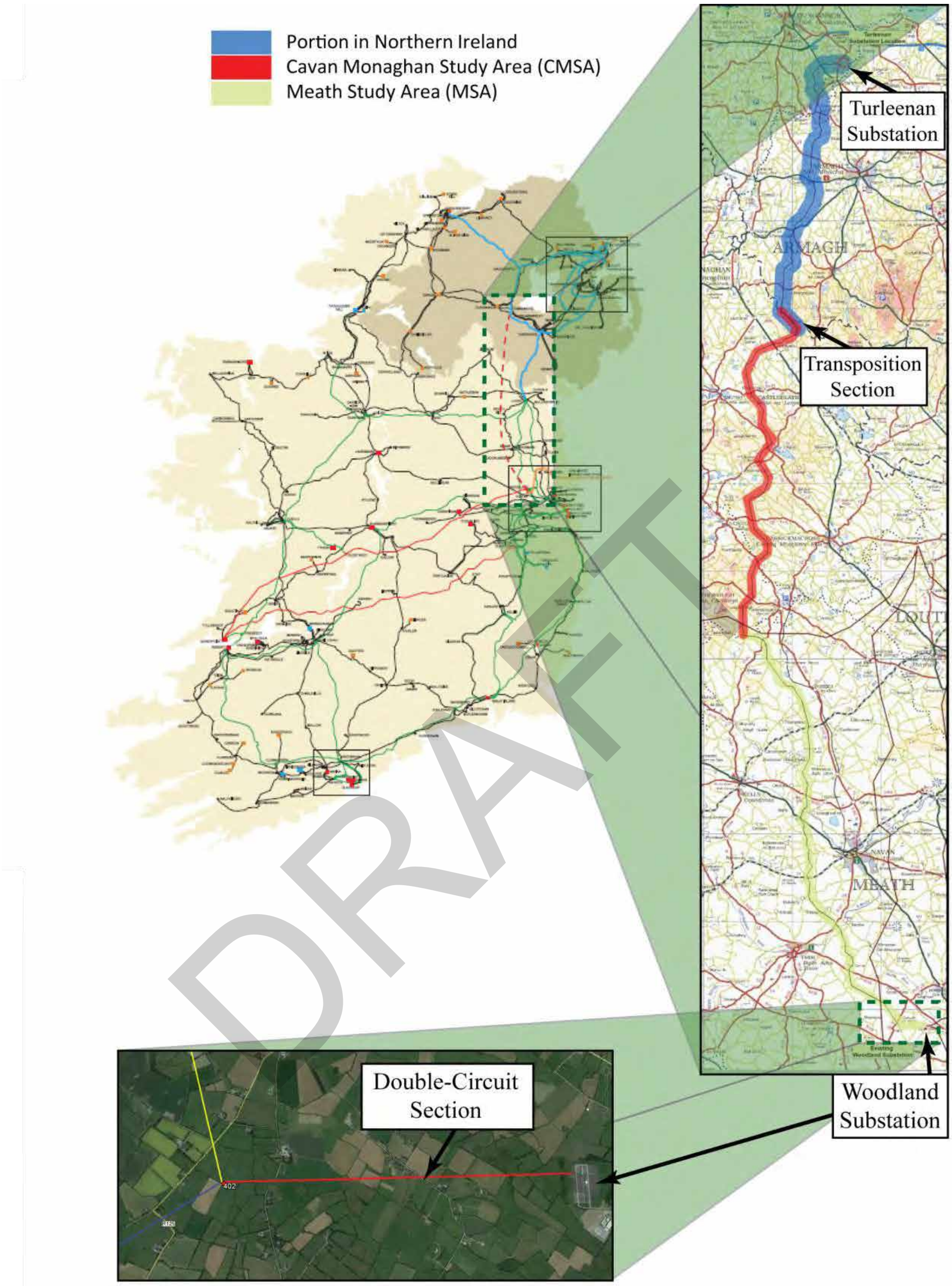


Figure 8.1: Map of the Proposed Interconnector Showing the Proposed Transmission Line Route

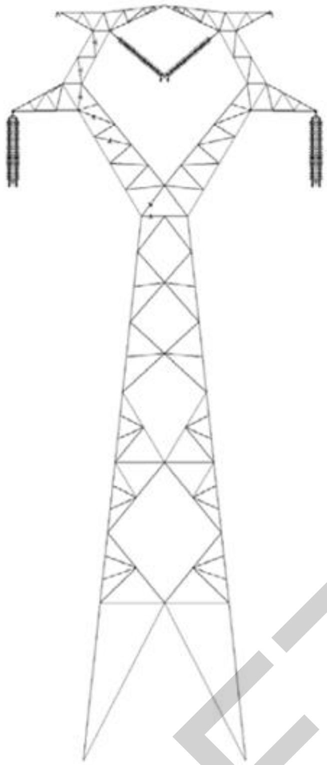


Figure 8.2: Intermediate 400 kV Lattice Towers for the Proposed Development

8.3.1 Magnetic Fields

26 The magnetic field associated with the Single-Circuit Intermediate Lattice Tower portion of the transmission line is shown in **Figure 8.3** for both average and peak loading[80]. The maximum magnetic field is calculated directly beneath the lines to be approximately 16μT at average loading. The magnetic field intensity diminishes with distance to about 1.0μT at a distance of 50m and to approximately 0.25μT at a distance of 100m from the centreline, a reduction by a factor of 64. Under peak loading conditions, the magnetic field levels will be higher. Peak loading is expected to occur rarely, perhaps only for a few hours per decade. Nevertheless, it is considered here in order to assess the conditions likely to produce the highest magnetic field

[80] The term ‗average' loading used in this EIS is intended to convey the same meaning as ‗indicative typical' loading used in the Consolidated ES.

levels[81] for the purpose of demonstrating that even in such emergency loading conditions of short duration, the proposed development will comply with applicable EMF guidelines. Under this rare scenario, the maximum magnetic field level beneath the line is calculated to be approximately 48μT, well below the restriction levels specified in the guidelines shown in **Table 8.2**. The maximum magnetic field level, as well as field levels at ±50m and ±100m from the centreline are shown in **Table 8.5** and **Table 8.6** in **Section 8.7** for average and peak loading, respectively.

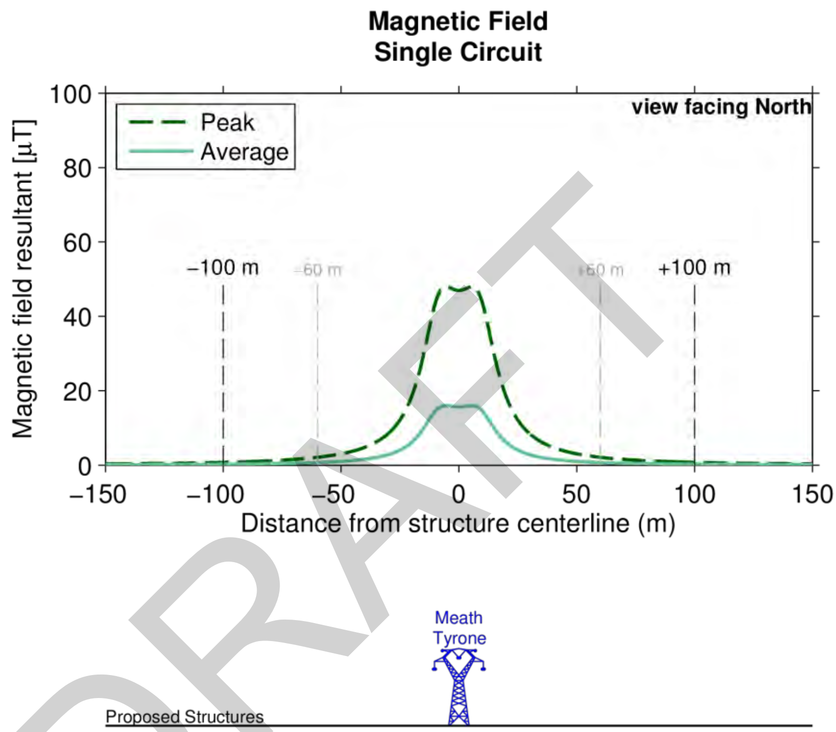


Figure 8.3: Calculated Magnetic Field Profile for the Proposed Intermediate Lattice Tower Configuration for Average and Peak Loading

[81] This scenario is the combination of a number of factors including 1,500MVA loading, 400 kV operating voltage and 9m minimum midspan conductor clearance. This is estimated to occur for only a few hours per decade, and only in limited locations.

8.3.2 Electric Fields

27 The electric field level associated with the Single-Circuit Intermediate Lattice Towers is shown in **Figure 8.4.** The maximum electric field levels beneath the transmission line is calculated to be approximately 7.9kV/m, and decreases to 0.20 kV/m at 50m, a 40-fold decrease, and below 0.04kV/m beyond approximately 100m from the transmission centreline, almost 200-fold lower than under the line. The electric field level is not directly affected by transmission line loading and results are presented for 400 kV operating voltage and 9m minimum midspan conductor height. The highest calculated electric field level, as well as field levels at ±50m and ±100m are shown in **Table 8.7** in **Section 8.7**.

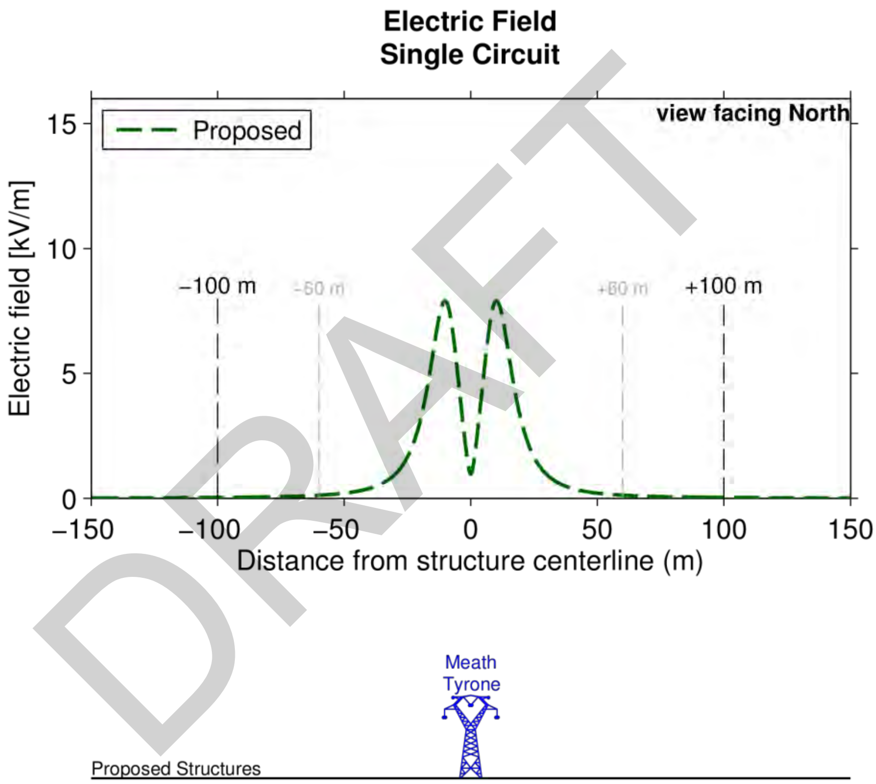


Figure 8.4: Calculated Electric Field Profile for the Proposed Intermediate Lattice Tower Configuration

8.4 COMPLIANCE WITH EXPOSURE GUIDELINES

8.4.1 Exposure Guidelines from International Organisations

28 International guidelines for both public and occupational exposure to ELF EMF were issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1998 and updated in 2010 (ICNIRP 1998, 2010). The EU used the 1998 guideline as the basis for guidelines on human exposure to ELF EMF from power sources that they incorporated into their recommendation for locations where people spend significant time (EU, 1999) and their directive on occupational exposure (EU, 2004). Numerous countries worldwide have also adopted or follow the ICNIRP guidelines. In Ireland, the Communications Regulator and the Commission for Energy Regulation have adopted the ICNIRP guidelines (DCMNR, 2007). A new directive on occupational exposure to ELF EMF, Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 which is based on the 2010 ICNIRP guidelines, has been passed by the EU.

29 In determining its guidelines, ICNIRP's main objective was “*to establish guidelines for limiting exposure to electric and magnetic field (EMF) that will provide protection against all established adverse health effects*.” ICNIRP conducted a thorough weight-of-evidence review of the cumulative research at the time (in both 1998 and 2010) and concluded that the epidemiologic data were too weak and not sufficient to establish any guidelines. The evidence on chronic effects of long term exposures did not conclusively indicate that ELF EMF exposure contributed to any health effect, including cancer. They did determine, however, that short term, neurostimulatory effects could occur at very high field levels and established guidelines to protect against these effects, which include perception, annoyance, small electrical discharges (microshocks), and the stimulation of nerves and muscles. These responses to exposure are transitory and non-life threatening. To allow for uncertainties that may be present in scientific data, further reductions in limits by safety factors have also been applied when exposure guidelines were established. The ICNIRP guidelines are summarised in **Table 8.2**.

30 The International Committee on Electromagnetic Safety (ICES), which operates under the rules and oversight of the IEEE Standards Association Board, also published guidelines for limiting public exposure to ELF EMF (ICES, 2002). They also adjudged that evidence for effects from long term exposure to low levels of EMF was insufficient for setting an exposure standard. The reference levels for whole body exposure to 50Hz fields for the general public are presented in **Table 8.2**.

31 Both ICNIRP and ICES set limits on exposure based on the physical quantities directly related to the established health effects. These are internal doses, termed ‗basic restrictions‘ that should not be exceeded. For EMF exposure, the basic restriction is specified in internal electric field strength. Since internal doses are difficult to measure directly, ICNIRP establishes and publishes ‗reference levels‘ that set forth levels of environmental exposures that, if not exceeded, would guarantee that the basic restrictions are met. These basic restrictions are listed in **Table 8.2**. For comparison, maximum permissible exposures (MPE) recommended by ICES and exposure levels required to produce the basic restriction on internal electric fields are also included in **Table 8.2.**

32 If environmental exposures exceed the reference levels or MPE values that does not mean that the basic restriction is exceeded; rather additional dosimetric determination is needed. Both organisations incorporate large safety factors, that is, basic restrictions in the guidelines are set at levels well below levels where effects are known to occur. These safety factors are implied to account for scientific uncertainty, potential variability in the population, and a hypothesised greater likelihood of effects in susceptible populations.

8.4.2 EirGrid's Compliance with Exposure Guidelines

33 EirGrid regards the protection of the health, safety, and welfare of its staff and the general public as a core company value in all of its activities. It is EirGrid‘s policy to design and operate the network to the highest safety standards and to continually review and update its standards in light of new developments and research findings. EirGrid will continue to implement the following mitigation measures:

- Design and operate the transmission system in accordance with the most up-to-date EU recommendations and guidelines of the various independent authoritative international expert bodies;
- Closely monitor and support engineering and scientific research in this area, and;
- Provide information to the general public and to staff on the issue of ELF EMF.

34 In addition, EirGrid‘s standard route planning criteria complies with all authoritative international and national guidelines for ELF EMF exposure and generally seeks to avoid heavily populated areas. Thus, the proposed line will be routed as far from existing homes as is reasonably possible.

35 EirGrid‘s position on ELF EMF and health is based solely on the conclusions and recommendations of established national and international health and scientific agencies that have reviewed the body of literature. These panels have consistently concluded that the

research does not suggest that ELF EMF causes any adverse health effects at the levels encountered in our everyday environment and compliance with the existing standards from ICNIRP provides sufficient public health protection.

Table 8.2: General Public Reference Levels (ICNIRP) and Maximum Permissible Exposure (ICES) and Exposure Levels Estimated to Produce Internal Current Densities and Electric Fields Equal to Basic Restrictions

Agency	Magnetic Field (µT)	Electric fields (kV/m)
ICNIRP (1998)		
Reference Level	100	5
Basic Restriction[a] exposure	364	9.22
ICNIRP (2010)		
Reference Level	200	5
Basic Restriction[b] exposure	200[c]/ 474[d]	9.9[d]
ICES		
Maximum Permissible Exposure	904	5 or 10[e]
Exposure = Basic Restriction[f]	361[g]	10.7[g]

[a] Basic Restriction is $2mA/m^2$ in the head. Calculated field levels from Dimbylow (2005).

[b] Basic Restriction is 20mV/m in CNS of head.

[c] Magnetic field level of 200µT described in ICNIRP (2010).

[d] Calculated magnetic and electric field value from Dimbylow (2005).

[e] ICES determined an exception of 10kV/m within transmission line rights-of-way because persons do not spend any significant amount of time here and very specific conditions are needed for a response to occur (ICES, 2002, p. 27).

[f] Basic Restriction is 5.89mV/m in the brain.

[g] Field levels calculated from Kavet et al (2012).

8.5 ELF EMF HEALTH RESEARCH

36 Research on potential health effects related to ELF EMF has been conducted for several decades. Studies prior to the 1970s mostly focused on direct effects of short term exposures, the basic nature of ELF EMF, and its interaction with the human body. Concerted research effort on potential health effects of low level, long term exposure to ELF EMF started following the publication of an epidemiology study that suggested a statistical association between childhood cancer and distribution power line characteristics near the children‘s homes (Wertheimer and Leeper, 1979). This study was followed by a large number of publications in the peer-reviewed scientific literature on various aspects of potential health effects of ELF EMF. The ensuing studies include numerous epidemiology studies on various health outcomes among both adults and children—cancers and non-cancerous diseases, such as heart disease

and reproductive effects—and consider various degrees of residential, occupational, and environmental exposure to ELF EMF. The published ELF EMF literature also includes a large number of experimental studies of both humans and laboratory animals (in vivo studies) and studies of potential effects on cells and tissues (in vitro studies). Over the past four decades, potential effects of ELF EMF on a number of health endpoints were suggested, but to date no causal link has been confirmed with any health outcome.

8.5.1 The Weight of Evidence Review Process

37 Scientific agencies and organisations have developed standard scientific methods to guide systematic evaluations of research and promote unbiased assessments of potential risk for developing exposure limits to protect human health (NRC, 1983; HCN, 2009, Section 3; IARC, 2002, preamble; ICNIRP, 2003; USEPA, 2005; S SCENIHR, 2009b, SCENIHR, 2012, 2013. Adherence to standard scientific methods helps to minimise or eliminate subjectivity in the evaluation and interpretation of scientific data. These methods require a systematic identification of relevant peer-reviewed literature[82] including epidemiology studies in humans, studies in laboratory animals (in vivo), and studies in cells and tissues (in vitro). Each identified study then needs to undergo a systematic review to assess the quality of study design and methods of analysis and evaluation. Flaws in the design or completion of a study may affect its reliability. Since no study is perfect, more weight is given to studies of higher quality—thus, the term weight-of-evidence review.

38 For proper health risk assessments, national and international scientific and health agencies put together multidisciplinary panels of scientists with the relevant expertise (e.g. epidemiology, neurophysiology, exposure assessment, and toxicology) to conduct weight-of-evidence reviews. Each of the three types of research studies has complementary strengths and limitations, thus the integration of the results of the different approaches are important in weighing evidence by the expert panels. While epidemiology studies are conducted in the species of interest (humans), they tend to be limited due to their observational nature and because they are not conducted under controlled exposure conditions. In vivo studies are valuable because they are conducted under controlled exposure conditions, and often are designed to include high levels of exposures frequently well above levels to which people are exposed; however, they result in

[82] The inclusion of peer-reviewed studies ensures that they have already passed a quality control review. Scientific journals typically have manuscripts reviewed by two or more experts in the field in addition to members of the editorial board to scrutinise for scientific merit and appropriateness of study design, analytical methods, and presentation of results prior to publication. While peer review is one measure to ensure that papers with inappropriate methods or flawed conclusions are screened out, publication of a paper in a peer-reviewed journal by no means guarantees the overall validity of the published study. The system of peer review has its limitations, and, in fact, true peer review in a wider sense starts with the publication of the scientific manuscript (Poole 1996; Bohannon, 2013).

some scientific uncertainty since the predictive value of extrapolating animal data to human health effects may vary. In vitro research is conducted to determine the potential mechanism for an adverse effect. It is, however, difficult to directly extrapolate results from in vitro studies to what actually would occur in the human body, as in vitro studies are not able to consider the body's overall compensatory and regulatory mechanisms.

39 Conclusions by multi-disciplinary review panels are reached considering the cumulative body of research, giving more weight to studies of higher quality. The conclusions of these reviews typically represent a consensus opinion of the experts participating in the panel.

8.5.2 The Weight of Evidence Evaluation of Carcinogenicity

40 The International Agency for Research on Cancer (IARC) is an agency of the WHO and is considered the primary organisation for cancer risk assessment. IARC regularly and systematically reviews various physical and chemical agents and exposure scenarios, such as various occupations, to determine their potential for carcinogenicity in humans. In their evaluations, IARC considers two main streams of evidence—epidemiology and laboratory animal (in vivo) studies. IARC also considers studies in cells and tissues (in vitro studies) to provide additional input on potential mechanism of effects, and exposure assessment studies to better understand potential impacts of the exposure in our daily life.

41 The IARC process applies a weight-of-evidence review to evaluate potential risk, which first includes classification of the evidence obtained from epidemiology and in vivo studies into one of the following categories.

- The evidence is considered *sufficient* when a causal relationship can be established between exposure and cancer; in epidemiology studies, a positive relationship has been observed between the exposure and cancer in studies in which chance, bias, and confounding could be ruled out with reasonable confidence; and for in vivo studies, increased incidence of cancer was observed in high quality studies in at least two species or from two independent laboratories.

- The evidence is *limited* if a credible positive association is observed but chance, confounding, or bias could not be excluded as explanations in epidemiology studies, and if the association is limited to one experiment or there are unresolved questions regarding adequacy of design features in laboratory animal studies.

- The evidence is *inadequate* if there is insufficient quality, consistency, or statistical power in epidemiology studies, and if there are major qualitative or quantitative limitations or lack of data from *in vivo* studies. In vitro research provides ancillary information and, therefore, is used to a lesser degree in evaluating carcinogenicity and is classified simply as strong, moderate, or weak.

42 Based on the above assessments, the agents are then classified into five overall categories (listed from highest to lowest risk): (1) carcinogenic to humans, (2) probably carcinogenic to humans, (3) possibly carcinogenic to humans, (4) not classifiable, and (5) probably not carcinogenic to humans. The category “possibly carcinogenic” typically denotes exposures for which there is limited evidence of carcinogenicity in epidemiology studies, and in vivo studies provide limited or inadequate evidence of carcinogenicity. IARC has reviewed over 900 substances and exposure circumstances to evaluate their potential carcinogenicity. Over 80% of exposures fall in the categories possibly carcinogenic (29%) or not classifiable (52%). This occurs because in science it is nearly impossible to prove the absence of an effect (i.e. that something is completely safe). Few exposures show a clear-cut or probable risk, so most agents will end up in either of these two categories. Throughout the history of the IARC, only one agent has been classified as probably not carcinogenic to humans, which illustrates the conservatism of the evaluations and the difficulty in proving the absence of an effect beyond all doubt.

8.5.3 Weight-of-evidence Reviews of ELF EMF Health Studies

43 Over the years, numerous reviews were performed to thoroughly evaluate and synthesize available scientific evidence on whether exposure to ELF EMF may result in potential adverse health effects. These reviews were performed periodically by multidisciplinary expert panels of national and international scientific and governmental health organisations and followed the weight-of-evidence review process that considers and weighs the available evidence in the respective scientific area. These weight-of-evidence evaluations guide future research priorities, lead scientific organisations to recommend limits and guidelines, and assist governmental organisations to establish regulations to reduce or limit exposure that may result in adverse effects.

8.5.3.1 Conclusions of International Review Bodies

44 In the past decade, weight-of-evidence reviews of the ELF EMF health research literature have been conducted by a number of international and national expert panels, including those by the IARC, WHO, and ICNIRP.

45 IARC evaluated the ELF EMF literature for carcinogenicity in 2001 (IARC, 2002). Overall, ELF magnetic field exposure was classified in the 2B category as ‗possibly carcinogenic to humans‘, based on limited evidence from childhood leukaemia epidemiology studies and inadequate evidence from laboratory animal studies. The IARC conclusion was heavily influenced by two

pooled analyses that combined and analysed data from available childhood leukaemia epidemiology studies (Ahlbom et al., 2000; Greenland et al. 2000). While the pooled analyses showed a statistical association, neither in vivo laboratory studies including lifetime rodent bioassays, nor mechanistic studies provided any support for a carcinogenic effect. Evidence for all cancers, other than childhood leukaemia, was considered inadequate for ELF magnetic fields as was evidence for all cancers with respect to ELF electric fields.

46 The Environmental Health Criteria (EHC) published by the WHO in 2007 contains a weight-of-evidence evaluation of the scientific literature relevant to potential effects of ELF EMF on both cancer and non-cancer human health outcomes. For ELF electric fields at the levels generally encountered by members of the public, the EHC concluded that there are no substantive health issues and did not recommend future epidemiologic research related to electric fields.

47 With respect to ELF magnetic fields and cancer outcomes, the EHC concluded that recent studies did not change the IARC classification of ELF magnetic fields as ‗possibly carcinogenic' based on limited epidemiologic evidence and inadequate evidence from in vivo studies. The WHO panel recognised the statistical association between childhood leukaemia and estimates of exposure to high levels of magnetic fields, but could not rule out the possible effect of other factors (chance, bias, and confounding) on these results. Thus, when limited epidemiologic data were considered along with the largely negative findings from experimental studies, the WHO panel stated that the cumulative evidence was not strong enough to conclude that magnetic fields are a known or probable cause of childhood leukaemia. For all other cancers and non-cancer health endpoints, including potential effects on the neuroendocrine system, reproductive effects, and neurodegenerative diseases, the available evidence were deemed inadequate. For cardiovascular diseases and breast cancer specifically, the EHC concluded that the evidence does not support an association with ELF magnetic fields.

48 ICNIRP, in its 2010 review, concluded that there are well-established acute effects of exposure to ELF EMF due to direct stimulation of nerves and muscles, induction of retinal phosphenes, and surface electric charges. Guidelines are set accordingly to prevent these effects. ICNIRP, however, in agreement with conclusions from IARC and WHO, also concluded that other than the limited epidemiologic evidence from studies of childhood leukaemia and ELF EMF, the evidence for other diseases are inconclusive or not in support for a potential causal association. With respect to the childhood leukaemia literature they conclude that ―*the currently existing scientific evidence that prolonged exposure to low frequency magnetic fields is causally related with an increased risk of childhood leuk[a]emia is too weak to form the basis for exposure guidelines*."

49 Likewise, none of the additional recent reviews of the scientific literature, conducted by the European Commission's (EC) Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR, 2009a, 2013), the European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN, 2010a), the National Radiological Protection Board of Great Britain (NRPB, 2004), the Health Council of the Netherlands (HCN, 2009), and the Swedish Radiation Protection Authority (SSM, 2013), concluded that magnetic fields are not a known, probable, or even a likely cause of any adverse health effect at the long term, low exposure levels found in the everyday environment.

50 In summary, the national and international agencies with the responsibility for protecting the health of persons in Ireland, Europe, and other countries have stated that the evidence does not indicate that ELF EMF causes any adverse health effect. They recognise that the main source of uncertainty lies with a weak but consistent association observed in some epidemiology studies that has not been confirmed or explained in experimental studies. They all recommend further well-designed research studies and continue to monitor the research and re-examine their positions periodically as new data become available.

8.5.3.2 Expert Group Evaluation of ELF EMF Health Studies for Ireland

51 The Irish Department of Communications, Marine and Natural Resources assembled an expert group in 2007 that reviewed the evidence on ELF EMF and health effects. The conclusions of this group were consistent with the conclusions noted above:

> *"There is limited scientific evidence of an association between ELF magnetic fields and childhood leukaemia. This does not mean that ELF magnetic fields cause cancer, but the possibility cannot be excluded. However, considerable research carried out in laboratories has not supported this possibility, and overall the evidence is considered weak, suggesting it is unlikely that ELF magnetic fields cause leukaemia in children. Nevertheless the evidence should not be discounted and so no or low cost precautionary measures to lower people"s exposure to these fields have been suggested*" (DCMNR, 2007, p. 3).

52 The report answers many questions commonly raised by the public in relation to EMF and health. The report confirms that the EU (1999) guidelines have been adopted by the Communications Regulator and the Commission for Energy Regulation in Ireland. One of the important points addressed in this report clarifies that –*the ICNIRP limit values apply to all exposure situations, including long-term exposures"* (DCMNR, 2007, p. 20).

8.5.3.3 Reviews of ELF EMF Health Studies by Other Groups

53 A few other groups that reviewed the literature have reached differing conclusions. For example, one review and risk evaluation was conducted by three scientists from the California Department of Health Services (CDHS) in 2002. They expressed a ‗degree of certainty‘ as to whether the increased risks of certain diseases due to exposure to ELF EMF are ‗real‘. Another review was conducted by a self-organised group of individuals from academic institutions and public interest groups. They were collectively called the BioInitiative Working Group and they published their report in 2007 and updated it in 2012. The conclusion of both of these reviews differed from the previously described weight-of-evidence reviews, and suggested that in addition to childhood leukaemia, a number of other health outcomes are linked to ELF EMF exposure. While the CDHS study was completed by scientists at a government health agency, the BioInitiative reports are a self-organised effort and were not sanctioned by any professional or scientific organisation. These reviews, particularly the BioInitiative reports, did not follow the weight-of-evidence approach and attributed importance mostly or only to studies showing some effect and discounted those that did not. These reviews also differed from previous reports in that the conclusions were not developed as consensus opinions, but were opinions of individual authors.

8.5.4 Epidemiology Research into Potential Association between ELF EMF and Childhood Cancer

54 In 1979, Wertheimer and Leeper published the first epidemiology study to suggest a statistical association between childhood cancer and residential proximity to power lines, indicating that case children with leukaemia or brain tumour lived in homes with higher ‗wire configuration codes‘ than did healthy control children.[83]

55 Some of the subsequent epidemiology studies on childhood leukaemia have shown great improvements in methodology of case ascertainment, control selection, exposure assessment, and analytical techniques. Exposure assessment in these studies included distance and calculated magnetic fields from power lines, short term and long term measurements in homes, and personal exposure measurements. When a number of relevant studies were combined in a single analysis, no association was evident at lower exposure levels, but small differences in the proportion of children with and without leukaemia that had average magnetic field exposure

[83] Wire configuration code is a classification system developed by the authors based on proximity and type of power lines in the vicinity of the children‘s residences.

greater than 0.3-0.4μT suggested a possible relationship or association (Ahlbom et al., 2000; Greenland et al., 2000). However, because of the inherent uncertainty associated with observational epidemiology studies, the results of these pooled analyses were considered to provide only limited epidemiologic support for a causal relationship. Various hypotheses were developed to explain the apparent statistical association (e.g. Fews et al., 1999), but none were considered likely or were supported by consequent epidemiology studies. Chance, bias, and confounding could not be ruled out with reasonable confidence. Further, in vivo studies (summarised in **Section 8.5.7**) have not found that magnetic fields induce or promote cancer in animals exposed for their entire lifespan under highly-controlled conditions, nor have in vitro studies (summarised in **Section 8.5.8**) found a cellular mechanism by which magnetic fields could induce carcinogenesis.

56 More recent epidemiology studies of childhood leukaemia have not materially changed the overall evidence. In 2010, Kheifets and colleagues conducted a pooled analysis of childhood leukaemia studies published between 2000 and 2010 to evaluate if more recent studies provide new insight regarding the nature of the association. While it also showed a positive association at exposure levels above 0.3 and 0.4μT, the association was statistically not significant and weaker than in the Ahlbom et al. (2000) and Greenland et al. (2000) pooled analyses. A recent meta-analysis (Zhao et al., 2013), that relied upon reported numbers of cases and controls in nine case-control studies published between 1997 and 2013, indicated a statistical association with exposure above 0.4 μT. The analysis, as it relied on published numbers and not on individual data from the original studies, provided little new insight following the publication of the earlier pooled analyses.

57 Several recent epidemiology studies examined residential proximity to power lines and childhood leukaemia risk, but overall provided no new evidence for an association. Sermage-Faure et al. (2013) reported on residential proximity to high voltage transmission lines and childhood leukaemia development using geocoded information on residential addresses of childhood leukaemia cases and controls and power line locations in France. Overall no association was observed between childhood leukaemia risk and residential proximity to high voltage transmission lines. The authors, however, also reported a statistically not significant association in a sub analysis within 50m of 225-400 kV lines based on a small number of cases (n=9). Pedersen et al. (2014) conducted a similar study in Denmark including 1,698 childhood leukaemia cases and 3,396 healthy control children; the authors reported no statistically significant association between risk and residential proximity to 132 kV, 220 kV, and 400 kV power lines. In the largest study to date, Bunch et al. (2014) provided an extension and update to the 2005 UK study by Draper et al. The authors extended the study period by 13 years (1962-2008), included lower voltage lines (132 kV) in addition to 275 /400 kV lines, and included Scotland in addition to England and Wales in their analyses. Bunch et al. included over 53,000 childhood cancer cases and over 66,000 healthy control children and reported no overall

association with residential proximity to 132 kV, 275 kV, and 400 kV power lines for leukaemia or any other cancer among children. The statistical association with distance that was reported in the earlier Draper et al. (2005) study was not apparent in the extended analysis.

58 Another recent pooled analysis by Schüz and colleagues (Schüz et al., 2012) followed up on suggestions from earlier studies (Foliart et al., 2006, Svendsen et al., 2007) that exposure to ELF magnetic fields may promote growth of leukaemia cells and thus affect survival of children diagnosed with leukaemia. The Schüz et al. pooled analysis combined data on more than 3,000 cases of childhood leukaemia from Canada, Denmark, Germany, Japan, the United Kingdom, and the United States. Based on their results the authors concluded that exposure to ELF magnetic fields had no impact on the survival probability or risk of relapse in children with leukaemia. A study by Yang et al. (2008) assessed the genetic variation of five genes among children with leukaemia in Shanghai, China, living in the vicinity of power lines and transformers. In addition, as it has been discussed by Ioannidis et al. (2011), genetic epidemiology is particularly prone to reporting false positive associations, that is, associations that are not replicated in follow-up investigations. This is primarily due to the large number of potential genes that could be tested.

59 Unlike childhood leukaemia, no consistent associations were reported for childhood brain cancer in epidemiology studies. Both the IARC and WHO assessments concluded that the evidence for an association with childhood brain cancer is inadequate. Nevertheless, the WHO EHC recommended that, similar to the childhood leukaemia pooled analyses, a pooled analysis of available childhood brain cancer epidemiology studies also be conducted. A pooled analysis following up on this recommendation in 2010 (Kheifets et al., 2010b) included primary data from 10 studies on a total of over 8,000 children diagnosed with a brain tumour. No consistent risk increase or exposure-response relationship was observed regardless of the type of exposure metrics, cutpoints, adjustment for confounders, exclusion of particular studies, and analytical methods used.

8.5.5 Epidemiology Research into Potential Association between ELF EMF and Diseases in Adults

8.5.5.1 Breast Cancer

60 Breast cancer is the most common cancer among women in industrialised countries; thus a potential relationship with ELF EMF would have a significant public health impact. Interest in ELF EMF and breast cancer research was further motivated by a hypothesised biological

mechanism operating through the melatonin pathway.[84] It was proposed by Stevens (1987) that exposure to ELF magnetic fields may decrease production of night-time melatonin, a pineal gland hormone with tumour suppressor effects, and suppression of circulating melatonin levels was hypothesised to increase the risk of breast cancer.

61 Some observational studies in humans reported associations between decreased melatonin metabolite excretion in urine and ELF EMF exposure, particularly in certain subgroups of people. Human laboratory studies, however, were not able to consistently confirm these findings. Overall the WHO EHC concluded that available data do not indicate that ELF EMF has an effect on the neuroendocrine system.

62 Epidemiology studies of ELF EMF and breast cancer examined potential effects of residential exposure (residential proximity to power lines, estimated fields in homes), electric blanket use, and occupational exposures. While in the earlier studies there were suggestions of risk increases in subgroup analyses, more recent studies with large sample sizes, improved exposure assessment methodologies, and less potential for bias weakened the evidence for an association. In 2007, the WHO evaluation concluded that with the addition of the newer studies the evidence does not support an association between ELF EMF and breast cancer. Other scientific organisations have similarly concluded that there is strong evidence in support of no relationship between magnetic fields and breast cancer or magnetic fields and cardiovascular disease (WHO, 2007b; SSI, 2008; ICNIRP, 2010; EFHRAN, 2010a; SSM, 2010). Three recent large and well-conducted epidemiology studies of both residential (Elliott et al., 2013) and occupational exposure (Li et al., 2013, Koeman et al., 2014) to ELF magnetic fields confirmed the lack of an association with female breast cancer.

8.5.5.2 Adult Leukaemia and Brain Cancer

63 Adult leukaemia and brain cancer are among the most studied diseases in ELF EMF epidemiology. After reviewing a large number of residential and occupational epidemiology studies, both IARC and WHO concluded that the evidence linking adult leukaemia and brain cancer to ELF EMF is inadequate. Results from neither *in vivo* nor *in vitro* experimental studies, nor mechanistic considerations, provide any support for a carcinogenic effect. Although some research questions remain, the epidemiologic evidence does not support a cause-and-effect

[84] Melatonin plays a primary role in the diurnal cycle. Melatonin production is suppressed by light during the day and increased in the dark at night. With age, nocturnal melatonin production gradually decreases, sometimes to very low levels. In addition to light, which is the main determinant of melatonin production, lifestyle and dietary factors (e.g. tryptophan and alcohol) may also modify circulating melatonin levels.

relationship between magnetic fields and adult leukaemia or brain cancer (WHO, 2007b; SCENIHR, 2009a, 2013; EFHRAN, 2010).

64 Of note is a recent updated meta-analysis (Kheifets et al., 2008), conducted in response to recommendations in the WHO EHC, which combined relevant published studies on occupational ELF EMF exposure and adult leukaemia and brain cancer. While a small statistically significant increase of leukaemia and brain cancer in relation to the highest estimate of magnetic field exposure in the individual studies was observed, the authors concluded that *"the lack of a clear pattern of EMF exposure and outcome risk does not support a hypothesis that these exposures are responsible for the observed excess risk"* (Kheifets et al., 2008, p. 677).

65 The recent large case-control study of residential ELF EMF exposure and adult cancer in the United Kingdom (Elliott et al., 2013) and a large cohort study of occupational ELF EMF exposure and adult cancers in the Netherlands (Koeman et al., 2014). In another recent study, Sorahan (2012), examining cancer incidence in a cohort of 81,842 electricity generation and transmission workers, reported no excess risk of leukaemia or brain cancer with estimated occupational exposure to ELF EMF.

66 Turner et al. (2014) examined the relationship between occupational ELF EMF exposure and brain cancer in a large international case-control epidemiologic study. While the authors reported both an increase (with exposure 1-4 years prior to diagnosis) and a decrease (with the highest maximum exposure) in associations with brain cancer in some of the sub-analyses, overall there was no association with lifetime cumulative or average exposure for either main types of brain cancer (glioma or meningioma).

8.5.5.3 Other Adult Cancers

67 A number of other cancers, such as prostate, pancreatic, lung, kidney, and testicular cancers, were also investigated in relation to ELF EMF exposure. The associations, however, remain sporadic and largely inconsistent providing no basis for an association with ELF EMF exposure.

8.5.6 Potential Non-cancer Outcomes

68 In addition to various cancer types, scientists have investigated a number of non-cancer health outcomes in relation to ELF magnetic field exposure. Among those are cardiovascular disease, reproductive outcomes, neurodegenerative disease, and electromagnetic hypersensitivity.

8.5.6.1 Cardiovascular Disease

69 According to a proposed hypothesis, ELF EMF may affect heart rate variability, which is considered to be a risk factor for heart disease and acute cardiac death (Sastre, 1999). In some laboratory studies of human volunteers, ELF magnetic field exposure was associated with decreased heart rate variability (Sastre et al., 1998). In other studies no association was observed (Graham, 2000a, 2000b). While the first occupational epidemiology study (Savitz et al., 1999) specifically following up on this hypothesis appeared to support it, later studies were not able to confirm the association (Sahl et al., 2002; Johansen et al., 2002; Ahlbom et al., 2004). The overall assessment of the literature led the WHO to conclude in 2007 that "the evidence does not support an association between ELF [EMF] exposure and cardiovascular disease" (WHO, 2007b, p. 8).

8.5.6.2 Reproductive Outcomes

70 A potential link with various reproductive outcomes was also extensively investigated. The early studies on this topic did not consistently identify an association between ELF EMF and any reproductive outcome in humans (NIEHS, 1998). Two epidemiology studies published in 2002 (Lee et al., 2002; Li et al., 2002) reported an association with peak exposure to ELF magnetic fields above 1.6μT during a 24-hour personal measurement day and risk of miscarriage. No association with TWA exposure was observed in the same studies. Methodological limitations (measurements taken after, but not prior to miscarriage) pointed out by scientific expert panels (NRPB, 2004; WHO, 2007b), and the possibilities that the association may be explained by behavioural differences between women with healthy pregnancies and women who miscarried (Savitz, 2002), however, limit the interpretation of the studies and prevents the drawing of causal inference. According to the proposed ‗mobility hypothesis‘, increased frequency of nausea experienced during early pregnancies and the cumbersomeness during late pregnancies would reduce the physical activity of women with healthy pregnancies, which in turn would reduce the opportunity for exposure to elevated peak magnetic fields compared to women who miscarry. While the mobility hypothesis could not be directly evaluated in the original pregnancy studies, more recent studies demonstrated that physical activity is associated with an increased likelihood of experiencing higher peak magnetic field exposures (Mezei et al., 2006; Savitz et al., 2006). These findings, while they do not exclude the possibility of a potential effect, provide support for the mobility hypothesis. New research evaluated by SCENIHR (2013) did not show an effect of ELF fields on the reproductive function in humans. A recently published study from England (de Vocht et al., 2014) did not observe statistically significant associations between any adverse clinical birth outcomes (such as preterm birth, small for gestational age, or low birth weight) and the mother‘s residential proximity to power lines during pregnancy.

8.5.6.3 Neurodegenerative Disease

71 Among neurodegenerative disease, Alzheimer‘s disease and amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig‘s disease, have been studied most extensively in the ELF EMF research literature. Most of these studies evaluated the relationship of neurodegenerative disease and estimates of occupational exposure to ELF EMF. The earlier studies of Alzheimer‘s disease, based on patients identified at clinics and treatment centres, showed an association with estimated occupational exposure to ELF EMF. The main limitation of these studies was reliance on recall for occupational exposure assessment, which is prone to bias. Later studies, some based on occupational cohorts of electric company workers and others based on census information to identify occupations with exposure to ELF EMF, showed mixed results and could not consistently confirm the association. A major limitation of these studies was that they relied on death certificates (mortality data) to identify cases with Alzheimer‘s disease.

72 Epidemiology studies of ALS also tended to rely on mortality data and assessed disease risk in relation to exposure estimates based on the study subjects‘ occupations. In some of the studies, ALS appeared to be associated with occupations deemed ‗electrical‘ in nature. Since most of the workers in ‗electrical‘ occupations were prone to electric shocks, in addition to exposure to ELF magnetic fields, it has been suggested that electric shocks may be a possible confounder in the association. However, recent studies did not provide convincing evidence for an association with electric shocks (van der Mark et al., 2014; Vergara et al., 2014).

73 A recent meta-analysis of a large number of epidemiology studies on occupational exposure to magnetic fields and neurodegenerative disease suggested that Alzheimer‘s disease risk was moderately associated with estimated magnetic field levels (Vergara et al., 2013). There was a statistical indication, however, of publication bias favouring the publication of positive studies, which the authors concluded may at least partially explain the association for Alzheimer‘s disease. For ALS, the meta-analysis indicated a moderate risk increase as well, but it was stronger in studies using occupational titles than in studies using estimates of magnetic fields, leading the authors to conclude that exposure to magnetic fields probably does not explain the observed association for ALS.

74 Two recent studies also examined the relationship between residential exposure to ELF EMF estimated by residential proximity to power lines and neurodegenerative disease (Huss et al., 2009; Frei et al., 2013). Huss et al. (2009) evaluated mortality due to neurodegenerative disease and distance from residence to the nearest high-voltage power lines in Switzerland between 2000 and 2005. A statistically significant increase in mortality due to Alzheimer‘s disease was observed among those who lived within 50m of the nearest 220-380 kV transmission line. The association was stronger with longer duration of residence within 50m.

The study in Denmark, of improved design, used hospital discharge records to identify newly-diagnosed cases of neurodegenerative disease between 1994 and 2010 (Frei et al., 2013). No association was reported between neurodegenerative disease (including Alzheimer's disease) and residential proximity to high-voltage power lines.

75 Both studies had the same limitation in that they used distance to power lines as an exposure assessment—no magnetic field levels were estimated, although the distance measurements are reported to be more accurate in the Danish study. The Swiss study was further limited because it relied on mortality data to identify cases. Mortality statistics from a given disease do not only depend on the incidence of the disease, but also on length of survival and case fatality. Death certificates may also underreport the presence of certain diseases, such as Alzheimer's disease. The Danish study identified newly-diagnosed cases, which represents a significant improvement. SCENIR (2013) reported that these new studies do not provide convincing evidence of an increased risk of neurodegenerative diseases or dementia related to ELF-EMF exposure and do not provide support for its previous conclusion that magnetic field exposure increases the risk for Alzheimer´s disease.

76 A large study published in 2014 examined mortality due to neurodegenerative diseases (Alzheimer's, Parkinson's, and motor neurone disease) and occupational exposure to magnetic fields among more than 70,000 electric power company workers in the UK (Sorahan and Mohammed, 2014). The authors reported no statistically significant association between any of the investigated diseases and lifetime, recent or distant exposure to magnetic fields.

8.5.6.4 Electromagnetic Hypersensitivity

77 Since a number of individuals attribute various health symptoms to perceived or real exposure to EMF, a significant amount of research has been conducted and published on the subject of electromagnetic hypersensitivity (EHS) over the years. EHS is characterised by a variety of non-specific symptoms that could vary among individuals. While these symptoms may be real, and in some cases could be severe, well-conducted provocation studies of healthy or self-identified EHS subjects demonstrated that symptoms are not related to exposure to EMF and EHS subjects cannot detect the presence of fields any better than non-EHS subjects (WHO, 2005 WHO, 2007b; SCENIHR, 2007).

8.5.7 In Vivo Research

8.5.7.1 Carcinogenicity

78 The WHO EHC reviewed large-scale, long term bioassays that investigated the potential role of magnetic field exposure in cancer development in which rodents were continuously exposed to high levels of magnetic fields over the course of their lifetime (Mandeville et al., 1997; Yasui et al., 1997; McCormick et al., 1999; Boorman et al., 1999a, 1999b; Otaka et al., 2002) and found the results do not support the hypothesis that chronic magnetic field exposure increases tumour development. They reviewed other similar studies that combined magnetic field exposure with exposure to a known carcinogen to test for promotional or co-carcinogenic activity of magnetic fields (e.g. McLean et al., 1991, 1995; Rannug et al., 1993a, 1993b; Svedenstål and Holmberg, 1993; Sasser et al., 1998; Babbit et al., 2000; Mandeville et al., 2000; Heikkinen et al., 2001) and found that these studies indicate a lack of cancer promotional effect of magnetic field exposure.

79 While a group of studies conducted in a single German laboratory reported an increased incidence of 7,12-dimethylbenz(a)anthracene-induced mammary tumours in F344 rats with magnetic field exposure (Löscher et al., 1993, 1994, 1997; Mevissen et al., 1993a,1993b, 1996a, 1996b, 1998; Baum et al., 1995; Löscher and Mevissen, 1995), the results have not been replicated in a subsequent series of experiments conducted in the United States (Anderson et al., 1999; Boorman et al.1999a, 1999b). A follow-up study in the German laboratory (Fedrowitz et al., 2004) reported that magnetic field exposure enhanced mammary tumour development in one sub-strain of rats (F344) but not in another, which argues against a general promotional effect of magnetic fields.[85] Overall, the reason for the discrepancy between the studies of the German laboratory and other studies investigating the tumour-promoting potential of magnetic fields remains elusive. The overwhelming evidence available, however, indicates that magnetic fields do not act as tumour promoters. A review of more recent studies does not change this assessment (SCENIHR, 2013).

8.5.7.2 Oxidative Stress and Altered Gene Expression

80 In addition to animal bioassays of tumour development, the WHO EHC also reviewed the results of studies conducted in animals to investigate biological processes related to cancer development, including genotoxicity and non-genotoxic mechanisms (e.g. oxidative stress,

[85] The WHO concluded with respect to the German studies of mammary carcinogenesis, *“Inconsistent results were obtained that may be due in whole or in part to differences in experimental protocols, such as the use of specific substrains”* (WHO, 2007b, p. 321).

altered gene expression). Overall, the WHO concluded that the available evidence did not suggest that magnetic field exposure causes genetic damage. Further, they judged the evidence for non-genotoxic mechanisms to be limited and inconclusive. Since the WHO EHC was released, numerous additional in vivo studies have been conducted to examine the ability of magnetic fields to cause non-genotoxic and genotoxic damage (e.g. Akdag et al., 2010; Goraca et al., 2010; Okudan et al., 2010; Mariucci et al., 2010; Martínez-Sámano et al., 2010, 2012; Chu et al., 2011; Ciejka et al., 2011; Miyakoshi et al., 2012; Kiray et al., 2013). Overall, it is hard to draw any conclusions from most of these studies because of the low numbers of animals per group (i.e. low statistical power of the studies), the lack of blinded analyses in most cases,[86] variability in the exposure parameters and effect markers examined, and contradictory findings across studies.

81 Two recent well-conducted studies, however, are worth mention here. In a double-blind study, Kirschenlohr et al. (2012) reported no alterations in gene expression in white blood cells from pairs of subjects exposed to magnetic fields for 2 hours on 4 different days for 2 weeks. Gene expression was determined via microarray analysis with an emphasis on genes previously reported to respond to magnetic field exposure. In a similarly well-conducted study, Kabacik et al. (2013) looked for changes in the expression of genes in the bone marrow of juvenile mice exposed to magnetic fields. In order to confirm consistent changes with exposure, gene expression in these replicate samples was analysed in a blinded manner using multiple methods and in different laboratories. Again, no consistent changes in gene expression in response to magnetic field exposure were found. SCENIHR (2013) noted that despite new studies that have investigated potential molecular and cellular mechanisms, particularly regarding effects on reactive oxygen species, none that would operate at levels of exposure found in the everyday environment has been firmly identified.

8.5.7.3 Childhood Leukaemia Models

82 The limited epidemiologic evidence suggesting a possible link between higher than average magnetic field exposure and childhood leukaemia has led researchers to conduct studies to investigate whether certain transgenic animal models are predisposed to developing a disease condition similar to acute lymphoblastic leukaemia. The WHO EHC discusses two studies that used such model systems (Harris et al., 1998; McCormick et al., 1998), both of which reported no effects of magnetic field exposure on lymphoma development. While another study (Fam and Mikhail, 1996) reported increased lymphoma in mice with magnetic field exposure over

[86] In a blinded analysis, the investigators are not aware of the exposure status of the samples being analysed.

successive generations, it was found to be unreliable due to numerous experimental deficiencies.

83 Four similar well-conducted studies in rodents genetically predisposed to develop hematopoietic cancers or chemically initiated to develop such cancers were published since the WHO EHC. These studies involved long term exposure, sham-treatment of controls, interim sacrifices, large sample sizes, and were conducted in a blinded fashion.

84 Chung et al. (2008) reported that 21 hour per day exposure for 40 weeks to high levels of magnetic fields had no effect on the incidence of lymphoma in AKR mice; markers of genetic damage also were unaffected.[87] Similarly, Sommer and Lerchl (2006) reported that neither continuous exposure nor exposure for 12 hours per day for 32 weeks had an effect on lymphoblastic leukaemia incidence or survival time in AKR mice. Negishi et al. (2008) chemically initiated mice to develop cancer shortly after birth; then, shortly after weaning, they were exposed to magnetic fields for 22 hours per day for 30 weeks with no effect on the incidence of lymphoma development. Finally, Bernard et al. (2008) co-exposed rats to both a cancer initiator and high levels of magnetic fields, both of which were found to have no effect on the incidence of leukaemia or survival time of the animals.[88]

8.5.7.4 Melatonin Production

85 As discussed in **Section 8.5.5.1**, the melatonin hypothesis posits that exposure to ELF EMF could affect susceptibility to develop breast cancer by inhibiting melatonin production. Three recent reviews address this hypothesis (Touitou and Selmaoui, 2012; Naziroğlu et al., 2012; Halgamuge, 2013) by summarising in vivo data (both animal and human) on EMF exposures and melatonin levels with conflicting conclusions. Many of the data included in these reviews, however, also were reviewed in the WHO EHC, which concluded that the available evidence was inadequate to show an adverse effect of ELF EMF exposures on melatonin secretion or other parameters of neuroendocrine function.

8.5.7.5 Neurobiological Effects

86 The WHO EHC found only a few field-dependent responses tentatively identified from in vivo data regarding neurobiological effects, and even the most consistent effects appeared small in

[87] This study also examined the ability of magnetic fields to affect development of neurogenic tumours. Pregnant rats were initiated with an injection of ethylnitrosourea to initiate cancer and the resulting offspring exposed to high magnetic field levels for 28 or 38 weeks beginning shortly after weaning. In this case, brain tumour development was similar across three ELF EMF exposed treatment groups and sham-exposed controls.

[88] This last study is of particular interest in that the animal model used develops the B-cell acute lymphoblastic leukaemia, the same type as observed in children.

magnitude and transient in nature. Since then, various in vivo studies have been performed to examine the possible effects of magnetic fields on neurobiological functions; a few of these studies have involved human subjects.

87 Barth et al. (2010) quantitatively summarised the results of seven human experimental studies of cognitive performance in which subjects were exposed to high magnetic field levels. The authors concluded that in aggregate the studies provided little evidence for any effects of magnetic fields on cognitive function.

88 Other studies in humans have examined the effects of magnetic field exposures on electroencephalogram readings, event-related potentials, and evoked potentials. The results of some of these studies are reviewed in a recent paper by Di Lazzaro et al. (2013), who suggest that the findings may be indicative of "a slight influence on human brain activity" from magnetic fields. The authors acknowledge, however, that these studies generally suffer from a lack of reproducibility and specificity of effects.

89 One recent study investigated the possible role of magnetic field exposure on the pathogenesis of Alzheimer's disease in the aluminium-overloaded rat (Zhang et al., 2013).[89] Rats were fed an aluminium chloride solution, or exposed to high magnetic field level, or combined exposure for 12 weeks. The experiment was repeated three times and analyses were conducted in a blinded fashion. Although the aluminium-overloaded rats showed deficits in learning and memory as well as neuronal loss and increased concentrations of amyloid-β in certain regions of the brain, the rats exposed to the magnetic field did not. Further, rats that underwent the combined exposure did not exhibit increased pathogenesis or behavioural deficits compared to the rats exposed to aluminium alone. Although more research is needed to confirm these findings, the study suggests that magnetic field exposure does not precipitate development of symptoms or lesions in a model of Alzheimer's disease.

8.5.7.6 Reproductive and Developmental Effects

90 Based on the data available at the time, the WHO EHC concluded that the existing in vivo studies were inadequate for drawing conclusions regarding potential reproductive effects. Further, studies conducted in mammalian models showed no adverse developmental effects associated with magnetic field exposure. Since that time, additional studies have been done to investigate the potential effects of magnetic fields on the female and male reproductive systems and on development of prenatally-exposed offspring (e.g. Yao et al., 2007; Al-Akhras et al.,

[89] Aluminum exposure causes symptoms and brain lesions in animals that are similar to those seen with Alzheimer's disease.

2008; Khaki et al., 2008; Aydin et al., 2009; Dundar et al., 2009; Kim et al., 2009; Bernabò et al., 2010; Rajaei et al., 2010).

91 In general, these studies suffer from various methodological deficiencies (e.g. low numbers of animals, inappropriate treatment of controls, and the absence of blinded analyses) and report conflicting findings. In particular, the studies of offspring development failed to incorporate methods to control for potential litter effects (littermates are known to be more similar to each other than offspring derived from separate litters). Further, although certain changes in reproductive organs or hormone concentrations were reported, none of the studies necessarily showed that the findings were associated with any adverse reproductive or developmental outcomes. Overall, the results of studies conducted since the WHO EHC provide little to alter the original judgment of the Working Group that the data are inadequate to show potential reproductive or developmental effects in association with magnetic field exposure. A recent review of studies reported *“recent results do not show an effect of the ELF fields on the reproductive function in humans.”* (SCENIHR, 2013).

8.5.8 In Vitro Research

92 Compared to in vivo studies, in vitro studies in isolated cellular or tissue systems are relatively inexpensive and require less laboratory space and staff. For this reason, copious in vitro studies of magnetic field exposures are available in the literature. While in vitro investigations allow for the control of various confounding factors in the experimental design of a study, they suffer from substantial limitations including the lack of whole body feedback mechanisms and protective processes.

93 The in vitro studies of magnetic field exposure, using a variety of different exposure conditions and examining a plethora of different biological endpoints, generally have shown positive findings only at magnetic field exposures of ≥1,000μT, well above levels to which people are typically exposed (SSM, 2013). Overall, while in vitro studies can be informative for understanding the potential effects of magnetic field exposures on underlying biological processes, in vitro exposures cannot necessarily be extrapolated to the in vivo condition, thus the results of such studies cannot be used for making regulatory policies.

94 In addition, recent studies have not aimed at elucidating a potential mechanistic link between magnetic field exposures and the increased risk of childhood leukaemia observed in epidemiology studies. As discussed in the EC‘s health effects review of EMF exposures, more hypothesis-driven in vitro studies into the role of magnetic fields exposure are needed because *“despite several decades of research into biological effects of EMF, there are still no generally accepted biological effects or interaction mechanisms that would explain human health effects below the thresholds for thermal effects and nerve stimulation”* (SCENIHR, 2009a). This

assessment is unchanged following review of new research, no mechanism that operates at levels of exposure found in the everyday environment has been firmly identified and experimentally validated." (SCENIHR, 2013).

95 In its review of the available in vitro research on potential mechanisms of carcinogenesis, the WHO concluded that these studies generally fail to show genotoxicity at magnetic-field exposures below 50,000µT (WHO, 2007b). One recent in vitro genotoxicity study (Burdak-Rothkamm et al., 2009) used blinded analyses to examine the effects of multiple magnetic field strengths produced by two different exposure systems and administered as either continuous or intermittent fields up to 1,000µT (50Hz). This study was conducted in an attempt to replicate positive genotoxic findings reported in a series of studies conducted under the European Union's REFLEX programme (Ivancsits et al., 2002, 2003a, 2003b), which were discussed in detail in the WHO EHC. Burdak-Rothkamm et al. (2009) evaluated multiple genotoxic endpoints, all of which were unaffected by magnetic field exposures of multiple field strengths; thus, the results of this comprehensive and well-conducted analysis do not support the findings of the earlier studies by Ivancsits et al.

96 Reviews published since the WHO EHC also suggest that magnetic field exposure alone is not genotoxic, although magnetic field intensities of ≥100µT have been suggested to interact with other chemical and physical agents to enhance the genotoxic responses resulting from those exposures (Juutilainen et al., 2006; Juutalainen, 2008; Ruiz-Gómez and Martínez-Morillo, 2009). The potential for magnetic fields to interact with genotoxic agents was also noted in the WHO EHC. This possibility was reiterated in the subsequent EC review on EMF (SCENIHR, 2009 a, 2013), which recommended more research into the potential for magnetic fields to alter the cellular response to other genotoxic agents.

97 In its report, the WHO further noted that studies of other potential carcinogenic mechanisms (e.g. cell proliferation, malignant transformation, altered gene expression) were inconsistent or inconclusive (WHO, 2007b). Since the WHO EHC was released, numerous additional studies investigating mechanisms of carcinogenesis have been published (e.g. Gottwald et al., 2007; Girgert et al., 2008, 2009, 2010; Koh et al., 2008; Markkanen et al., 2008; Jian et al., 2009; Frahm et al., 2010; Polaniak et al., 2010). These studies have examined the effects of magnetic fields on such biological processes as cellular proliferation, oxidative stress, apoptosis, gene expression, and immune cell responses. Many of these studies suffer from experimental deficiencies such as small sample sizes, the absence of sham-exposure of controls, no control of confounding variables (e.g. temperature), and the lack of blinded analyses. Further, findings are generally inconsistent across the body of studies. As such, the results of recent in vitro studies do not alter the previous conclusions of the WHO EHC. This assessment of the in vitro data is also consistent with that of EFHRAN (2010b), which found the

in vitro studies of cellular functions provided ‗inadequate‘ evidence for cancer processes and ‗limited‘ evidence for other select cellular functions.

8.5.9 Potential Interference with Implanted Medical Devices

98 The most common implanted medical devices are pacemakers and implantable cardioverter defibrillators (ICD). Pacemakers are designed to maintain a regular heart rate, which they achieve by delivering electric impulses to the heart muscle to trigger regular heartbeats. ICDs are designed to deliver an electric impulse or shock to control life-threating arrhythmias.

99 These devices typically contain a metallic casing, a built-in battery, electronic circuitry, and electric leads leading to the heart tissue. Cardiac pacemakers may have a single lead (unipolar devices) or two leads (bipolar devices). Modern pacemakers are almost exclusively bipolar devices. Detection and sensing of the heart‘s intrinsic electric activity is an integral part of both pacemakers and ICDs to ensure that electric impulses are delivered at the right time, but external electric signals may potentially interfere with or disrupt the normal functioning and operation of pacemakers and ICDs, a phenomenon called electromagnetic interference (EMI). While most external sources of EMF are too weak, interference may potentially occur from various electric appliances, medical and industrial equipment (e.g. magnetic resonance imaging), radio communication technologies (e.g. cell phones), and magnets. Patients are advised to keep these sources away from their implants.

100 The probability of interference and the mode of response depend on the strength of the interference signal, the distance from the signal, signal duration, its frequency and the patient‘s orientation in the electromagnetic field, the type and design of the device, and the variable parameters and settings of the device. Modern devices incorporate various technological safeguards (e.g. shielding by titanium casing and electrical filtering) to minimise the potential for EMI (Dyrda and Khairy, 2008).

101 Pacing abnormalities were shown to occur at magnetic field levels that are much higher than the levels a person would encounter on a daily basis. While electric fields did produce interference at levels that can be produced by certain electrical sources (Toivonen et al., 1991; Astridge et al., 1993; Scholten and Silny, 2001; Joosten et al., 2009), most pacemakers were not affected by high levels of electric fields (up to 20kV/m) and did not exhibit any pacing abnormalities. Joosten et al. showed that the most sensitive unipolar pacemakers may be affected by electric field levels between 4.3kV/m and 6.2kV/m. However, most modern pacemakers are bipolar devices, which are designed specifically to reduce the potential for EMI. Joosten et al. (2009), for example, found that in Germany, only 6% of the pacemakers in use have a unipolar sensing system.

102 A more recent study tested the function of 31 pacemakers placed in human shaped phantoms directly under a 400 kV transmission line (Korpinen et al., 2012). The results showed no interference with bipolar sensing and interference with only one unipolar pacemaker. The electric field level was 6.7-7.5kV/m at the time of this interference. Souques et al. (2011) investigated electric utility workers with ICDs at electric substations in France. No interference with ICDs was observed with a magnetic field as high as 650μT and electric fields as high as 12.2kV/m. Tiikkaja et al. (2013) tested 11 volunteers with pacemakers and 13 volunteers with ICDs in an experimental setting at ELF magnetic field levels up to 300μT. No interference was observed with ICDs or pacemakers with bipolar sensing, while three pacemakers with unipolar sensing experienced some form of interference.

103 Suggested exposure levels have been recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) to prevent against pacemaker EMI—below 1kV/m for electric fields and 100μT for magnetic fields (ACGIH, 2001). These are general recommendations and do not address the classes of pacemakers that are quite immune to interference even at levels much greater than these recommended guidelines. ACGIH recommends that patients consult their physicians and the respective pacemaker manufacturers before following the organisation‘s guidelines.

104 The European Committee for Electrotechnical Standardization (CENELEC) has developed specific procedures to assess the potential risk to workers with an active implantable medical device (AIMD) and provides guidelines to determine when reference levels are sufficient to ensure compliance (CENELEC 50527-1:2010).[90] In the ELF band of EMF exposure, recommended reference levels not to be exceeded are 5.0kV/m and 100μT for general exposure (Council Recommendation 1999/519/EC).

105 For the transmission line configurations proposed as part of this project, the general magnetic-field reference levels will not be exceeded over any portion of the line and the electric field level will be above the 5.0kV/m reference level only within approximately 17m of the transmission tower centreline. For the majority of people, exposure to field levels in excess of the reference level would occur only for a very short term or transient periods in which case these exposures may be acceptable for AIMD. For persons with an AIMD and who will spend significant time very close to the transmission line centreline, or who may work in the open air (e.g. outside a metal vehicle or at higher distances off the ground), a consultation with their physician may be warranted to determine the compatibility of their specific AIMD with higher electric fields.

[90] An AIMD is defined by the EU to be ―*any active medical device which is intended to be totally or partially introduced, surgically or medically, into the human body or by medical intervention into a natural orifice, and which is intended to remain after the procedure”* (Council Directive 90/385/EEC).

106 In a survey of almost 1,000 physicians who dealt with patients with active implanted medical devices in France, 16% of the physicians were aware of at least one incident of electromagnetic interference between the implanted device and an EMF source (Hours et al., 2014). However, none of the reported sources were high-voltage transmission lines, the main sources being electronic security systems and medical electromagnetic devices. A German survey of 110 patients with implanted cardioverter-defibrillators evaluated the threshold for interference with 50 Hz electric and magnetic fields (up to 30 kV/m and 2,550 μT, respectively) in clinical settings (Napp et al., 2014). No interference occurred at exposure levels below limits set by the European Union for the general public or at exposure scenarios that could be experienced near 400-kV transmission lines. A Finnish study using old designs (>10 years old) of implantable cardioverter-defibrillators in human shaped phantoms observed a potential interference at exposure levels above the current European Union limits of with one unit out of the investigated 10 units (Korpinen et al., 2014). The authors acknowledged that they were not able to replicate the interference in the following day with the same unit, the designs were old, and the use of phantoms instead of humans limit the interpretation of their findings.

107 A query of the database of the Medicines and Healthcare Products Regulatory Agency, the relevant regulatory body in the United Kingdom, and the Manufacturer and User Facility Device Experience (MAUDE) database maintained by the United States Food and Drug Administration (FDA) has not identified any reports, up until August 2014, that would suggest episodes where electromagnetic interference occurred with implanted cardiac devices due to electric or magnetic fields from electric power lines.

8.5.10 Potential Effects of ELF EMF on Plants

108 Electric currents are suggested to play a role in cell to cell communication in plants (Framm and Lautner, 2007). Significant scientific literature has accumulated, both from laboratory and field studies, on potential effect of ELF EMF from transmission lines on plants, including agricultural crops and trees, and forest and woodland vegetation. The various investigations include seed germination, seedling emergence and growth, leaf area per plant, flowering, seed production, longevity, and biomass production. Some studies showed changes with EMF exposure to plant size and weight in radish (Davies, 1996), growth rate of mung bean (Huang and Wang, 2008), and yield of tomato plants (Costanzo, 2008; De Souza et al., 2010). These findings, however, were not consistently observed. Overall, no confirmed adverse effects on plants were reported due to EMF exposure at levels comparable to what could be observed near high-voltage transmission lines (e.g. Hodges et al., 1975; Bankoske et al., 1976; McKee et al., 1978; Miller et al., 1979; Rogers et al., 1980; Lee and Clark, 1981; Warren et al., 1981; Rogers et al., 1982; Greene 1983; Hilson et al., 1983; Hodges and Mitchell, 1984; Brulfert et al., 1985; Parsch and Norman, 1986; Conti et al., 1989; Krizaj and Valencic 1989; Ruzic et al., 1992; Reed et al., 1993; Smith et al., 1993; Mihai et al., 1994; Davies 1996; Zapotosky et al., 1996). The only

confirmed adverse effect was damage to the tops of trees growing under or within 12.92m of an experimental transmission line operating at a voltage of 1,200 kV. This effect was attributed to corona-induced damage to branch tips. The clearance of tall growing trees under and near transmission lines that are set to prevent flashover and other interference would be sufficient to prevent effects on trees. This literature does not provide a basis to confirm any adverse effects of EMF on plant life (SCENIHR, 2009)

8.5.11 Potential Effects of ELF EMF on Animals

109 Similar to human health concerns, concerns have been expressed about potential effects of ELF EMF from transmission facilities on animal health, welfare, behaviour, and productivity. Both economically important domesticated animal species and wildlife have been investigated since the 1970s. Studies include a variety of study designs including observational studies of animals in their natural habitats, such as farms, and highly-controlled experimental studies. Overall, the research conducted to date does not suggest that ELF EMF have any adverse effects on the health, behaviour, or productivity of animals, including livestock (e.g. dairy cows, sheep, and pigs) and a variety of other species (e.g. small mammals, deer, elk, birds, bees, or marine life).

8.5.11.1 Dairy Cows and Cattle

110 Cows have been one of the most investigated species in scientific studies. The most notable series of experimental studies, under controlled settings, were conducted at McGill University by request of the government of Québec (e.g. Rodriguez et al., 2002, 2003, 2004; Burchard et al., 2003, 2004, 2007). The studies were designed to assess the potential effect of electric field and magnetic fields, separately and in combination, on dairy cattle‘s milk production, fertility, and hormone levels. The experiments were conducted in a laboratory setting to control extraneous factors, and exposed the cows to magnetic fields up to 30µT and electric fields up to 10kV/m. While some of the studies showed differences in milk fat content and dry matter intake, these differences were not consistently observed in the series of experiments and none of these differences were in excess of normal variations. Various measures of fertility of investigated pregnant heifers were not affected by ELF EMF exposure. The research team also investigated potential changes in various hormone levels (including progesterone, melatonin, cortisol, and thyroid hormones). They did not find an association with the majority of the investigated variables. Some subgroup analyses showed minor changes, but according to the authors‘ conclusions, these were small, within the range of normal for dairy cattle, and unlikely to represent adverse health effects.

111 More recently, two studies on cattle orientation have been published by the same research team (Begall et al., 2008; Burda et al., 2009). Both studies used publicly available satellite images to identify cattle on various pastures in Africa, Asia, Australia, Europe, North America, and South America. In the first study, the researchers report that cattle tend to orient themselves in the north-south direction, which the authors argue is due to magnetic alignment in response to the earth‘s geomagnetic field. In the second publication, the authors suggest that in the immediate vicinity of high-voltage power lines this alignment is changed by the ELF EMF from the conductors. No mechanism exists to explain a potential basis for magnetoreception by cows. The papers were later criticised by other investigators who performed their own analyses (Hert et al., 2011) were unable to replicate the initial findings. They also pointed out methodological shortcomings, such as the limited quality of the publicly available satellite images, the unblended nature of herd and animal selection and evaluation, and that potential alternative explanations to magnetoreception were ignored. A recently published study that was specifically designed to replicate the original findings reported mixed results and was unable to confirm the earlier findings (Slaby et al., 2013).

8.5.11.2 Sheep

112 Sheep were also evaluated in a number of studies to investigate the potential effect of ELF EMF from high-voltage transmission lines on hormone levels (melatonin, cortisol), weight gain, wool production, behaviour, onset of puberty and immune function (Stormshak et al., 1992; McCoy et al., 1993; Lee et al., 1993; Thompson et al., 1995; Hefeneider et al., 2001). While some parameters showed variation, no changes were consistently observed or replicated in these studies.

8.5.11.3 Pigs

113 Pigs were assessed by one research group for possible effects of ELF EMF from a 345 kV transmission line on production parameters, carcass quality, and reproductive performance (Mahmoud and Zimmerman, 1983, 1984). No differences with exposure were observed in body weight, carcass quality, behaviour, food intake, rate of pregnancy, number of pigs born alive, average birth weight, or rate of weight gain after birth.

8.5.11.4 Bees

114 Potential effects of ELF EMF on commercial honeybees also have been investigated since farmers may often place hives on fields near transmission lines. Greenberg et al. (1981) studied the effect of a 765 kV transmission line on honeybee colonies placed at varying distances from the transmission line‘s centreline. Exposed hives were compared to hives shielded from electric fields. Differences between the exposed and unexposed hives were

reported at exposures above 4.1kV/m, including: decreases in hive weight, abnormal amounts of propolis at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overwinter survival. These adverse effects, however, were indirect as they were attributed to small shocks induced on the metallic components of the hives due to the electric fields (Rogers et al., 1980, 1981, 1982), thus the effects were not direct effects of EMF on bees. Further studies indicated that field levels greater than 200kV/m were required to affect the behaviour of free-flying bees (Bindokas et al., 1988a, 1988b, 1989). Prevention of electric field induced microshocks is easily accomplished by placing a grounded metal cover on top of the hive. As for magnetic fields, laboratory studies indicate that bees are unable to discriminate 60Hz magnetic fields reliably at intensities less than 430μT, although they can detect fluctuations in the earth's static geomagnetic field as weak as 26 nanotesla (Kirschvink et al., 1997).

115 A study of native bees in Maryland found that within AC transmission line corridors there were more spatially and numerically rare species and richer bee communities than at the grassy fields away from transmission lines (Russell et al., 2005). Power line sites also had more parasitic species and more cavity-nesting bees. There were no EMF measurements in the study and no direct evaluation of EMF effects was undertaken. A more recent similar study conducted by some of the same investigators in Maryland, Wisconsin, and Oregon, also included measurements of EMF and aimed to evaluate potential EMF effects on native bees, as well (Russell et al., 2013). There was no indication of any effect of EMF on bee abundance, diversity, larval development, or behaviour such as floral visitation and pollination success.

8.5.11.5 Fish and Marine Species

116 A variety of salmon, other fish, and eels are among marine species for which there is some evidence that they make use of the earth's geomagnetic field in navigation. While salmon may detect the geomagnetic field, their behaviour appears to be governed by multiple stimuli including light, smell, current flow, and other factors. The principal hypothesis as to how these species are able to detect the earth's geomagnetic field involves the movement of tiny magnetic crystals coupled to sensory nerves in the head. The rate of oscillation of a 50Hz magnetic field, however, is too fast for a force to be effectively coupled mechanically to magnetite particles and it is unlikely that the brief and relatively low levels of exposure to 50Hz AC magnetic fields from the line would overcome other thermal and biological processes that govern migration (Adair, 1994). This is consistent with the finding that Atlantic salmon and American eels do not show evidence of detection or behavioural response to 75Hz magnetic fields at an intensity of 50μT (Richardson et al., 1976). This conclusion is supported by recent experimental studies by the Oak Ridge National Laboratory in the United States in which few detectable behavioural responses to 60Hz magnetic fields at intensities below 670μT were observed in any of six

freshwater fish species, including two known to exhibit electrosensitivity (Bevelhimer et al., 2013).

117 The exposure of fish to EMF beneath the conductors, where the line crosses rivers and streams, will be relatively low. The electric field in water will be 500,000 to 1,000,000 times lower than in the air above, thereby preventing any meaningful exposure to fish and other species in the water. While the magnetic field will not be appreciably attenuated by water, the intensity in the water will be lower since the conductors at locations over rivers and streams are higher than the minimum conductor heights that were assumed for modelling magnetic fields. For example, over the rivers Boyne and Blackwater the clearance from the highest bank of the Blackwater is approximately 13m and the clearance from the highest bank of the Boyne is approximately 16m. Additionally, prolonged exposure is not a critical issue for most river species of interest because their normal activities take them away from the area directly under the line where the magnetic field levels are the highest. Furthermore, there is no data to suggest that ELF–EMF will adversely impact salmon.

118 The scientific literature on sensitivity of marine species to EMF has been recently reviewed for the Bureau of Ocean Energy Management of the U.S. Department of Interior (Normandeau et al., 2011). Evidence suggests that a number of marine species have the ability to sense electric or magnetic fields, including some marine mammals, sea turtles, many groups of fishes (including elasmobranchs), and several invertebrate groups. The authors of the report also conclude, however, that most marine species may not sense low intensity AC magnetic fields (<5µT).

8.6 THE PRECAUTIONARY PRINCIPLE AND EMF

119 Even though everyone is exposed to magnetic fields daily in their homes and workplaces from many sources, the idea of a new transmission line can raise public concern. While the WHO points out that “*exposure of people living in the vicinity of high voltage transmission lines differs very little from the average exposure of the population*” (WHO, 2014), some persons may express concern about the perceived risk of exposure from such lines (Repacholi, 2012).

120 The precautionary principle was developed as a policy measure for risk management of possible but unproven adverse effects, such as those perceived to be associated with magnetic field exposure. The WHO has outlined precautionary measures that involve no cost or low cost actions that adhere to the general recommendation that “*any actions taken should not compromise the essential health, social and economic benefits of electric power*” (WHO, 2007b, p. 372).

121 The following specific measures were suggested (adapted from WHO, 2007b, pp. 372-373):

- Countries are encouraged to adopt international science-based guidelines;
- Provided that the health, social, and economic benefits of electric power are not compromised, implementing very low-cost precautionary procedures to reduce exposures is reasonable and warranted;
- Policy-makers and community planners should implement very low-cost measures when constructing new facilities and designing new equipment including appliances;
- Changes to engineering practice to reduce ELF exposure from equipment or devices should be considered, provided that they yield other additional benefits, such as greater safety or involve little or no cost;
- When changes to existing ELF sources are contemplated, ELF field reductions should be considered alongside safety, reliability, and economic aspects;
- Local authorities should enforce wiring regulations to reduce unintentional ground currents when building new or rewiring existing facilities, while maintaining safety. Proactive measures to identify violations or existing problems in wiring would be expensive and unlikely to be justified;
- National authorities should implement an effective and open communication strategy to enable informed decision-making by all stakeholders; this should include information on how individuals can reduce their own exposure;
- Local authorities should improve planning of ELF EMF-emitting facilities, including better consultation between industry, local government, and citizens when siting major ELF EMF-emitting sources; and
- Government and industry should promote research programs to reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure.

122 In the review conducted by an expert scientific panel for the Department of Communications, Marine and Natural Resources, specific precautionary recommendations were made in relation to the siting of power lines and community input:

> *"Where possible new power lines should be sited away from heavily populated areas so as to minimise 50 Hz field exposure. Where major new power lines are to be constructed, there should be stakeholder input on the routing. This could take the form of public hearings or meetings with interested parties"* (DCMNR, 2007, p. 5).

123 The above precautionary goals have been achieved by reducing the fields from the adjacent 400 kV lines by recommending a line phasing that reduces the magnetic field away from the lines, and constructing the transmission line on existing towers where possible. Other actions by EirGrid during siting have resulted in the lines of the project being located as far from existing residences as is reasonably possible and have incorporated stakeholder input during the consultation process as described in the *Planning Report*, **Volume 2A** of the application documentation.

8.7 TECHNICAL CALCULATIONS AND RESULTS - EMF ASSOCIATED WITH THE PROPOSED DEVELOPMENT

8.7.1 INTRODUCTION

124 The proposed development is a 400 kV transmission line intended to link the existing 400 kV substation in Woodland, County Meath, with a planned substation in Turleenan, County Tyrone. The portion of the project in Northern Ireland will be constructed by SONI while the portion in Ireland is being proposed by EirGrid.

125 The proposed OHL in the CMSA extends over a distance of approximately 46km from the Northern Ireland border to Tower 236 in the townland of Clonturkan, County Cavan. The transmission line comprises a single circuit 400 kV overhead transmission circuit supported by 134 towers, the vast majority of which (78%) are Intermediate Lattice Towers.[91] An example of an Intermediate Lattice Tower is shown in **Figure 8.5** for reference.

126 The proposed OHL in MSA extends a distance of approximately 54.5km from the townland of Clonturkan, County Cavan to Bogganstown (ED Culmullin), County Meath. The transmission line comprises a new single circuit 400 kV overhead transmission circuit supported by 165 new towers, 72% of which are Intermediate Lattice Towers as shown in **Figure 8.5**. It also includes the addition of a new 400 kV circuit for some 2.85km along the currently unused (northern) side of the existing double circuit 400 kV OHL (the Oldstreet to Woodland 400 kV transmission line) extending eastwards from Tower 402 in the townland of Bogganstown (ED Culmullin), County Meath to Tower 410 and the Woodland Substation in the townland of Woodland, County Meath. An example of the Double-Circuit Lattice Tower is shown in **Figure 8.6**.

91 The remaining towers are primarily ‗Angle Towers', which are used when the transmission line must change direction.

127 In addition, due to the length of the alignment, EirGrid has determined that the proposed transmission line would benefit from a transposition approximately 40-50km south of the proposed substation at Turleenan. This transposition would involve rearranging the location of the three conductor bundles. The transposition would occur over an alignment consisting of four towers, two Transposition Lattice Towers, specifically designed for this purpose and two Angle Towers. An outline drawing of the Transposition Lattice Tower is shown in **Figure 8.7**. The EMF from the transmission line on this segment of the route will differ from the transmission line on the Intermediate Lattice Towers and therefore is considered as a separate case.

128 As described above, the proposed transmission line is proposed to be constructed in three primary configurations:

1. Single-circuit on Intermediate Lattice Towers;
2. Single-circuit on Transposition Lattice Towers; and
3. Double-circuit on Double-Circuit Lattice Towers.

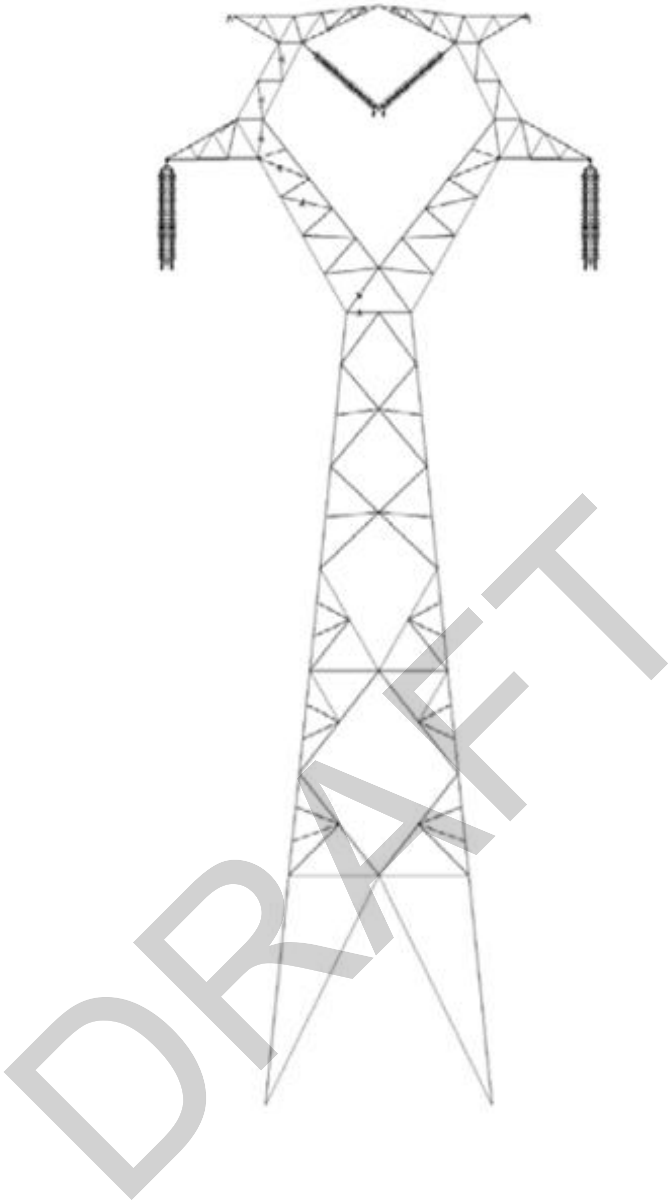


Figure 8.5: Proposed 400 kV Intermediate Single-Circuit Lattice Tower (Not to Scale) for the Proposed Development

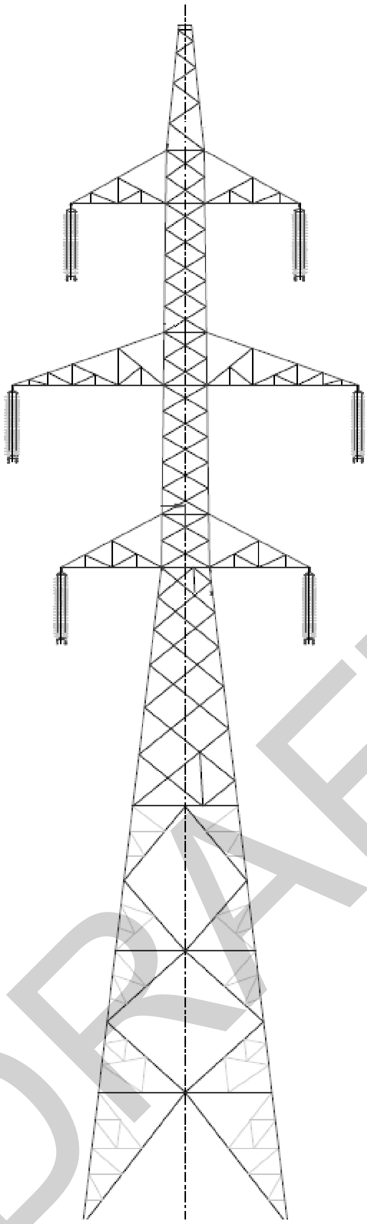


Figure 8.6: Proposed 400 kV Double-Circuit Lattice Tower (Not to Scale) for the Proposed Development

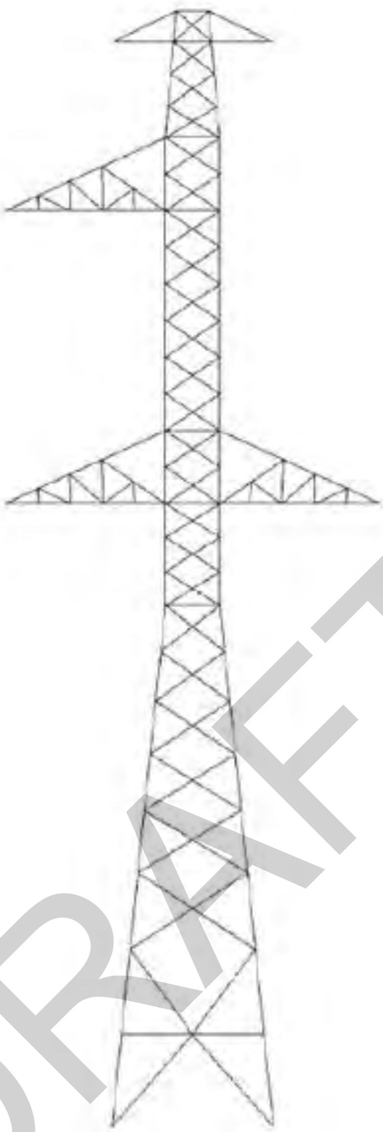


Figure 8.7: Proposed 400 kV Transposition Lattice Tower (Not to Scale) for the Proposed Development

8.7.2 METHODS

129 This section provides calculations of the 50Hz resultant EMF produced by the 400 kV OHL discussed above, all calculated by algorithms developed by the Bonneville Power Administration (BPA) of the U.S. Department of Energy (BPA, 1991). This evaluation is performed for three separate tower configurations encountered along the route. Calculations are made both under average and peak loading operation along cross sections perpendicular to the route. In locations along the route where there are existing transmission lines, the existing and proposed conditions are compared to assess project-related changes to EMF levels.

130 Magnetic fields are the result of the flow of electric currents through wires and electrical devices. The strength of a magnetic field is expressed as magnetic flux density in units called Tesla (T), or in microtesla (μT), where 1-T = 1,000,000μT. In general, the strength of a magnetic field increases as the current increases, but at any point also depends on characteristics of the source, including the arrangement and separation of the conductors. Electric fields are produced by voltage applied to electrical conductors and equipment. The electric field is expressed in units of volts per meter (V/m) or kilovolts per meter (kV/m); 1kV/m is equal to 1,000V/m. The electric field level increases as the voltage increases. Electric fields are present if an appliance is still connected to the power source even when it is turned off.

131 Electric and magnetic fields were calculated at 1m above ground, in accordance with IEC Std. 61786 (1998), and are reported as the root-mean-square resultant quantities of the field ellipse at each location along a transect perpendicular to the transmission line‘s centreline at distances out to ±150m. Data for the proposed transmission line‘s geometrical configurations, conductor type, and loading were provided to Exponent by EirGrid.

132 The inputs to the BPA program are data regarding voltage, current flow, phasing, and conductor configurations. The circuit loadings, in mega-volt-amperes (MVA), for both average and peak load are summarised in **Table 8.3**. All calculations were performed using modelling assumptions that ensure the calculated values represent the maximum expected values for each of the specified parameters. For the cases analysed, these assumptions include modelling at conductor mid-span, where conductors sag to a level closest to ground and assuming that conductors are infinite in extent.[92] A summary of the transmission line configuration for each portion of the route is summarised in **Table 8.4**.

[92] Near the transposition towers where the phase transposition takes place the assumption of conductors of infinite extent is not satisfied, but field levels in these locations would be lower than those presented in calculations for midspan conductor heights.

Table 8.3: Transmission Line Loading (MVA) for Average- and Peak-Load Cases

From	To	Voltage (kV)	Existing		Proposed	
			Average load (MVA)	Peak load (MVA)	Average load (MVA)	Peak load (MVA)
Meath	Tyrone	400	N/A	N/A	500	1,500
Oldstreet	Woodland	400	500	1,500	500	1,500

133 The ‗peak load‘ of 1,500MVA is derived from the nominal maximum power carrying capacity of the OHL. While the OHL would be capable of carrying this level of load for a sustained period, it would not be expected to approach this level other than in emergency situations. Compliance with system planning standards and system operations procedures will ensure that this would rarely occur, perhaps for as little as a few hours per decade. Under normal system conditions the annual peak load for this circuit is not expected to exceed 750MVA and would be expected to occur for about 1% of the time.

134 The term ‗average load‘ as used here is similar in meaning to the term ‗indicative typical load‘ and at 500MVA is equivalent to 66% of an annual peak load of 750MVA. This would be considered to be a conservative estimate (i.e. on the high side) for average loading (NIEHS, 2002).

Table 8.4: Proposed Transmission Line Configuration and Model Inputs

<table>
<tr><th>Parameter</th><th>Intermediate Lattice Tower</th><th>Transposition Tower</th><th colspan="2">Double-Circuit Lattice Tower[b]</th></tr>
<tr><td>Voltage (kV)</td><td>400</td><td>400</td><td colspan="2">400 / 400</td></tr>
<tr><td>Minimum Conductor Height (m)</td><td>9</td><td>9</td><td colspan="2">9 / 9</td></tr>
<tr><td rowspan="4">Phase Spacing (m)[a]</td><td rowspan="4">H: 9.5
V: 6.0</td><td rowspan="4">H: 6.9
V: 10.5</td><td>V: 10.25</td><td>V: 10.25</td></tr>
<tr><td>H: 6.45</td><td>H: 6.45</td></tr>
<tr><td>H: 9.75</td><td>H: 9.75</td></tr>
<tr><td>H: 7.00</td><td>H: 7.00</td></tr>
<tr><td rowspan="3">Phase Arrangement</td><td rowspan="3">1-2-3</td><td rowspan="3">3
1 2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td></tr>
<tr><td>3</td><td>1</td></tr>
<tr><td>Number and diameter of Conductors
(# x mm)</td><td>2x31.68
(Curlew)</td><td>2x31.68
(Curlew)</td><td colspan="2">2x31.68 / 2x31.68
(Curlew / Curlew)</td></tr>
<tr><td>Conductor Separation (mm)</td><td>450</td><td>450</td><td colspan="2">450</td></tr>
<tr><td>Earth wire midspan height (m)</td><td>18.6</td><td>28.76</td><td colspan="2">42.78</td></tr>
<tr><td>Earth wire diameter (mm)</td><td>19.53
(Keziah)</td><td>19.53
(Keziah)</td><td colspan="2">25.97
(Goat)</td></tr>
</table>

[a] H = horizontal spacing, V = vertical spacing
[b] Oldstreet-Woodland / Meath-Tyrone

135 In the double-circuit portion of the route, the presence of a second transmission line means that the specific arrangement of the new conductors on the tower will have an effect on the calculated levels of EMF beneath and in the vicinity of the transmission line towers. Therefore, at the request of EirGrid, Exponent performed an optimisation analysis in which all possible phase permutations are considered for the two 400 kV circuits. The permutation that results in the lowest total magnetic field level beyond a distance of approximately 6m from the centreline of the Double-Circuit Lattice Tower is identified as the optimal phasing.

8.7.3 RESULTS

136 The results of this modelling effort are summarised in tables and illustrative figures showing the levels of EMF as a function of transverse distance away from the transmission line. Tables of modelling results describing the maximum magnetic field and electric field levels as well as at a

distance of ±50m and ±100m from the transmission line centreline are shown in **Table 8.5** to **Table 8.7**. The magnetic field levels at average loading are shown in **Table 8.5** and at peak loading in **Table 8.6**. Similarly, the electric field levels are shown in **Table 8.7**. Figures depicting modelling results for EMF for all modelled cross sections are shown in **Figure 8.8** to **Figure 8.15**. Magnetic field levels at average loading are shown in **Figure 8.8** to **Figure 8.11** and electric field levels are shown in **Figure 8.12** to **Figure 8.15**. Each figure shows the transmission line tower together with the calculated field profiles for ease of comparison.[93]

8.7.4 PHASE OPTIMISATION

137 An important parameter in the calculation of the optimal phasing that minimises the magnetic field is the relative direction of current flow between the two transmission lines. In this particular case, both transmission lines will carry electrical current in the same direction. Calculations for all possible permutations provide results describing the range over which the evaluated parameters could vary as a function of the selected phasing. The configuration identified as optimal through this analysis (optimal phasing) was based on minimising the magnetic field level at distances greater than about 6m from the transmission line centreline. This identified configuration has the conductor phasing arrangement of 1-2-3 and 3-2-1 from top to bottom for the Oldstreet-Woodland and Meath-Tyrone transmission lines, respectively. The highest magnetic field values would result from the conductor phasing arrangement of 1-2-3 and 1-2-3 from top to bottom (non-optimal phasing). On infrequent occasions when current flow on one (but not both) of the transmission lines reverses direction, the electric and magnetic fields from the double-circuit portion of the transmission line will change. This current (and voltage) reversal would essentially change the selected phasing from optimal to non-optimal for that brief period, resulting in electric and magnetic field levels slightly elevated compared to the optimal configuration (see non-optimised phasing in **Table 8.8**), but still beneath the EU limits.

8.7.5 MAGNETIC FIELDS

138 As shown in **Figure 8.8** to **Figure 8.11** and **Table 8.5** to **Table 8.6**, the magnetic fields associated with each of the different transmission line towers are quite similar, with the maximum magnetic field (48.46μT) beneath the transmission line calculated to occur beneath the relatively short segment where the line is supported on Transposition Lattice Towers.

[93] In the double-circuit portion of the project, existing transmission line towers and associated EMF are shown in addition to the proposed configuration and associated quantities.

139 At average loading the maximum magnetic field beneath the transmission line is calculated to be approximately 16μT. The magnetic field intensity diminishes rapidly with distance to about 1.0μT at a distance of 50m and to approximately 0.25μT at a distance of 100m from the centreline, a reduction by a factor of 64. Results at peak loading, which might be expected to occur during a few hours a year or even in a decade, show a similar trend with the highest magnetic field level observed directly beneath the transmission lines and decreasing rapidly with distance away from the centreline.

140 Of the three OHL arrangements proposed for this development the magnetic field under the double circuit section of the line is the lowest at 41.6μT at peak load and 13.87μT at average load. Adoption of optimal phasing of the new line at expected loading will diminish the magnetic field the of the proposed arrangement relative to the existing line, and produce magnetic fields lower than or similar to other phasing permutations at distances more than 6m from the tower centreline. If optimal phasing were not adopted for the double-circuit section, the magnetic field for the proposed configuration would be higher than from the existing line at all locations (see **Figure 8.11**). With optimal phasing, the reverse occurs; the magnetic field of the proposed configuration is lower than the existing line at distances greater than 9m south of the transmission line centreline and greater than 40m north of the transmission line centreline (see **Figure 8.10**). The magnetic field level near the transmission line centreline will increase due to the installation of the new circuit on the existing structures. To the south the magnetic field levels will decrease by as much as 1.4μT beyond approximately 10m from the transmission line centreline. To the north of the transmission line the magnetic field levels will not change appreciably (<1μT) beyond approximately 25m from the transmission line centreline and will decrease beyond approximately 40m from the transmission line centreline.

141 The impact of optimising the phases is a ‗no or low cost‘ mitigation measure that may be implemented to reduce magnetic field levels in the double-circuit portion of the route. A summary table describing the variation in magnetic field level at various distances for the optimal and non-optimal phasing configurations is shown in **Table 8.8**.

8.7.6 ELECTRIC FIELDS

142 **Figure 8.12** to **Figure 8.15** show graphical profiles of the electric field associated with the transmission line for the three configurations with results at distances of ±50 and ±100m. The electric field at these locations is summarised in **Table 8.7**. As with the magnetic field, the electric field levels associated with each of the different transmission line configurations are similar, with the maximum electric field (8kV/m) calculated beneath the relatively short portion of the project with the Transposition Lattice Towers. Adoption of optimal phasing of the new line to minimise the magnetic field also minimises the electric field from the new line. With optimal phasing the maximum electrical field will decrease from the existing 7.7kV/m to 7.1kV/m while

non-optimal phasing would result in the maximum electric field increasing from today‘s 7.7kV/m to 8.8kV/m. The change from existing conditions is <1kV/m beyond approximately 20m from the transmission line centreline. In addition, beyond approximately 40m from the transmission line centreline the proposed configuration results in electric fields which are lower than under existing conditions.

143 The range of the maximum electric field beneath the transmission line is calculated to be between approximately 7.9kV/m - 8.8kV/m for the different configurations. Even for the non-optimised double-circuit portion of the project, however, the electric field decreases to below 0.4kV/m within a distance of 50m from the transmission line centreline. If optimal phasing were not adopted for the double-circuit section, the electric field for the proposed configuration would be higher than from the existing line at virtually all locations (see **Figure 8.15**). With optimal phasing, the reverse occurs; the electric field of the proposed configuration is lower than the existing line at all locations to the south of the transmission line centreline and greater than the existing line approximately 40m north of the transmission line centreline (see **Figure 8.14**).

144 The impact of optimising the phases is a ‗no or low cost‘ mitigation measure that may be implemented to reduce electric field levels in the double-circuit portion of the route. A summary table describing the variation in electric and magnetic field levels at various distances for the optimal and non-optimal phasing configurations is shown in **Table 8.8.**

Table 8.5: Calculated Magnetic Field Values (µT) for Existing and Proposed Configurations at Average Load

Route Portion	Case	Location				
		-100 m from centre	–50 m from centre	Maximum	+50 m from centre	+100 m from centre
Single-Circuit Lattice Tower	proposed	0.25	1.02	15.98	1.02	0.25
	existing	--		--	--	--
Transposition Lattice Tower	proposed	0.24	0.93	16.15	1.01	0.25
	existing	--	--	--	--	--
Double-Circuit Lattice Tower (optimal phasing)	proposed	0.08	0.55	13.87	0.55	0.08
	existing	0.29	1.18	11.94	0.71	0.22
Double-Circuit Lattice Tower (non-optimal phasing)	proposed	0.50	1.85	13.51	1.85	0.50
	existing	0.29	1.18	11.94	0.71	0.22

Table 8.6: Calculated Magnetic Field Values (µT) for Existing and Proposed Configurations at Short Duration Peak Load

Route Portion	Case	Location				
		-100 m from centre	–50 m from centre	Maximum	+50 m from centre	+100 m from centre
Single-Circuit Lattice Tower	proposed	0.76	3.05	47.94	3.05	0.76
	existing	--		--	--	--
Transposition Lattice Tower	proposed	0.73	2.79	48.46	3.02	0.76
	existing	--		--	--	--
Double-Circuit Lattice Tower (optimal phasing)	proposed	0.24	1.66	41.62	1.66	0.24
	existing	0.87	3.53	35.81	2.12	0.65
Double-Circuit Lattice Tower (non-optimal phasing)	proposed	1.50	5.54	40.54	5.54	1.50
	existing	0.87	3.53	35.81	2.12	0.65

Table 8.7: Calculated Electric Field Values (kV/m) for Existing and Proposed Configurations

Route Portion	Case	Location				
		-100 m from centre	–50 m from centre	Maximum	+50 m from centre	+100 m from centre
Single-Circuit Lattice Tower	proposed	0.0	0.2	7.9	0.2	0.0
	existing	--		--	--	--
Transposition Lattice Tower	proposed	0.0	0.2	8.0	0.3	0.1
	existing	--		--	--	--
Double-Circuit Lattice Tower (optimal phasing)	proposed	0.0	0.2	7.1	0.2	0.0
	existing	0.1	0.3	7.7	0.2	0.1
Double-Circuit Lattice Tower (non-optimal phasing)	proposed	0.1	0.4	8.8	0.4	0.1
	existing	0.1	0.3	7.7	0.2	0.1

Table 8.8: Calculated Electric Field (kV/m) and Magnetic Field Values (μT) for Optimal and Non-optimal Phasing Configurations of the Double-Circuit Lattice Tower

Route Portion	Field	Case	Location				
			-100 m from centre	–50 m from centre	Maximum	+50 m from centre	+100 m from centre
Double-Circuit Lattice Tower	Magnetic	Optimal	0.08	0.55	13.87	0.55	0.08
		Non-Optimal	0.50	1.85	13.51	1.85	0.50
Double-Circuit Lattice Tower	Electric	Optimal	0.0	0.2	7.1	0.2	0.0
		Non-Optimal	0.1	0.4	8.8	0.4	0.1

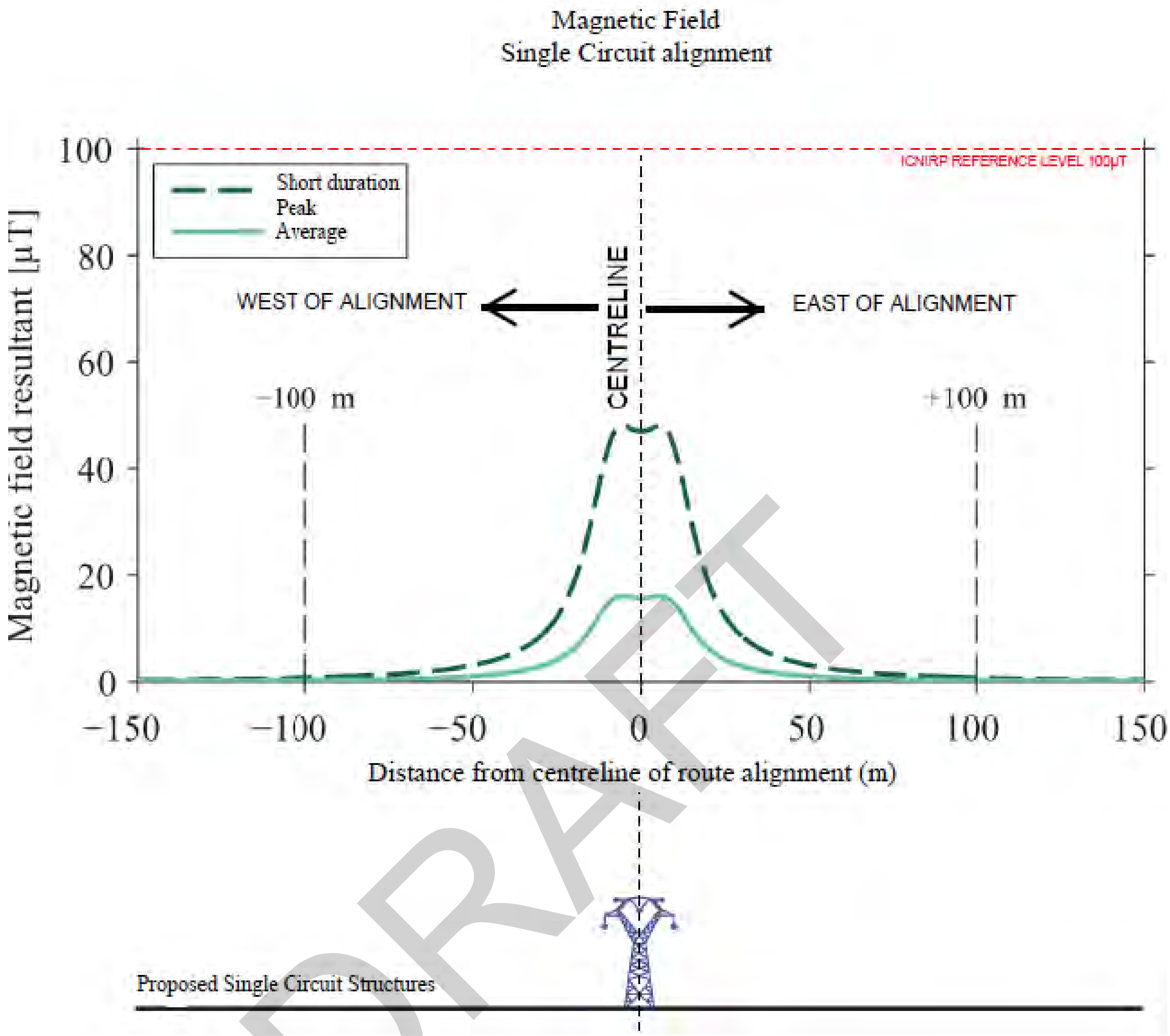


Figure 8.8: Calculated Magnetic Field Profile for the Proposed Intermediate Lattice Tower Configuration for Short Duration Peak and Average Load

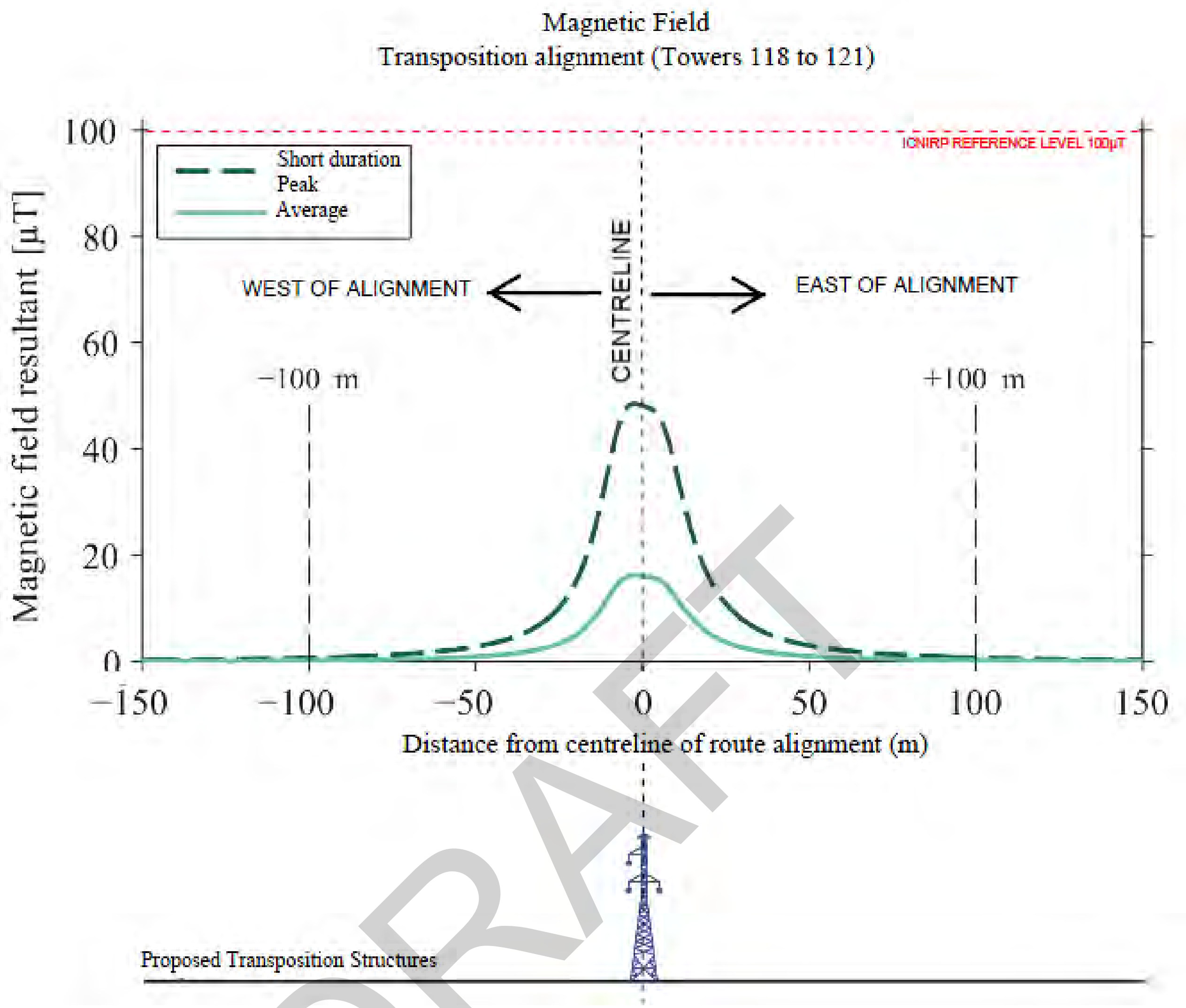


Figure 8.9: Calculated Magnetic Field Profile for the Proposed Transposition Tower Configuration for Short Duration Peak and Average Load

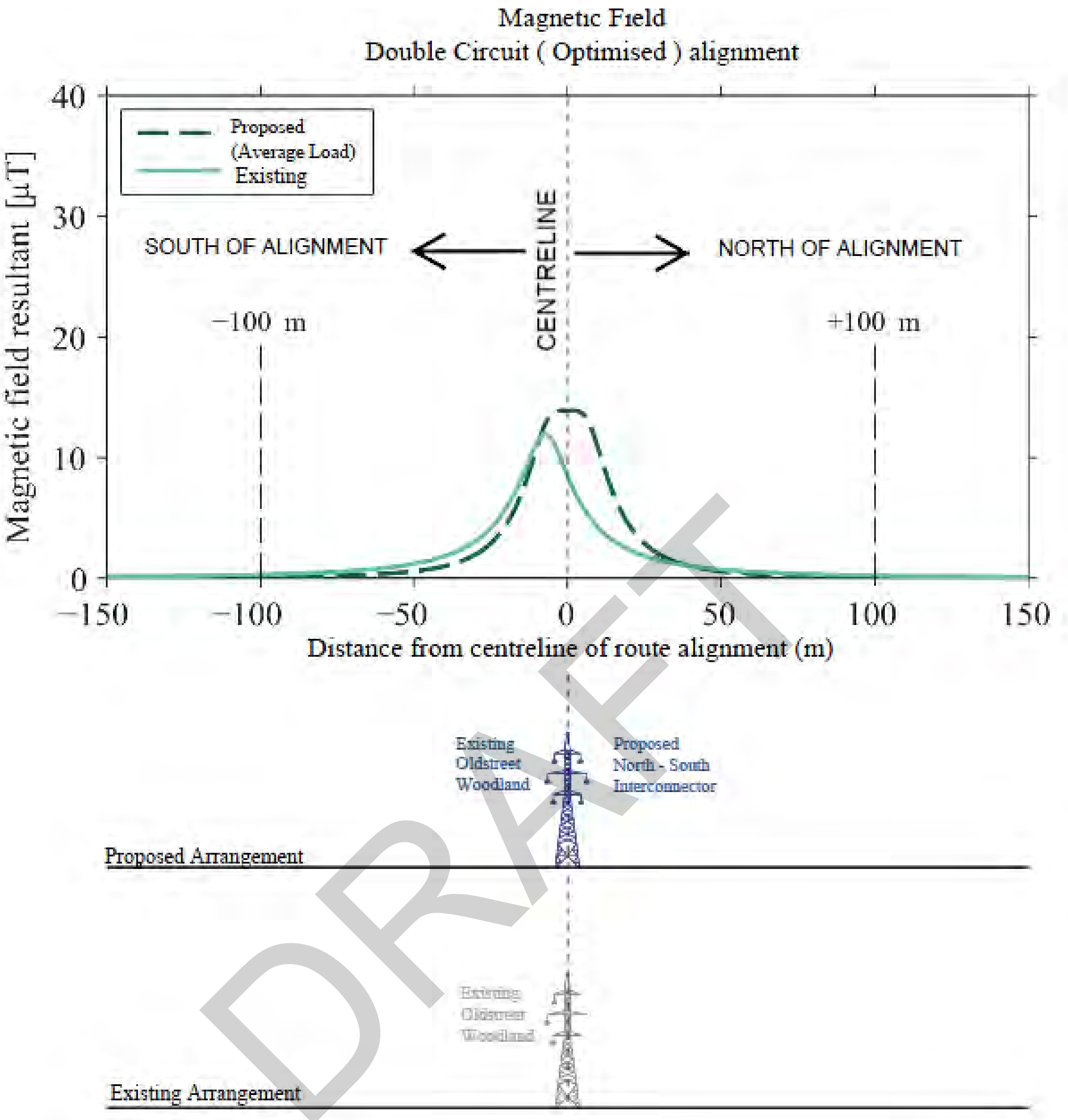


Figure 8.10: Calculated Magnetic Field Profile for the Existing and Proposed Double-Circuit Lattice Tower Configuration for Average Load and Using Optimised Phasing

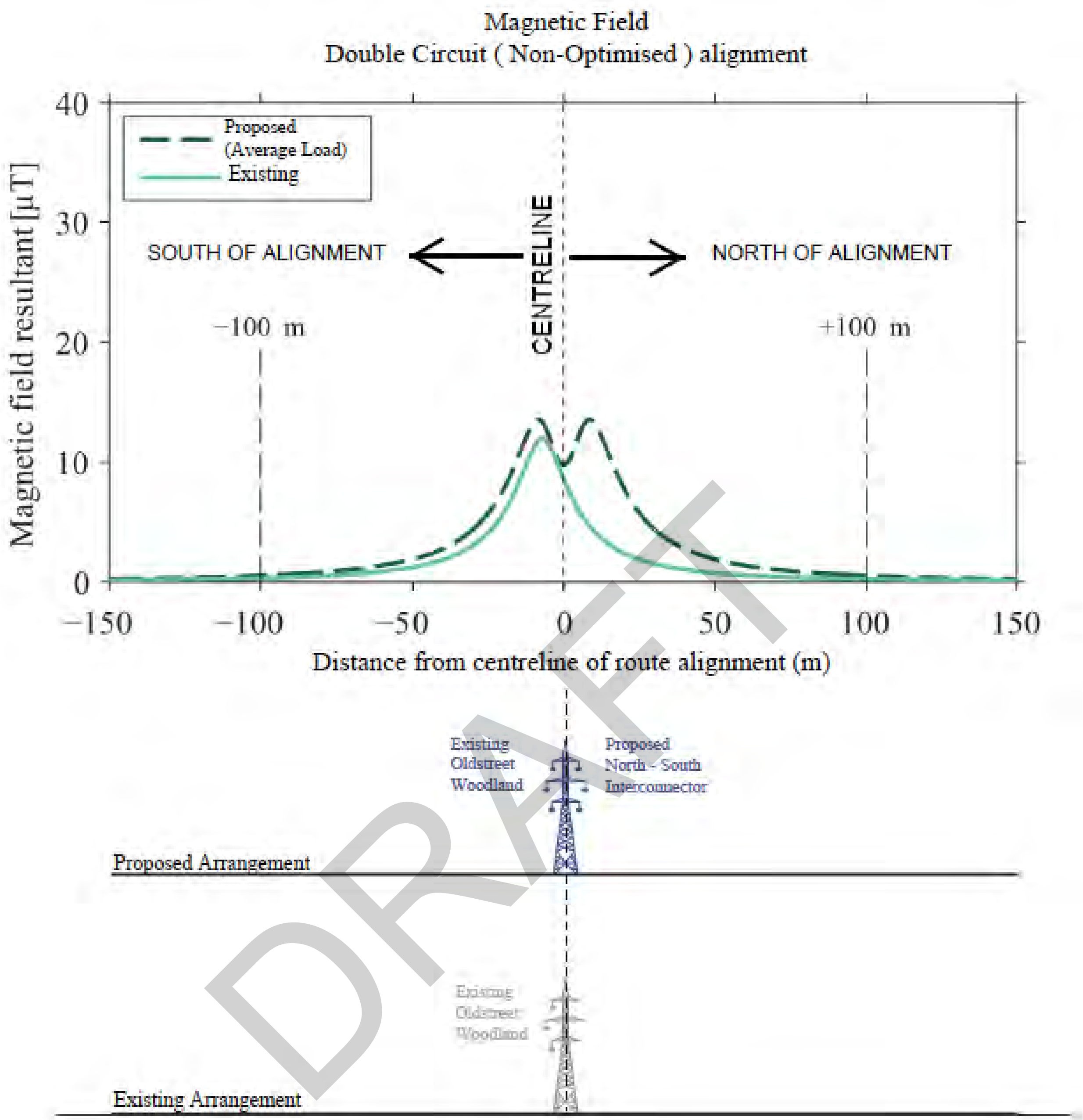


Figure 8.11: Calculated Magnetic Field Profile for the Existing and Proposed Double-Circuit Lattice Tower Configuration for Average Load and Using Non-Optimised Phasing

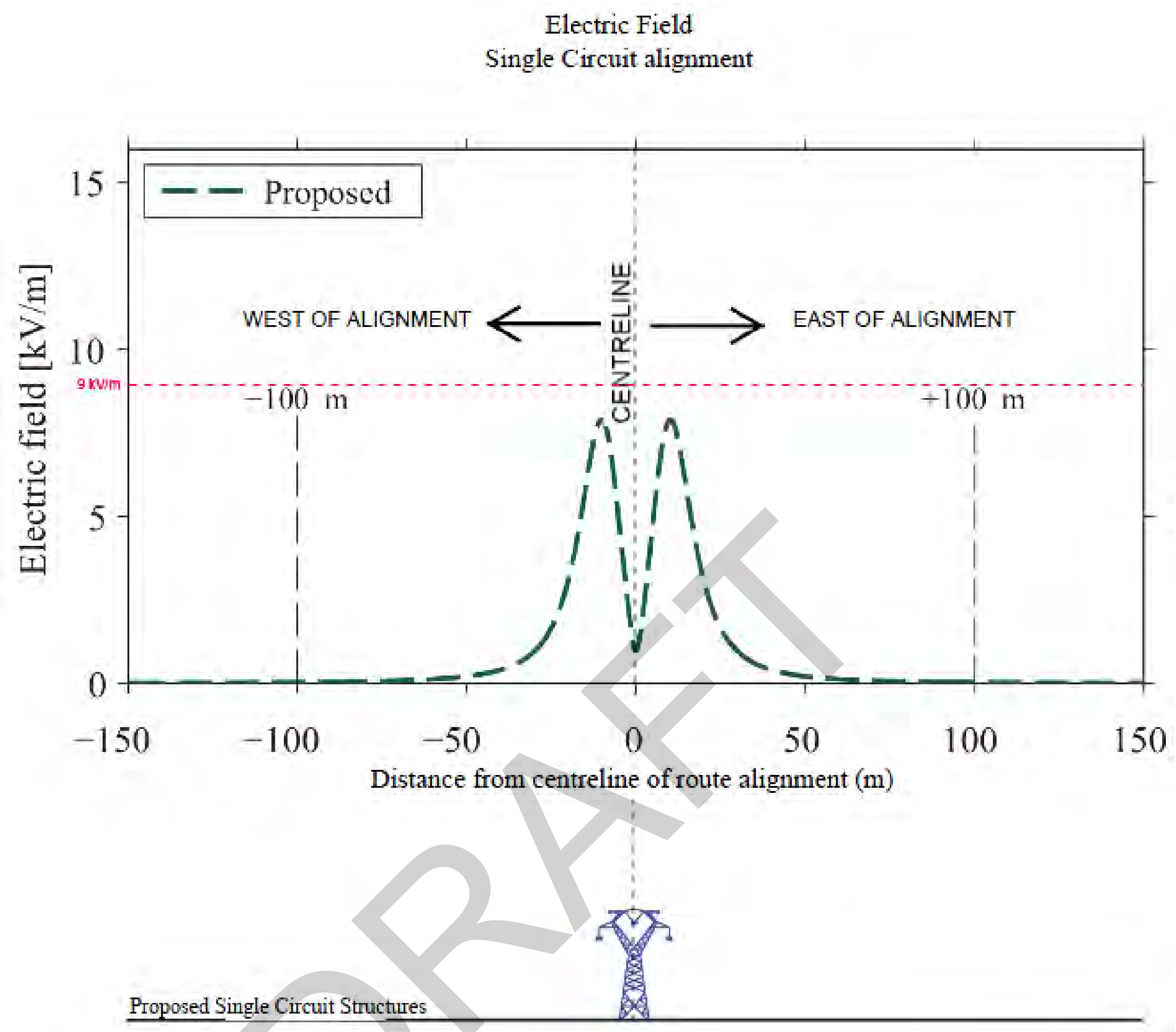


Figure 8.12: Calculated Electric Field Profile for the Proposed Intermediate Lattice Tower Configuration

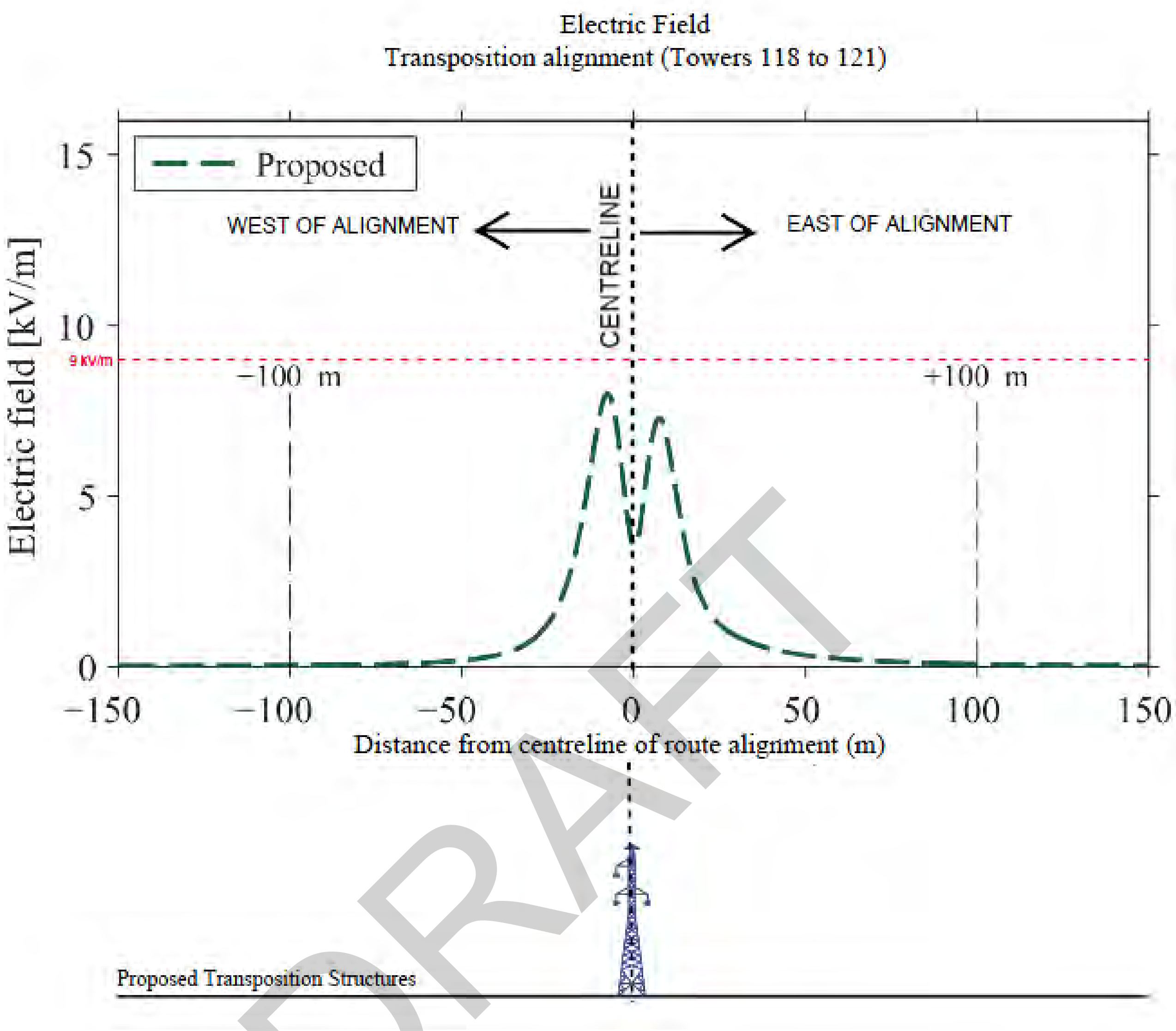


Figure 8.13: Calculated Electric Field Profile for the Proposed Transposition Tower Configuration

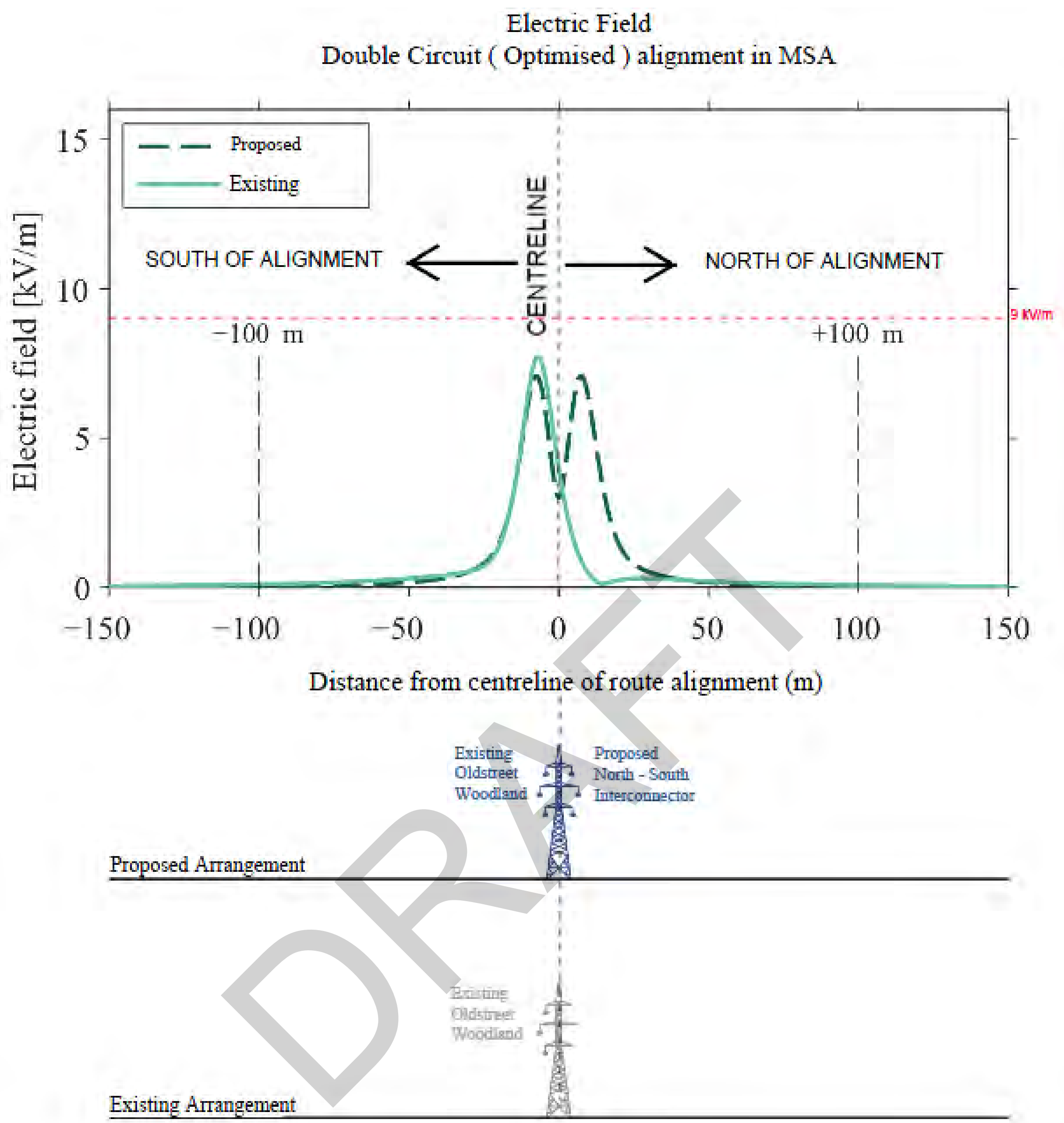


Figure 8.14: Calculated Electric Field Profile for the Existing and Proposed Double-Circuit Lattice Tower Configuration Using Optimal Phasing

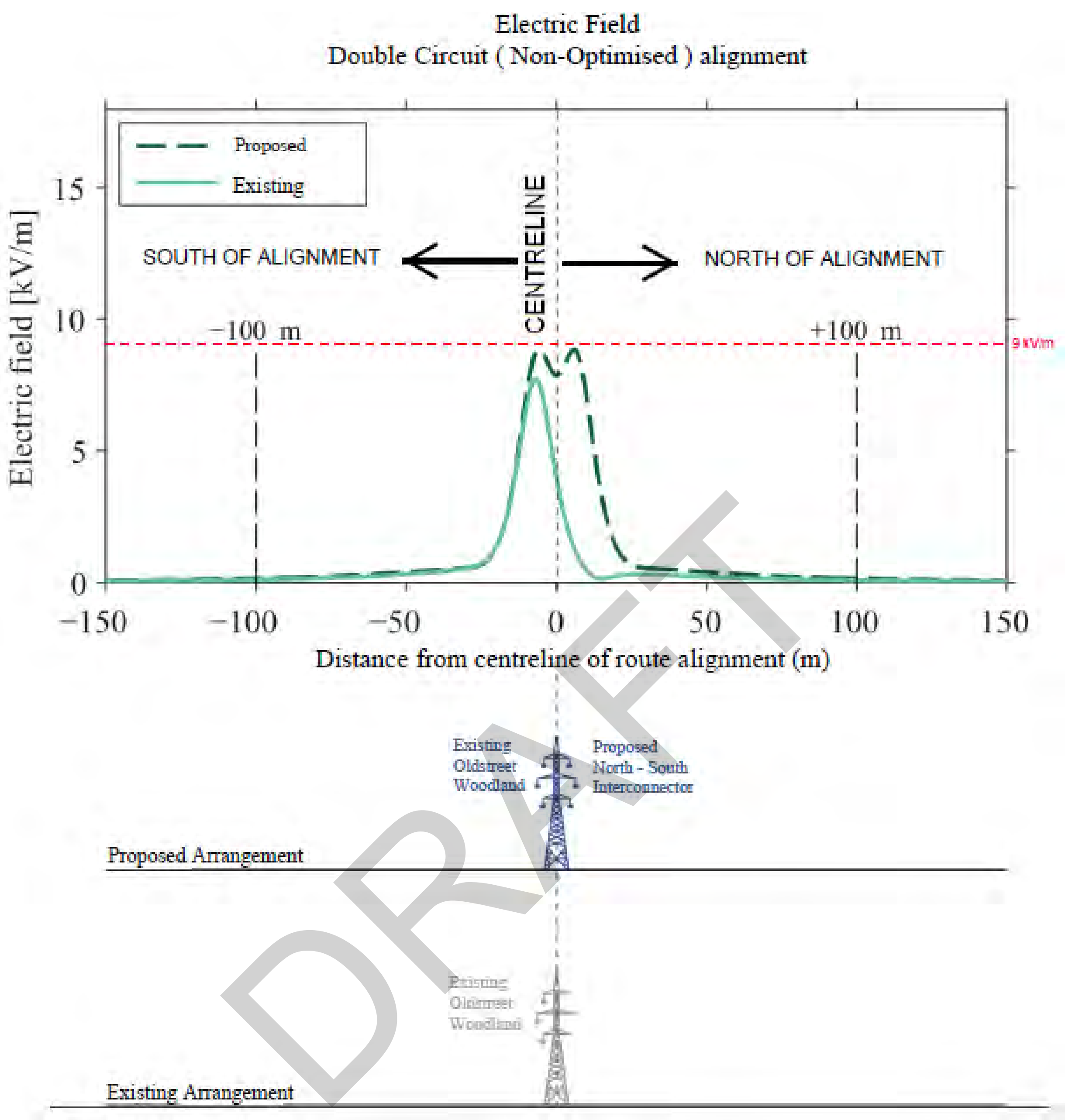


Figure 8.15: Calculated Electric Field Profile for the Existing and Proposed Double-Circuit Lattice Tower Configuration Using Non-Optimal Phasing

8.9 SUMMARY AND CONCLUSIONS

145 Although most people are constantly exposed to background levels of magnetic fields daily from common sources such as appliances, electronic devices, and distribution lines in home and workplace environments, proposed transmission line projects can raise public concern. Perceived risk of exposure from transmission lines is a relatively common response to such projects (Repacholi, 2012), although the WHO points out that –*exposure of people living in the vicinity of high voltage transmission lines differs very little from the average exposure of the population*" (WHO, 2014).

146 This chapter provides information on calculated levels of ELF EMF that can be anticipated in the vicinity of the proposed 400 kV transmission line and summarises the results of scientific research that has been conducted to investigate potential health effects related to ELF EMF. It provides a summary of the conclusions of reviews and exposure guidelines developed by national and international scientific and health agencies to protect the health of workers and the general public and it demonstrates by calculations that the proposed development complies with the relevant exposure guidelines. This information addresses both regulatory requirements and responds to issues raised by stakeholders during the public consultation.

147 EMFs are present in both natural and manmade environments. Natural sources of EMF include, for example, the earth's geomagnetic field and the electric field beneath an active thunderstorm. Electricity used in Ireland is alternating current that oscillates 50 times each second (i.e. at a frequency of 50Hz) and creates both electric and magnetic fields wherever electricity is generated, transmitted, distributed, or used in the home, in the workplace, and other areas.

148 The strength of an electric field is directly related to the voltage of the source and so the electric field under an outdoor power line is higher than the electric field from the low voltage on home wiring. The transmission lines operating at 400 kV will produce a 50Hz electric field of approximately 7.9kV/m beneath the transmission line. The electric field level decreases to 0.04kV/m approximately 100m away from the transmission line centreline, a reduction by a factor of almost 200. Electric fields are easily blocked by conductive objects, such as fences, trees, and even the human body.

149 Magnetic fields are created by the flow of electrical current (i.e. by the flow of electric charges through power lines). The earth's geomagnetic field which is used for navigation by compass is approximately 50μT throughout Ireland. Magnetic fields are not easily blocked by objects, so the range of exposures to ELF EMF encountered in daily life can range widely from as little as 0.01μT away from specific sources and as high as 1-2μT at 50cm from home appliances; exposures greater than 10μT are uncommon except very close to some household appliances

or directly beneath a high voltage transmission line; both of these occasions generally occur for short periods. The ELF magnetic field from the proposed 400 kV transmission line is calculated to be highest directly under the line at the location where the wires are closest to the ground, usually the midspan point, and based on average loading on the line is calculated to have a maximum level of approximately 16μT, but the intensity of the magnetic field diminishes by a factor of more than 50 to approximately 0.25μT at a distance of 100m from the centreline.

150 Since the publication of the first epidemiology study that examined a potential association between ELF EMF sources and childhood cancer in 1979 (Wertheimer and Leeper), researchers in various scientific disciplines have conducted studies to investigate potential health effects of EMF exposure. These studies include both epidemiology studies and laboratory studies of humans, animals, tissues, and cells. Epidemiology studies investigated whether persons with certain health conditions, including cancer, had greater exposure to EMF. Laboratory studies examined whether exposure to EMF in the laboratory could affect the health of persons and animals or produce biological responses in cells and tissue. A summary of recent research on the epidemiology of childhood and adult cancer, and other conditions (e.g. neurodegenerative disease, melatonin production) provides a context for understanding why health and scientific agencies have not concluded that exposures to ELF EMF at levels encountered in our daily life are a health hazard. While some of the epidemiology studies have reported statistical associations between higher average long term exposure to magnetic fields and childhood leukaemia, in particular, the role of chance, systematic error, and confounding by other factors cannot be ruled out as explanations. Moreover, a biological basis for these statistical associations is not supported by studies involving lifelong exposures of laboratory animals to magnetic fields. Similarly, studies of cells and tissues have not confirmed a mechanism by which weak ELF magnetic fields commonly encountered in our environment could have carcinogenic effects by either initiating or promoting cancer.

151 Everyone in developed and in most developing countries has exposure to ELF EMF wherever they live. Numerous national and international scientific and health organisations, including the WHO, the IARC, ICNIRP, the National Institute of Environmental Health Sciences in the United States, and the HPA in the United Kingdom have reviewed the existing scientific literature to assess the potential health risks arising from this widespread exposure to EMF. Following its most comprehensive in-depth review of the scientific literature on potential health effects related to EMF, the WHO made the following statement –*Based on recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields”* (WHO, 2014).

152 Scientifically-based exposure guidelines have been recommended by ICNIRP to protect the public and workers from known effects of EMF that occur at high levels of exposure, such as nerve and muscle stimulation and annoyance due to micro-shocks. The guidelines incorporate

large safety factors to ensure that allowable exposures are far lower than the lowest threshold for confirmed potentially adverse biological effects. ICNIRP also determined that evidence from studies with exposures below these guidelines and from studies of long term health outcomes “*is too weak to form the basis for exposure guidelines*.” The guidelines developed by ICNIRP form the basis for the EC‘s Recommendation (1999/519/EC) which sets out guidelines for member states on limiting the exposure of the public to EMF in locations where people spend significant time. The EC Recommendation is the de facto guideline applicable in Ireland and “*provides adequate protection for the public from any EMF sources*” (DCMNR, 2007).

153 The calculations of EMF provided above clearly demonstrate that the electric and magnetic field levels produced by the proposed 400 kV line meet the EU (1999) exposure limits (basic restrictions) and so would not cause internal electric fields and current density to exceed these biologically-based limits on exposure. Since these calculations are based on conservative assumptions about the operation of the proposed line, they are likely to overestimate levels of EMF from the transmission line.

154 While consideration of low-cost precautionary measures to minimise exposure to EMF in siting or line design have been recommended (DCMNR, 2007; WHO, 2007b) and followed in the case of this proposed development (i.e. avoiding residences to the greatest extent possible and minimising EMF by optimal phasing of the transmission line where it is supported on double-circuit structures), changes to current EMF guidelines were judged inappropriate by the EC “*as there are no clear scientific indications that the possible effects on human health may be potentially dangerous”* (EU, 2002). Undergrounding the proposed line, which might minimise the area where magnetic field exposure occurs, depending upon routing, cannot be considered as a “*reasonable and warranted”* precautionary measure under the WHO‘s recommendations based on both scientific grounds as discussed above, or on economic grounds (Parsons Brinkerhoff, 2009 and 2013).

155 Other topics that were referenced in public submissions include potential interference with implanted medical devices (such as pacemakers) and potential effects on plants and animals. CENELEC has indicated that exposure to fields below reference levels given by the EU (1999) mentioned above for human exposure also are sufficient to prevent interference with active implanted medical devices (CENELEC 50527-1 2010).

156 Research accumulated over the past 40 years on plants and animals exposed to ELF EMF from transmission lines and research conducted in the laboratory does not confirm any harmful effects of EMF on the health, behaviour, productivity, or reproductive potential of plants and animals.

157 In summary, even making conservative assumptions about the operating conditions assumed for the EMF calculations that would tend to overestimate field levels, the EMF levels from the proposed 400 kV line are still below EMF guidelines of Ireland and the EU. A survey of scientific research on topics relating EMF to health of humans and other species did not show that EMF at these levels would have adverse effects on these populations. This assessment is consistent with reviews by national and international health and scientific agencies.

9 TRANSBOUNDARY

9.1 INTRODUCTION

1 The issue of likely significant transboundary effects is of importance in the context of this proposed development, as it comprises part of an overall interconnection project between Ireland and Northern Ireland.

2 Article 7 of the consolidated EIA Directive 2011/92/EU provides the basis for consultation between Member States in relation to the likely significant effects of proposed development in one state on the environment in another Member State. The principal obligation is in respect of information and consultation and is imposed by Article 7(1):

> *"Where a Member State is aware that a project is likely to have significant effects on the environment in another Member State or where a Member State likely to be significantly affected so requests, the Member State in whose territory the project is intended to be carried out shall send to the affected Member State as soon as possible and no later than when informing its own public, inter alia:*
>
> *(c) a description of the project, together with any available information on its possible transboundary impact;*
>
> *(d) information on the nature of the decision which may be taken,*

3 Accordingly, potential transboundary impacts from the proposed development located in counties Meath, Cavan and Monaghan may have effects on the environment in Northern Ireland, and these potential transboundary impacts are considered in this chapter.

4 It should be noted that transboundary impacts on the environment of Ireland from System Operator Northern Ireland's (SONI) proposals for that portion of the proposed interconnector located in Northern Ireland are reported separately in a separate consolidated Environmental Statement (ES), prepared and submitted by NIE to the relevant competent authority in respect of the application for development consent in Northern Ireland.

5 Furthermore, the respective applicants note the publication by the European Commission (EC) of *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects* (May, 2013), in which the EC recognises that large-scale projects, physically located in more than one country (i.e. transboundary projects) are likely to have significant environmental effects in each country and involve many stakeholders. The EC also recognises that the environmental and socio-economic impacts of transboundary projects go beyond local, regional and national borders. Accordingly, the stated purpose of the EC's

document is to provide guidance for applying the legal provisions related to EIA for large-scale transboundary projects. Significantly, “*large-scale transboundary projects*” is defined in the ECs guidance document as projects which are implemented in at least two Member States and which are likely to cause significant effects on the environment or significant adverse transboundary impacts. This definition is based on a combination of Articles 2 of the EIA Directive and Espoo Convention. Finally, it is specifically stated that the guidance has to be viewed in conjunction with Regulation EU/347/2013 *on guidelines for trans-European energy infrastructure [TEN-E regulation],* which sets out a number of legal requirements designed to streamline permitting procedures for energy infrastructure ‘Projects of Common Interest‘ (PCI) contained in a European Union (EU) list established pursuant to the regulation. By way of Commission Delegated Regulation 1391/2013 (made on 14 October 2013), the *“Ireland – United Kingdom interconnection between Woodland (IE) and Turleenan (UK – Northern Ireland*” was expressly listed as a PCI (Annex V11, para. 2.13.1).

6 Accordingly, a *Joint Environmental Report* has been prepared by the respective applicants that cover the proposed interconnector from Turleenan, County Tyrone to Woodland, County Meath in a manner which assesses its overall effects and, in particular, cumulative and significant adverse transboundary effects, in a manner consistent with the approach suggested in the European Commission‘s guidance. The *Joint Environmental Report* comprises **Volume 4** of the application documentation.

9.1.1 Transboundary Consultation

7 As set out in **Chapter 3** of this volume of the EIS, the Department of the Environment (Northern Ireland) (DOENI) was consulted as part of the formal scoping exercise undertaken by An Bord Pleanála, and other statutory agencies made submissions to DOENI in that context. EirGrid also met with representatives of the DOENI. Potential impacts on the environment of Northern Ireland identified during this consultation have been evaluated in the EIS.

9.2 POTENTIAL TRANSBOUNDARY IMPACTS

9.2.1 Human Beings

9.2.1.1 Population & Economic

8 The overall project will not give rise to transboundary impacts in respect of population demographics, as this is influenced by factors outside this project.

9 Economic impacts during the construction stage are likely to remain local to the Meath, Monaghan and Cavan areas with no significant transboundary impacts anticipated. There will be wider economic benefits arising from improvements to the electricity grid on the island of Ireland; and these will be experienced in both jurisdictions. As noted in **Chapter 2** of this volume of the EIS, it is estimated that there will be savings in the Single Electricity Market (SEM) of approximately €20m in 2020 rising to a range of between €40m and €60m by 2030 once the interconnector is constructed. This is a significant positive transboundary impact.

9.2.1.2 Land Use

10 There are six land parcels located in County Armagh (reference numbers NI_165, NI_173, NI_174, NI_176, NI_177 and NI_045 & 166), along the border in the vicinity of the border crossings at Lemgare, County Monaghan (see Figure 3.2, **Volume 3C Figures**, of the EIS). The impacts from the proposed development (towers and overhead line (OHL)) located in County Monaghan on these six land parcels located in County Armagh (and land uses thereof) are considered Imperceptible.

9.2.1.3 Tourism

11 The majority of the most significant tourism attractions in Northern Ireland are located in counties that are a significant distance from the proposed development. Of the top 10 tourist attractions identified in statistics from the Northern Ireland Tourist Board (NITB), the majority (five) are in County Antrim, with one each in counties Fermanagh, Down, Derry / Londonderry, Tyrone and Armagh.

12 The main tourist attractions identified in County Armagh within 5km of the proposed development are within Armagh City, with the exception of the Navan Centre, an ancient monument (located 4km to the west of Armagh City). The Armagh / Monaghan border area is not in one of the Fáilte Irelands or the Northern Ireland Tourism Boards established tourism regions and no specific tourist attractions or amenities are identified in this area.

13 Due to the intervening distance from tourist attractions in Northern Ireland it is not anticipated that the proposed development will have any significant impact on tourism and amenity in the Armagh / Monaghan border area.

9.2.1.4 EMF

14 EMF emissions, will comply with the International Commission on Non-Ionising Radiation Protection (ICNIRP) and EU guidelines on exposure. Furthermore, as electric and magnetic field (EMF) levels dissipate within a short distance of the OHL, no significant transboundary

impacts will occur from the proposed development located in counties Meath, Cavan or Monaghan.

9.2.2 Flora & Fauna

15 Works on the proposed development within counties Monaghan, Cavan or Meath will have no direct impacts on habitats located in Northern Ireland. There is some potential for impacts on mobile species, but these are not likely to be significant. Badgers, Otters and Bats may have territories that straddle the jurisdictional border, but the nature of the proposed electricity transmission development means that these species are unlikely to be significantly adversely affected. There will be no impacts on sites designated for their conservation interest at either European or national level within Northern Ireland. The impact on Whooper swans and other mobile bird species that may use sites on both sides of the border is likely to be of imperceptible significance in terms of both population numbers and on availability of feeding sites. Following extensive surveys undertaken during the current appraisal no flights were observed between jurisdictions and the most important sites in both jurisdictions are well removed from the border area. Considering the landscape that dominates the northern part of the border area, there is no reason to suspect the presence of regular flight paths or commuting routes that may be used by Whooper swans or other water birds (i.e. an absence of large river valleys etc.). Mitigation measures to render the OHL more visible in those parts considered to present the greatest risk will be implemented in both jurisdictions, and will reduce the overall collision risk identified.

9.2.3 Soils, Geology and Hydrogeology

16 Impacts on the soils and geology are limited to the immediate area of the proposed towers (and associated excavations and works). In these circumstances, it is noteworthy that Towers 98-102 are located in Northern Ireland and, insofar as this appraisal is concerned, Towers 103-107 are located in County Monaghan within 200m of the jurisdictional border.

17 Based on an evaluation of predicted impacts, it is considered no significant impacts will occur on the geology of and groundwater conditions in Northern Ireland from excavation or other works at the sites of proposed towers in counties Monaghan, Cavan or Meath. Accordingly, it is concluded that the proposed development would have no significant transboundary impacts on soils, geology and hydrogeology.

9.2.4 Water

18 Impacts on the water environment are limited to the immediate area of the proposed towers (and associated excavations and works). Part of the proposed development is located in the

River Bann International River Basin District (IRBD), as defined in the Water Framework Directive (WFD) and the North-West International RBD (River Erne System).

19 Towers 98-102 are located in Northern Ireland adjacent to the border and Towers 103-107 are located in County Monaghan, within 200m of the border, and within the catchment of the Clontibret Stream. The Clontibret Stream, which actually delineates the border in the areas of Towers 103 to 107, ultimately flows into the Northern Ireland section of the River Bann Catchment at Ardgonnell Bridge, Middletown, County Armagh, 11km down-gradient. The Annalee and Knappagh Rivers flow through the central section of the proposed development (between Towers 131 and 200) before ultimately flowing into the Northern Ireland section of the River Erne Catchment to the north of Belturbet, 40km down-gradient of the proposed development.

20 Based on an evaluation of predicted impacts, it is considered that no significant impacts will occur on the surface water environment in Northern Ireland from construction or operation of the proposed electricity transmission development located in counties Monaghan, Cavan or Meath. Accordingly, it is concluded that the proposed development would have no significant transboundary impacts on the surface water environment.

9.2.5 Air

9.2.5.1 Noise and Vibration

21 No significant transboundary impacts associated with noise and vibration are predicted. Construction and operational phase impacts are predicted to meet the relevant noise and vibration limits at the nearest sensitive receptors. Noise sensitive receptors comprise houses, schools, hospitals, places of worship, heritage buildings, special habitats, amenity areas in common use and designated quiet areas. There are none of these sensitive receptors located within 50m of a proposed tower location in County Monaghan, which could have the potential to cause an impact on the environment of any receptor in Northern Ireland. As such, no significant transboundary impacts are therefore predicted.

9.2.5.2 Air - Climate

22 The proposed transmission line will contribute positively to a reduction in transboundary impact on climate through facilitating a reduction in national greenhouse gas emissions in compliance with the EU emission targets for Ireland and Irish national policy. Ireland has committed to achieving the EU's integrated approach to climate and energy policy that aims to combat climate change through achieving the climate and energy targets (i.e. 20% reduction in GHG below 1990 levels, 20% of energy consumption from to come from renewable energy targets

and 20% reduction in primary energy use). This is a key climate change mitigation identified in the EU's *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment*.

23 An imperceptible negative impact on transboundary air quality will arise due to the construction of the transmission line with the level of impact being reduced by the implementation of the mitigation measures outlined in this chapter of the EIS and the mitigation measures outlined in the Environmental Statement (ES) relating to Northern Ireland section of the proposed interconnector.

24 *Irelands Transboundary Gas Emissions* in 2011 published by the EPA in February 2013 indicates that in 2011 Ireland was below 3 of the 4 Annex 1 ceilings for 2010, under the *National Emissions Ceiling Directive* (2001/81/EC). The submission shows Ireland exceeding its 2010 NO_x ceiling by 2.6 kilotonnes. Emissions of each of the four pollutants in 2011 are shown below:

- SO_2 23.4 kilotonnes;
- NO_x 67.6 kilotonnes;
- VOC 43.6 kilotonnes; and
- NH_3 108.7 kilotonnes.

25 The provision of the 400 kV transmission circuit will increase the availability of renewable energy contributing to further reductions in SO_2 and NO_x emissions associated with displaced fossil fuelled power generation and through provision of an efficient transmission system.

26 Climate change is a globally occurring phenomenon with impacts on the global climate related largely to atmospheric CO_2 levels and other greenhouse gas levels and emissions.

9.2.6 Landscape

27 There will be localised transboundary landscape and visual effects arising from the part of the alignment between Towers 102 (the actual tower is located in Northern Ireland) and 110, as this section of the proposed development in County Monaghan is closest to the jurisdictional border with Northern Ireland.

28 These transboundary effects will occur at the edge of the Armagh Drumlins Landscape Character Area (LCA 66), which is a relatively small scale and hilly-farmed landscape with high sensitivity. The proposed transmission development will run adjacent to the border through a

small, relatively enclosed valley. The Monaghan Way travels along the southern part of the valley, and Doohat and Crossbane roads in Northern Ireland are located along the northern part. A quarry is located just south of the valley at Lemgare.

29 The localised landscape character will experience a change in the sense of scale with the inclusion of the towers, as the proposed development will introduce a new scale of structure into a man-altered landscape that contains existing houses, farm buildings and roads. This change is considered a locally significant effect on landscape character.

30 Due to the enclosed nature of this valley, there will be localised, significant visual effects on views looking south from the parts of Crossbane Road and Doohat Road, located in County Armagh, where unscreened open views are possible into the valley. The visual effects at one such open view are shown in **Figure 9.1** (Photomontage 3).

Photomontage 3 looking south from Crossbane Road in Armagh (321m to closest tower)[94]
Existing view 
Proposed view including transmission line 

[94] Full scale photomontages and wireframes are contained in Appendix 11.2, **Volume 3C Appendices,** of the EIS.

Wireframe – blue shows what is in view, red shows what is screened by intervening vegetation or topography

Reason for selection: This photomontage represents an open view from Crossbane Road, Armagh into the valley that parallels the border in this location.

Landscape effects – There would be significant localised effects on this small scale valley. The character of the valley will change with the introduction of structures that are of larger scale than anything else within the valley, with resulting significant localised effects. Landscape effects are closely related to visual effects and the more enclosed parts of the valley with hedgerows or stands of trees will experience less landscape impact.

Visual effects – The transmission line will be visible from parts of Crossbane Road where there are gaps in the roadside vegetation. The towers will be mainly seen against the backdrop of hills.

Figure 9.1: Photomontage 3 - from Crossbane Road, County Armagh

31 Other viewpoints will not experience any visual effects due to screening provided by intervening vegetation. While the visual effects are significant within the valley, the topography also serves to limit the visibility over a wider area. The transmission line will cross a local road in Coolartragh, a stretch of which is located in County Armagh. The proposed development is likely to be visible for a stretch of approximately 500km along the part of the road located in County Armagh.

32 There will be no significant transboundary landscape or visual effects, beyond distances of 600-800m from the towers, although views of parts of certain towers will be distantly visible from unscreened locations up to 1-1.5km from the transmission line, particularly from elevated parts of the landscape.

9.2.7 Material Assets

9.2.7.1 Other

33 There will be a positive transboundary impact associated with providing a high capacity electricity transmission line between Ireland and Northern Ireland. This will lead to improvements in the efficiency of the all-island electricity market, ensure a secure supply of electricity, and will allow more renewable energy to be connected to the network.

34 The proposed development in counties Monaghan, Cavan and Meath will have no transboundary impacts on the gas infrastructure in Northern Ireland. Additionally the proposed development will have no transboundary impacts on telecom services operating in Northern Ireland. Where telecom services traverse the border, consultation will take place as required with service providers prior to any construction works in the proximity of existing telecoms services.

35 To manage construction waste, the main contractor will be required to develop, implement and maintain a *Construction Waste Management Plan* during the construction works and there are adequate waste management facilities in counties Monaghan, Cavan and Meath - therefore waste material will not be transported to facilities in Northern Ireland.

36 There are no licenced airfields in Cavan and Monaghan. As confirmed by the Irish Aviation Authority (IAA), the closest licenced airfield to the proposed development is Trim Airfield, in County Meath. Aircraft originating in Northern Ireland with Trim Airfield as their destination would need to be visually aware of tower positions and a formal approach procedure of *„visual contact of pylons / cables required before field approach‟* should be introduced, even though there is a clear margin between the top of the towers and the obstacle limitation surface for Trim Airfield.

37 Ballooning companies operating in Northern Ireland will have to be cognisant of the proposed development close to the jurisdictional border. The potential presence of transmission lines in this area will have to be considered by balloon pilots as part of their flight planning procedures. The transmission lines will have to be taken into account by the balloon pilots for launching and landing, but as stated by the IAA, balloon pilots are permitted to fly over power lines.

9.2.7.2 Traffic

38 Each tower site will be, in effect, a separate temporary construction site which will be accessed by road. Access locations have been identified for each site and haul routes to these accesses have also been identified for the delivery of materials and personnel to site, all of which are in Ireland. All such routes identified close to the jurisdictional border are located within County Monaghan, and do not cross the border into Northern Ireland. Thus, despite the proximity of the northern end of the proposed development to the border between Northern Ireland and the Ireland, it is not expected that traffic delivering materials to site will cross the border into Northern Ireland.

39 It is expected that the materials used for the construction of the towers will emanate from the proposed material storage yard located at the townlands of Monaltyduff and Monaltybane, Carrickmacross, County Monaghan. However the possibility remains that some construction materials which are stored at the materials storage yard may actually be sourced from suppliers based in Northern Ireland. Similarly, the location where construction workers reside is not known and they may also commute to the construction materials storage yard or construction sites from Northern Ireland.

40 The volumes of traffic associated with materials and / or workers coming from Northern Ireland would not be large and as such the transboundary traffic impact as a result of the proposed development is considered to be minimal.

9.2.8 Cultural Heritage

41 All known archaeological, architectural and cultural heritage sites listed on the Northern Ireland Environment Agency (NIEA) website were included in this appraisal of the potential impacts that the proposed development located in counties Monaghan, Cavan or Meath would have on the receiving cultural heritage environment in Northern Ireland. The appraisal of the potential transboundary impacts of the proposed development on the setting of cultural heritage sites was also considered. This appraisal comprised an evaluation of a site‘s ‗Sensitivity to Impacts on Setting‘ and was based on analysis of the data sources noted above and a consideration of the criteria as described in Appendix 14.1.5.1, **Volumes 3C** and **3D** of the EIS and professional judgement. It is concluded that there will be no direct physical impacts on known archaeological, architectural or cultural heritage sites, structures, monuments or features located in Northern Ireland as a result of the construction or operation of the proposed development located in counties Monaghan, Cavan or Meath. There is only a single archaeological monument located in Northern Ireland listed in the Northern Ireland Sites & Monuments Record (NISMR) in a site classified as an enclosure (ARM 023:004), which is proximate to any part of the proposed development in County Monaghan. This tree-covered

site is located in County Armagh, approximately 197m from Tower 106, which is located in County Monaghan, and is described as a *"polygonal earthwork on a slight eminence*". Looking south and south-east from the site located in County Armagh towards the proposed alignment located in County Monaghan, there will be inter-visibility, however, the sensitivity of the site to impacts on setting is considered to be moderate and the magnitude of the impact substantial. The overall significance of this transboundary impact of the proposed development located in County Monaghan on the setting of the site in Northern Ireland was considered to be moderate. The residual impact will consist of a permanent, moderate, negative impact on the setting of the archaeological monument throughout the operational phase of the proposed development.

42 There will be no impacts on the previously unrecorded cultural heritage resource in Northern Ireland, as a result of the construction of the proposed development within counties Monaghan, Cavan or Meath.

9.3 CONCLUSIONS

43 Based on the evaluations carried out by EirGrid and its consultants, which are summarised in this chapter, transboundary impacts are predicted to range from imperceptible to moderate, apart from localised significant landscape and visual impacts (specifically a locally significant effect on landscape character).

44 The significance of the transboundary impact of the proposed development located in County Monaghan on the setting of an archaeological site in Northern Ireland (NISMR enclosure site (ARM 023:004) was considered to be moderate. The residual transboundary impact will consist of a permanent, moderate, negative impact on the setting of the archaeological monument throughout the operational phase of the proposed development.

10 CUMULATIVE IMPACTS AND IMPACT INTERACTIONS

10.1 INTRODUCTION

1 This chapter considers the potential for cumulative impacts arising from the proposed development in association with other development, as well as the interaction between potential impacts on the environment arising from the proposed development.

10.1.1 Legislative Requirements

2 As described in **Chapter 1** (of this volume of the Environmental Impact Statement (EIS)), pursuant to Article 3 of the Consolidated EIA Directive 2011/92/EU, *"the environmental impact assessment shall identify, describe and assess in an appropriate manner, in light of each individual case and in accordance with Articles 4 to 12, the direct and indirect effects of a proposed development on the following factors*:

(a) *human beings, flora and fauna;*

(b) soil, water, air, climate and the landscape;

(c) material assets and the cultural heritage,

*(d) the **interaction between the factors referred to in points (a), (b) and (c)."** [emphasis added]*

3 Furthermore, the information to be included in an EIS must provide *"a description of the likely significant effects (including direct, indirect, secondary,* ***cumulative,*** *short, medium and long term, permanent and temporary, positive and negative) of the proposed development on the environment"* [emphasis added].

4 The Environmental Impact Assessment (EIA) process is only concerned with projects. However, many projects, especially in the area of public infrastructure, have been prefigured in plans, strategies and policies previously adopted. In May 2012, EirGrid published the *Grid25 Implementation Programme 2011-2016* (IP), which is a strategic overview of how the early stages of 'Grid25' are intended to be implemented. The publication of this document, and an associated Strategic Environmental Assessment (SEA), followed a national scale public consultation process. The IP document identifies EirGrid's understanding of those parts of the transmission system that are envisaged as likely to be developed over the next five years in order to give effect to Government policy. Indeed, the proposed development is specifically referred to in the IP document. The Environmental Report, for the purposes of SEA, which accompanied the IP, provides the strategic environmental framework for the proposed

development and future related projects and, at an appropriate level or tier, considers cumulative impacts and interactions arising.

10.2 CUMULATIVE IMPACTS

10.2.1 Methodology

5 The European Commission's *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (EC, 1999) refer to the following in its consideration of cumulative impacts:

- "***Cumulative Impacts:*** *The impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project, for example:*
    - *Incremental noise increase from a number of separate developments;*
    - *Combined effect of individual impacts e.g. noise, dust and visual from one development on a particular receptor; and*
    - *Several developments with insignificant impacts individually but which together have a cumulative effect e.g. development of a golf course may have an insignificant impact, but when considered with several nearby golf courses there could be a significant cumulative impact on local ecology and landscape.*"

6 For this EIS the methodology and approach is informed by the 1999 EU Guidelines for the Assessment of Indirect and Cumulative Impacts and reference was also made to 2002 and 2003 Environment Protection Agency (EPA) guidance documents.

10.2.2 Other Developments

7 Cumulative impacts may arise from the combined effects of a number of other existing or proposed developments, in combination with the development being evaluated, on a single receptor / source. Where relevant these have been identified in the individual environmental chapters.

8 For the purpose of the evaluation proposed development included in the cumulative impact appraisal has been taken to include:

- A permitted electricity transmission development, or one currently in the planning process, located within the counties of Monaghan, Cavan and Meath;

In this particular instance, in assessing cumulative impacts, an appraisal has been conducted of the proposed interconnector, including that section of the project located between the border with Northern Ireland and Turleenan, County Tyrone (i.e. to include the SONI portion of the proposed second interconnector); and

- Permitted development with the potential for significant cumulative effects with the proposed development, e.g. major linear infrastructure development, such as road proposals, windfarms, other Strategic Infrastructure Development (SID), or public utilities and services along the route corridor.

9 The following is noted in this regard:

- There are a number of proposals for future development within counties Monaghan (including along the jurisdictional border with Northern Ireland), Cavan and Meath in the vicinity of the development. This would include *inter alia* proposed quarries, windfarm and electricity generation development which is subject to Gate 3 connection offers. However, as the location and exact nature of such development is not clear, and those prospective developments have not yet been made the subject of a planning application or decision, they have been scoped out of the cumulative impact assessment.

- Planning applications in the vicinity of the proposed development are monitored on a regular basis to ensure conflicts do not arise. The types of planning applications that typically occur in the vicinity of the proposed development primarily relate to applications for single rural dwellings and agricultural developments. Permitted developments in close proximity to the centre line of the OHL, with extant permissions are identified on the Line Route Map – Detail (1:2,500) contained in **Volume 1B** of the application documentation.

- Due to the generally modest nature and scale of these types of planning applications and agricultural developments they have been scoped out of the cumulative impact assessment.

10.2.3 Transmission Projects

10.2.3.1 Overhead Line and Substation Transmission Developments

10 The proposed overhead line (OHL) and substation developments (including electricity transmission infrastructure developments) included within the cumulative assessment are summarised in **Table 10.1.** In addition the following proposed developments are specifically acknowledged:

10.2.3.2 SONI Element of the Proposed Interconnector

11 In December 2009, an application for the SONI proposal was submitted to the Northern Ireland Planning Service for that portion of the proposed cross-border transmission infrastructure development located in Northern Ireland (Ref. O/2009/0792/F). The application was accompanied by an Environmental Statement (ES).

12 As set out in **Section 1.1.3.1**, in August 2010, the Northern Ireland Environment Minster referred the SONI proposal to the Planning Appeals Commission (PAC) for a public inquiry. Subsequently, further information was requested in respect of the application. Addenda to the ES were submitted in January 2011 and October 2011. The public inquiry commenced in March 2012 and, as at the date of this EIS, stands adjourned. At the public inquiry, the PAC made a number of requests for additional information with regard to the application. When adjourning the public inquiry, the PAC requested that a consolidated ES be prepared. In May 2013 a second application was submitted for planning permission for works associated with the construction of the main infrastructure under the 2009 application (Ref. 0/2013/0214/F). Subsequently a consolidated ES was submitted in June 2013. The ES for the purposes of that application is a consolidated ES which assesses the environmental effects of both the main infrastructure works under the 2009 application and the associated works under the 2013 application.

13 The SONI proposal is included within the cumulative assessment.

10.2.3.3 Future Substation in the Vicinity of Kingscourt

14 As noted in **Chapter 2** of this volume of the EIS, the need for the intermediate substation near Kingscourt is not now expected to arise for at least another ten years and is not, therefore, included in this application for planning approval, but rather will be the subject of a separate future application for approval (which will itself be the subject of an EIA).

15 Notwithstanding this fact, the future substation is also included within the cumulative impact appraisal for the project. This is addressed at a strategic level as the exact nature or location of such development is not clear, except insofar as an appropriate location for an intermediate substation, and associate tie-in would be in the vicinity of the point of intersection of the north-south oriented proposed development and the existing east-west oriented Flagford-Louth 220 kV OHL, near Kingscourt, County Cavan.

10.2.4 Major and Strategic Infrastructure Developments

16 Other permitted and proposed developments with the potential for significant cumulative effects with the proposed development and included within the cumulative assessment are also summarised in **Table 10.1**. This includes major infrastructure proposals such as roads, which are identified within relevant County Development Plans.

Table 10.1: Permitted and Proposed Transmission, Major and SID Projects

PLANNING APPLICATION REFERENCE	PLANNING AUTHORITY	NAME OF APPLICANT	DEVELOPMENT	ADDRESS OF THE PROPOSAL	DECISION / STATUS	DATE OF FINAL GRANT
09447	Cavan County Council	ESB Networks	To build a 38 kV OHL from existing Shercock 38 kV Station	Shinan, Shercock and across the townlands Lecks, Croley, Lisdrumskea, and to a point at Lisdrumfad, Shercock	Grant with conditions	22/07/2010
09561	Monaghan County Council	ESB Networks	To build a 38 kV OHL from existing Shercock 38 kV Station	Shinan, Shercock and across the townlands Lecks, Croley, Lisdrumskea, and to a point at Lisdrumfad, Shercock	Grant with conditions	23/06/2010
PL17.PA0013	Meath County Council	College Proteins	Biomass Combined Heat And Power (CHP) Plant	College Road, Nobber, County Meath	Grant with conditions	28/02/2013
PL25.VA0013	Westmeath County Council & Meath County Council	EirGrid	Proposed 110 kV Circuit From Mullingar 110 kV Station, Co. Westmeath to Kinnegad 110 kV Station at Killaskillen Townland, Co. Meath	County Westmeath and County Meath	Grant with conditions	10/01/2013
PL17.PA0026	Meath County Council	Indaver Ireland Limited	Amendments to existing Permissions for Waste Energy Plant	Carranstown, Duleek, County Meath	Grant with conditions	04/02/2013
Ka / 120679	Meath County Council	SSE Renewables Ireland Ltd.	Five wind turbines of up to 80m hub height and up to 82.5m rotor diameter with a total tip height not exceeding 121.25m, a transformer	Teevurcher and Agheragh, Tierworker, Kells (see **Figure 10.1**)	Granted	06/06/2013

PLANNING APPLICATION REFERENCE	PLANNING AUTHORITY	NAME OF APPLICANT	DEVELOPMENT	ADDRESS OF THE PROPOSAL	DECISION / STATUS	DATE OF FINAL GRANT
			and crane handstand area at each turbine, underground electrical and communication cables linking the turbines, internal site tracks, a permanent meteorological mast 80m high, drainage works, a substation and associated equipment and control building with a wastewater treatment system and associated works.			
Ka / 120679	Meath County Council	SSE Renewables Ireland Ltd.	Five wind turbines of up to 80m hub height and up to 82.5m rotor diameter with a total tip height not exceeding 121.25m, a transformer and crane handstand area at each turbine, underground electrical and communication cables linking the turbines, internal site tracks, a permanent meteorological mast 80m high, drainage works, a substation and associated equipment and control building with a wastewater treatment system and associated works.	Teevurcher and Agheragh, Tierworker, Kells (see **Figure 10.1)**	Granted	06/06/2013

PLANNING APPLICATION REFERENCE	PLANNING AUTHORITY	NAME OF APPLICANT	DEVELOPMENT	ADDRESS OF THE PROPOSAL	DECISION / STATUS	DATE OF FINAL GRANT
PA0038	An Bord Pleanála	North Meath Windfarm Limited	Construction of 3 windfarm clusters comprising *inter alia:* a combined total of 46 no. wind turbines with a maximum tip height of up to 169 metres and associated turbine foundations, hardstanding areas and drainage; 1 meteorological mast (80 metres in height); a 110 kV substation; 6 no. borrow pits, new entrances and site tracks; cabling between turbines and on-site substation and the existing Gorman substation; and all associated site development works. Details of the proposed development including an EIS are available at www.emlaghwindfarm.ie.	County Meath [It is located in the vincity of the North South 400 kV Interconnector between Towers 282 and 295 Refer to **Figure 10.2.**]	An application for planning approval was lodged with An Bord Pleanála on 6th October 2014.	
N/A		National Transport Authority	Phase II of the Dublin to Navan rail link. The Railway Order was substantially complete but was deferred by the Infrastructure and Capital Investment 2012–2016 Medium Term Exchequer	Dublin to Navan rail link	On hold	N/A

PLANNING APPLICATION REFERENCE	PLANNING AUTHORITY	NAME OF APPLICANT	DEVELOPMENT	ADDRESS OF THE PROPOSAL	DECISION / STATUS	DATE OF FINAL GRANT
			Framework (November 2011)			
N/A	N/A	NRA	Leinster Orbital Route (LOR) - in the vicinity of Trim	Feasibility / On hold		
N/A	Cavan and Meath County Council	NRA	The improvement / replacement of a section of the N3	From a location south of the Cavan / Meath County boundary (in the townland of Derver, County Meath), to an appropriate location on the existing network between the townlands of Thomas Court or Drumroosk and Kilnaleck, Butlersbridge County Cavan, a potential distance of 46km	Suspended	N/A
N/A	Louth and Meath County Council	NRA	The N52 Ardee bypass consists of 4.48km of reduced single carriageway roadway and commences to the west of Ardee running east to the N2 road North of Ardee. The scheme includes two river crossings of the River Dee and River Garra, a staggered junction at Silver Hill road and a T-junction with	North of Ardee, County Louth	Planning Stage	N/A

PLANNING APPLICATION REFERENCE	PLANNING AUTHORITY	NAME OF APPLICANT	DEVELOPMENT	ADDRESS OF THE PROPOSAL	DECISION / STATUS	DATE OF FINAL GRANT
			the Mullinstown Road.			
N/A	Monaghan County Council	NRA	Upgrade approximately 28km of the N2 in north County Monaghan between the village of Clontibret and the border of County Tyrone.	Clontibret to the border of County Tyrone.	Suspended	N/A

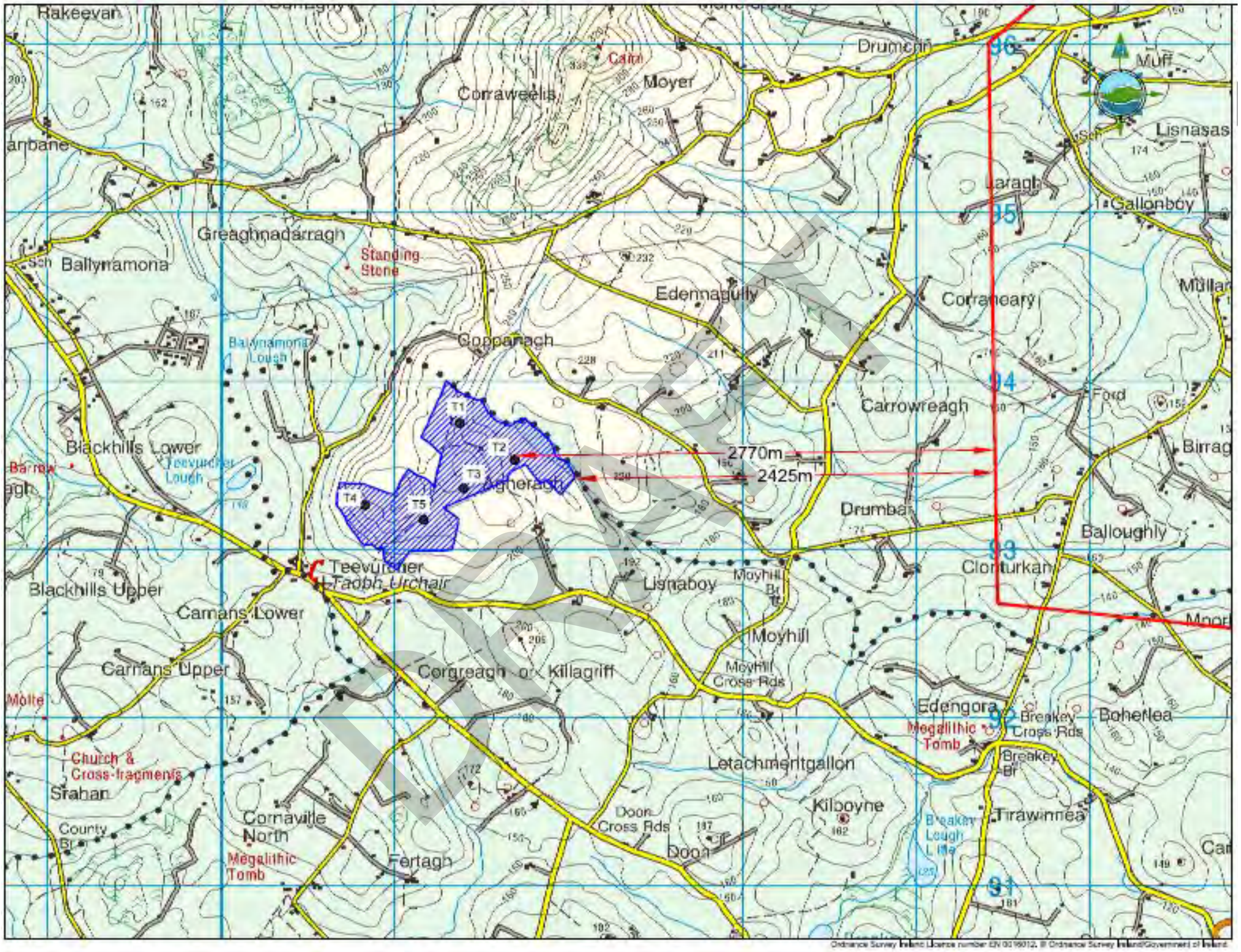


Figure 10.1: Teevurcher Windfarm Relative to the Proposed Development

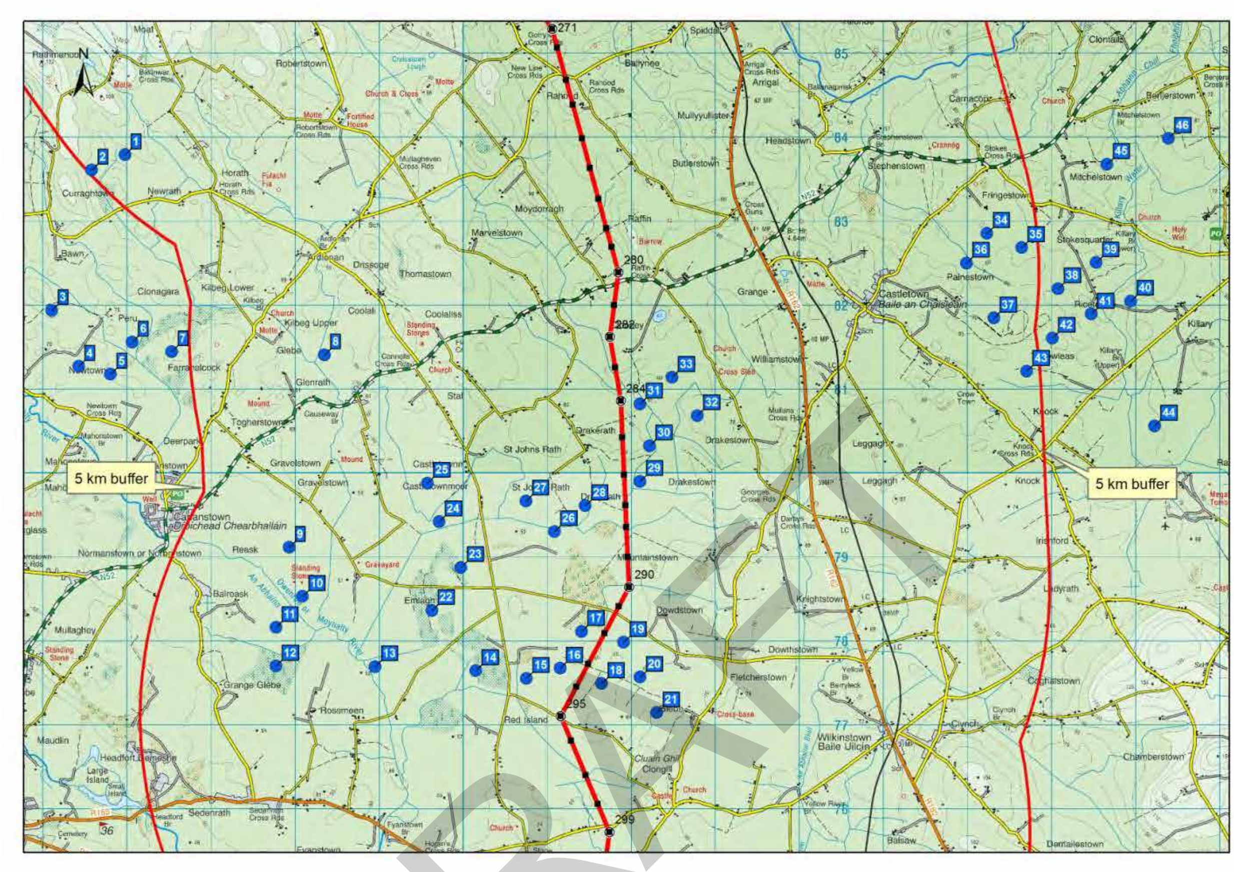


Figure 10.2: Proposed Emlagh Windfarm Relative to the Proposed Development

10.2.4.1 Emlagh SID Windfarm Development

17 As identified in **Table 10.1,** an application for approval has been submitted to the SID Division of An Bord Pleanála (the ‗Board‘) for a windfarm (the ‗Emlagh Windfarm‘) (ABP Ref. PA0038). The windfarm which is proposed in three clusters, is located north-east of Kells, County Meath and includes 46 turbines with a tip height of 169m, 18 of which are to be located within 2km of the proposed North-South 400 kV Interconnector. The location of the windfarm turbines relative to the North-South 400 kV Interconnection Development is illustrated in **Figure 10.2**.

18 The distance of the individual turbines to the North-South 400 kV Interconnection Development is set out in **Table 10.2**.

19 An EIS accompanied the application for approval to the Board.

Table 10.2: Distance of Proposed Emlagh Windfarm Turbines to the North-South 400 kV Interconnection Development

Turbine	Distance to MSA Line Route (m)	Turbine	Distance to MSA Line Route (m)
1	4540	24	2220
2	4950	25	2340
3	6640	26	855
4	6320	27	1180
5	5950	28	475
6	5680	29	185
7	5200	30	320
8	3400	31	225
9	4005	32	902
10	3385	33	650
11	3545	34	4400
12	3430	35	5105
13	2280	36	4140
14	1140	37	4500
15	570	38	5230
16	270	39	5685
17	250	40	6105
18	250	41	5645
19	252	42	5185
20	620	43	4840
21	995	44	6330
22	1940	45	5950
23	1980	46	6730

10.3 EVALUATION OF CUMULATIVE ENVIRONMENTAL EFFECTS

10.3.1 Human Beings

20 No developments have been identified in the study area which could give rise to significant cumulative impacts on human beings in terms of **population & economic** considerations.

21 There are a number of landholdings along the line route already traversed by existing high voltage transmission infrastructure and localised cumulative impacts are predicted due to the introduction of the proposed development. The **land use** impacts include additional land taken up by towers and

additional land oversailed by OHL with associated implications for farming practices. A detailed consideration of these impacts is included in the baseline assessment in Appendix 3.1, **Volume 3C Appendices** and **Volume 3D Appendices** of the EIS. The proposed Emlagh Wind Farm will also have significant impacts on a number of land parcels along the line route. These impacts have also been considered and evaluated in Appendix 3.1, **Volume 3C Appendices** and **Volume 3D Appendices** of the EIS. As discussed in **Chapter 2,** of this volume of the EIS, it is possible at some point in the future that a new substation may be developed in an area west of Kingscourt. The cumulative land use impacts arising from the construction of this substation are likely to be locally significant however in the absence of a location and design for such a substation the degree of such impacts cannot be quantified at this point.

22 In terms of **tourism and amenity,** and having regard to the tourism assets identified by Fáilte Ireland relative to the location of the proposed development, no other projects have been identified in the study area which could give rise to significant cumulative impacts.

23 No other projects have been identified which could give rise to significant cumulative impacts arising from **EMF** related to the proposed development.

10.3.2 Flora & Fauna

24 Cumulative effects may arise from the combination of effects of the development being assessed with a number of other developments and land management practices including agricultural, industrial, point source pollution and waste water treatment. This can include multiple impacts of varying sources and magnitudes upon the same receptor / resource.

25 Projects identified in the vicinity of the development and considered to potentially result in cumulative impacts include:

- SONI Element of the proposed interconnector. This section of the proposed interconnector links to the most northerly tower of the proposed development and is part of the interconnection project located in Northern Ireland.

- 38 kV Overhead Line from Tullymalra Station to Shercock Station. The majority of supporting structures for the line are single pole intermediate structures. Condition 3 of the grant of planning permission requests that bird flight diverters be installed at appropriate locations along the line.

- Teevurcher Wind Farm Development. This is a windfarm development located partly in the River Boyne catchment.

- North Meath Wind Farm Limited: This extensive windfarm development occurs close to the proposed development. The residual impacts identified in the EIS for this windfarm development to shared ecological receptors are; negligible for birds (including Whooper Swan) and low for bats. Residual impacts to aquatic ecology including designated sites common to this development are not significant i.e. the conservation status of ecology receptors in receiving waters will not be affected.

26 The residual impacts for the projects detailed were reviewed to inform this appraisal. No significant adverse impacts are outlined regarding potential impacts common to relevant ecology receptors outlined in this EIS for the proposed development. The potential receptors that may be common to other projects are identified as Whooper swans and other birds, protected mammals, habitats of ecological interest and the River Boyne and Blackwater SAC.

27 Projects detailed have identified appropriate mitigation measures for minimising potential impacts to relevant ecological receptors. Mitigation includes water protection measures (relevant to River Boyne and Blackwater cSAC / SPA) and bird flight diverters for OHL developments. No residual impacts are identified to birds including Whooper swan and protected mammal species. Cumulative habitat loss is not significant as only a relatively small area is expected to be impacted and this is mostly restricted to habitats of low ecological value.

28 In conclusion, it is considered that no significant cumulative (additional) effects will arise to relevant flora and fauna from the proposed development.

10.3.3 Soils, Geology and Hydrogeology

29 Based on a review of the construction methodology, ecology and water chapters, there are no significant cumulative impacts arising as a result of the proposed development in association with other development. Intact peatlands and fens have been avoided by the proposed development and, therefore, there are no potential impacts on the ecohydrogeology of these areas. All groundwater bodies have been classified as being of Good Status as defined in the Water Framework Directive (WFD). No significant predicted impacts are likely to occur on the River Boyne and Blackwater groundwater dependent terrestrial ecosystems (GWDTE) as part of this proposed development. The proposed development will not have a significant impact on the WFD status of groundwater bodies either short term or long term.

10.3.4 Water

30 Cumulative effects may arise from the combination of effects of the development being assessed with a number of other developments and land management practices including agricultural, industrial, point source pollution and waste water treatment. This can include multiple impacts of varying sources and magnitudes upon the same receptor / resource. The main pressures on surface water quality along the proposed development are agriculture and wastewater discharges (wastewater treatment plants and septic tanks).

31 Based on a review of the construction methodology, ecology and soils, geology and hydrogeology chapters, there are no significant cumulative impacts as a result of the proposed development in association with other planned developments. Intact peatlands and fens have been avoided and therefore there are no potential impacts on the ecohydrology of these areas. Most surface water catchments currently do not meet Good Status as defined in the WFD. The main pressures on surface water catchments along the proposed development are agriculture and wastewater treatment plants. The proposed development will not have a significant impact on the WFD status of streams either short term or long term. No significant predicted impacts are likely to occur on the River Boyne and Blackwater cSAC / SPA as part of this proposed development.

10.3.5 Air –Noise and Vibration

32 There a number of areas within the study area where the line route crosses over or near to existing power or other similar infrastructure. The noise impact from these existing sources is catered for in the background noise surveys.

33 As discussed in **Chapter 2,** of this volume of the EIS, it is possible at some point in the future that a new substation may be developed in an area west of Kingscourt. The development of a substation and intensification of associated OHL infrastructure in the area may result in cumulative noise impact on sensitive receptors in the area, however in the absence of a location and design for such a substation the degree of such impacts cannot be quantified at this point.

34 There is the potential for cumulative impact with the construction phase of the interconnector project and that of the Emlagh Windfarm project. However, neither project is sufficiently advanced at time of writing to facilitate scheduling comparison for construction phases. Should the projects construction phases coincide in proximity to a noise sensitive receptor, site management will be used to adhere to the construction phase noise limits as discussed above. There will be no significant cumulative impact to sensitive recptors in the operational phase.

35 No other project has been identified in the study area that might produce cumulative noise and vibration impacts to sensitive receptors.

10.3.6 Air – Climate and Air Quality

36 No other permitted projects have been identified in Monaghan, Cavan and / or Meath which could give rise to significant cumulative impacts on human beings (Air & Climate).

10.3.7 Landscape

37 There are a number of areas within which the alignment of the proposed development crosses over or near to existing power infrastructure. As a result, there is potential for significant localised cumulative landscape effects between Towers 130 and 131 in the townland of Drumsook at Drumgristin and Coogan's Loughs, County Monaghan and between Towers 233 and 234 in the townland of Corraneary (ED Enniskeen), County Cavan. Localised significant visual cumulative effects will occur between Towers 180 and 181 in the townland of Corrinenty / Corbane, County Monaghan and between Towers 233 and 234 in the townland of Corraneary (ED Enniskeen), County Cavan.

38 As identified in **Table 10.1,** a 46 turbine wind farm is proposed in three clusters north-east of Kells. Due to the turbine height of 169m, the wind farm is potentially widely visible within the North-South Interconnection Development study area.

39 A number of photomontages have been prepared to illustrate the nature of cumulative effects (refer to Photomontages 48A, 48B, 48C, 49, 50, 50A, and 54 included in **Volume 3B Figures**). Analysis has concluded that there are two distinct types of cumulative effect.

40 Where the viewer is in close proximity to the transmission line, and turbines are visible, there is an adverse cumulative landscape effect. Proximity to transmission line towers means that they are perceived as being of comparable height to the more distant turbines in some views (although the average height of towers in this location is approximately 39m and the turbines are 169m). In such views, both proposals appear as one development. This results in a localised industrialisation of the landscape character. Refer to Photomontages 48A, 50, 50A included in **Volume 3B Figures**.

41 Where the viewer is in close proximity to a wind turbine and the transmission line is visible in the distance, there is less adverse landscape effect. The scale of the transmission line is diminished by the much larger scale of the wind farm and the two developments are perceived as separate.

While the cumulative effects remain high, they diminish with increased distance from the transmission line. Refer to Photomontages 48B, 48C and 49 included in **Volume 3B Figures**.

42 Therefore, while there would be many opportunities to view both the proposals sequentially and simultaneously, the highest cumulative impacts will occur within approximately 500m of the transmission line when both developments are visible at close distance.

43 Cumulative landscape effects will arise from the construction of the proposed 5 wind turbines at Teervcurcher, intensifying the industrialised character of the rural landscape in this location to the south and east of Lough an Leagh mountain.

44 There is potential for cumulative landscape and visual effects arising from the future construction of a substation at the point of intersection of the proposed interconnector and the existing Flagford-Louth 220 kV OHL near Kingscourt. The cumulative landscape and visual effects will depend on the exact location of the substation but will most likely be locally significant after construction, reducing as the screening effects of planting come into effect.

10.3.8 Material Assets

45 In terms of **Material Assets - General** – no other projects have been identified which could give rise to significant cumulative impacts on the material assets general.

46 In terms of **Material Assets – Traffic**, North Meath Wind Farm Ltd. propose to construct a windfarm at Emlagh, County Meath. Chapter 13 of the EIS submitted with the windfarm application estimates the daily volume of traffic to be generated by the construction phase of the windfarm development to be 339 No. vehicular trips per day. When combined with construction traffic estimated to be generated during the construction phase of an angle tower (in the worst case scenario) of 46 No. vehicles, this results in a total cumulative generated traffic volume of 385 No. vehicles.

47 For this cumulative impact assessment it has been assumed that the towers for the proposed development will be constructed in the vicinity of Emlagh Windfarm at the same time as construction of the windfarm. It has also been assumed that construction traffic for both developments will use both the N52 and R162 to access the respective local site access roads.

48 From Table 13.1 of the Emlagh EIS, the N52 has an Annual Average Daily Traffic (AADT) of 3,045 vehicles. The additional 385 No. vehicles would equate to a 12.6% increase in AADT.

49 From Table 13.2 of the Emlagh EIS the R162 has an AADT of 3,724 vehicles. The additional 385 vehicles would equate to a 10.3% increase in AADT.

50 As outlined above, traffic on the road network will increase for the duration of the construction phase. While the percentage increases are slightly above 10%, this is generally reflective of the low number of vehicles generally using these roads. Furthermore, the figures above present the peak additional flow along each road and assume all construction traffic will access both the N52 and R162 and therefore a worst case scenario. These peak flows would only be occurring for short durations. From a capacity perspective, the road network will be able to cater for the flows predicted.

10.3.9 Cultural Heritage

51 The proposed Emlagh Wind Farm development is to be located within 2km of the proposed OHL development. It is noted that the scale of the wind turbines is much greater than the OHL towers proposed and that they will have an influence over a much greater distance.

52 Should the windfarm development proceed, there will be cumulative impacts on the setting of archaeological and architectural sites in the vicinity, in particular, these include Mountainstown House (RPS No. MH012-100) with its associated demesne landscape (NIAH Garden Survey No. ME-42-N-829790) and Dowdstown House (RPS No. MH011-124) with its associated demesne landscape (NIAH Garden Survey No. ME-42-N-903631).

53 It is acknowledged in this evaluation, that the proposed OHL development crosses the western extent of Mountainstown demesne landscape, where it will have a negative direct, physical impact as well as a moderate impact on the setting of the demesne as a whole. However due to its scale and remove from Mountainstown House, it will only slightly, negatively affect the setting of the house. The proposed turbines, although situated outside the demesne landscape, are located to the north, south and west of the demesne and will have an adverse impact on the setting of the demesne – turbines will be visible to the rear of the house when accessing it along the entrance avenue to the east. The proposed windfarm would result in an adverse cumulative impact on the setting of Mountainstown House and its associated demesne landscape.

54 The proposed North-South 400 kV Interconnection Development passes from north to south approximately 500m to the west of Dowdstown House. The principal view from the front of the house is to the south and there are extensive agricultural buildings to the west of the house between it and the proposed OHL development. The proposed OHL development is expected to

have a slight to imperceptible impact on the setting of the house. There are four wind turbines (18, 19, 20 and 21) proposed to the south of Dowdstown at a distance from 550m to 1200m. These would be visible from the house and its surroundings and would result in an adverse cumulative impact on the setting of the house.

10.4 IMPACT INTERACTIONS

10.4.1 Methodology

55 The European Commission's *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (EC, 1999) refer to the following in its consideration of interactive impacts:

- "***Impact Interactions:*** *The interactions between impacts whether between the impacts of just one project or between the impacts of other projects in the area, for example:*
    - *A chemical plant producing two streams of waste that are individually acceptable but react in combination producing highly significant levels of pollution;*
    - *Emissions to air from one project reacting with emissions from an existing development; and*
    - *Two major developments being constructed adjacent to one another and during overlapping time periods will have many interactive impacts, from land use issues to construction and operational noise."*

56 For this EIS the methodology and approach is informed by the 1999 EU *Guidelines for the Assessment of Indirect and Cumulative Impacts* and reference was also made to 2002 and 2003 EPA guidance documents.

57 **Table 10.2** shows a matrix of significant interactions likely to occur between potential impacts arising from the proposed development. The boxes marked in **Table 10.3** indicate that a potential relationship exists between any two environmental issues associated with the proposed electricity transmission development. The level of interaction between the various topics will vary greatly; however, the table allows the interactions to be recognised and developed further, where necessary. Summary details on each of the interactions anticipated are provided in **Table 10.4.**

Table 10.3: Overview of Potential Interactions / Interrelationships

		Human Beings				Flora and Fauna	Soils, Geology and Hydrogeology	Water	Air		Landscape	Material Assets		Cultural Heritage
		Population & Economic	Land Use	Tourism & Amenity	EMF				Noise & Vibration	Climate & Air Quality		General	Traffic	
Human Beings	Population & Economic			✓					✓		✓			
	Land Use					✓	✓	✓	✓					
	Tourism & Amenity	✓									✓			✓
	EMF	✓				✓								
Flora and Fauna			✓				✓	✓			✓			
Soils, Geology and Hydrogeology						✓		✓						
Water						✓	✓							
Air	Noise & Vibration	✓											✓	
	Climate & Air Quality												✓	
Landscape		✓				✓	✓	✓	✓			✓		✓
Material Assets - General						✓					✓			
Material Assets - Traffic						✓		✓	✓	✓	✓			✓
Cultural Heritage				✓		✓			✓		✓			

58 The following are the interactions anticipated from the proposed development.

Table 10.4: Summary of Potential Interactions / Interrelationships

Subject	Interaction With-	Interactions / Interrelationships
Human Beings – Population & Economic	Tourism and Amenity	There may be a slight reduction in tourism spend and associated economic activity in the immediate areas where the proposed development will be located.
	Landscape	There is a negative impact which arises from the visual impacts, where dwellings are located in close proximity to the proposed development.
	Air – Noise & Vibration	There is the potential for noise impact to Human Beings in the form of impact to sensitive receptors such as private dwellings etc. in the construction phase and the operational phase. In the operational phase corona noise has the potential to cause noise impact during inclement weather conditions. These impacts are addressed in the EIS and are not deemed to be significant.
Human Beings – Land Use	Flora & Fauna	Many farmers participate in Environmental Schemes funded by the Department of Agriculture, Food and the Marine, for example the Agricultural Environmental Options Scheme (AEOS). Environmental Options such as Species Rich Grass, Traditional Hay Meadows and Tree Planting may be affected by the placement of the OHLs and the towers. Therefore there is a potential impact on biodiversity on farms. In addition, if trees are cleared in the vicinity of OHLs there is a potential impact on shelter. Overall, the impact from the proposed development on the biodiversity on farms and the availability of shelter is imperceptible.
	Soils, Geology and Hydrogeology	Soil quality will be affected by the construction works and there is a potential effect on land drainage. Both of these consequences of construction will have a negative impact on crop growth. With effective implementation of the mitigation measures recommended the overall impact is assessed to be negligible.

Subject	Interaction With-	Interactions / Interrelationships
	Water	During construction there is a potential effect on water quality due to surface runoff and this could impact on water sources for livestock. With effective implementation of the mitigation measures recommended this impact is negligible.
	Air – Noise & Vibration	During the construction and operational periods noise may impact on livestock. Maintenance works and helicopter inspections will cause noise that may have an effect on livestock. With effective implementation of the mitigation measures recommended this impact is imperceptible.
	Air Quality & Climate	Dust may be generated at construction sites and along access tracks which may affect quality of crops.
Human Beings – Tourism and Amenity	Landscape	The OHL will be visible from some short sections of the Monaghan Way and the Boyne Valley Driving Route. This may be perceived as reducing the attractiveness of these areas for tourism and amenity purposes.
	Cultural Heritage	The OHL will be visible from specific areas within Bective Abbey. This may be perceived as reducing the attractiveness of this location for tourism and amenity purposes.
	Population & Economic	There may be a slight reduction in tourism spend and associated economic activity in the immediate areas where the proposed development will be located.
Human Beings – EMF	Human Beings - Population & Economic	There is a potential for interactions with human beings. However, the operating conditions for the proposed 400 kV line will ensure that EMF will remain below EMF guidelines for Ireland and the EU. A survey of scientific research on topics relating EMF to health of humans and other species did not show that EMF at these levels would have adverse effects on these populations.

Subject	Interaction With-	Interactions / Interrelationships
	Flora & Fauna	There is potential for interactions from EMF with flora and fauna. The types of interactions that can occur and the related research and scientific studies are detailed in **Chapter 8** of this volume of the EIS. Research accumulated over the past 40 years on plants and animals exposed to ELF EMF from transmission lines and research conducted in the laboratory does not confirm any harmful effects of EMF on the health, behaviour, productivity, or reproductive potential of plants and animals.
Flora & Fauna	Soils, Geology and Hydrogeology	The transport of soil or vegetative material during construction works could potentially facilitate the spread of invasive alien species such as Japanese Knotweed (Fallopia japonica). Appropriate controls will be in place to ensure that the proposed works do not result in the spread of invasive alien species. The mobilisation and transport of soil via surface water runoff could potentially impact ecologically sensitive receptors that occur within watercourses downstream of the proposed development. Soil water runoff controls during construction are a key consideration relevant to downstream aquatic species and habitats and suitable mitigation controls are detailed. Construction works will not be undertaken within wetland sites and no significant impacts on the eco-hydrology of wetlands are foreseen.
	Water	Any impacts on surface or ground water quality could impact on water dependent habitats and species that occur within the study area. In this regard effective implementation of the mitigation measures recommended is detailed to protect water quality which is adequate for protecting such water dependent ecological receptors.

Subject	Interaction With-	Interactions / Interrelationships
	Human Beings - Land Use	The approach of locating towers in areas of low ecological interest (mostly managed grassland) has had the effect of minimising the impacts on ecology while at the same time potentially increasing the impact on agricultural production. Some towers located, in particular, on arable farmland will lead to small permanent areas under towers where intensive agriculture will not take place. This will be of local ecology gain in particular for seed eating bird species such as Yellowhammer (red listed species of high conservation concern).
	Landscape	Interrelationships between ecological impacts and landscape have been identified in the case where the removal or trimming of wooded features (including woodlands, hedgerows and treelines) may have adverse effects on both ecology and landscape. The impacts on such wooded features has been minimised by, where possible, locating towers away from hedgerows and other wooded areas. The use of bird flight diverters, to mitigate potential impacts on birds in flight, may also increase the visual impact of the alignment at specific location.

Subject	Interaction With-	Interactions / Interrelationships
Soils, Geology and Hydrogeology	Water, and Flora and Fauna	Soils and geology has an important inter-relationship with the water and ecology environment, as a determinant of water chemistry, river flow regimes, water storage capacity and watercourse location. It also has a potential impact on water quality through the ability of bedrock and surface deposits to filter potential pollutants. Potential ecological impacts could occur through the mishandling of soils or through the deposition of excavated soils in ecologically sensitive areas. These potential impacts have been identified and mitigations suggested in Section 7.5 and Section 7.6, Chapter 7 Soils and Geology of **Volumes 3C** and **3D** of the EIS. An evaluation was undertaken based on the identification of potential sources, pathways and receptors along the line route. If all three elements (source, pathway and receptor) are present, there is a linkage and there is a potential impact to the receptor(s). In terms of surface water and ecology, a groundwater dependent terrestrial ecosystem (GWDTE) - the Boyne and the Blackwater cSAC is oversailed by the line route, no towers are located in the cSAC in County Meath. However, no significant predicted impacts are likely to occur as part of this development. In terms of surface water and ecology in the CMSA, there are no cSACs or groundwater dependent terrestrial ecosystems (GWDTE) in close proximity to the line route.

Subject	Interaction With-	Interactions / Interrelationships
Water	Soils, Geology and Hydrogeology and Flora & Fauna	Water has an important inter-relationship with the soils and ecological environment, as a determinant of water chemistry, river flow regimes, water storage capacity and watercourse location. It also has a potential impact on water quality through the ability of bedrock and surface deposits to filter potential pollutants. Potential ecological impacts could occur through the mishandling of soils or through the deposition of excavated soils in ecologically sensitive areas. These potential impacts have been identified and mitigations in Chapter 6 Flora and Fauna of **Volumes 3C** and **3D**, and Chapter 7 Soils and Geology of **Volumes 3C** and **3D**, of the EIS. This chapter should be read in conjunction with **Chapter 6** Description of Development and **Chapter 7** Construction, of this volume of the EIS. An evaluation was undertaken based on the identification of potential sources pathways and receptors along the line route. If all three elements (source, pathway and receptor) are present, there is a linkage and there is a potential impact to the receptor(s). In terms of water, in counties Monaghan and Cavan there are no cSACs or groundwater dependent terrestrial ecosystems (GWDTE) in close proximity to the line route. In terms of water in Meath, the Boyne and Blackwater cSAC and groundwater dependent terrestrial ecosystems (GWDTE) are crossed by the line route. No significant predicted impacts are likely to occur as part of this development at the crossing locations or at towers adjacent to the cSAC. In counties Monaghan and Cavan, a number of non-designated ecological sites (wetlands) of varying value that occur in proximity to the alignment have been identified during the desktop studies. Only those sites within 1km of the alignment were considered due to their non-designated status (of lower importance than designated sites listed above) and the essentially non-destructive nature of works associated with the proposed OHL.

Subject	Interaction With-	Interactions / Interrelationships
Air – Noise & Vibration	Material Assets - Traffic	In terms of traffic, during the construction phase, the noise and vibration impacts will be predominantly associated with the road traffic impacts. These potential impacts have been addressed in Chapter 9 Noise and Vibration of **Volumes 3C** and **3D** of the EIS. No significant noise and vibration impacts are predicted
	Human Beings	There is the potential for noise impact to Human Beings in the form of impact to sensitive receptors such as private dwellings etc. in the construction phase and the operational phase. In the operational phase corona noise has the potential to cause noise impact during inclement weather conditions. These impacts are addressed in the EIS and are not deemed to be significant.
Air – Climate and Quality	Material Assets - Traffic	During the construction phase, air and climate impacts will be associated with the construction activities of the project and road traffic impacts. Traffic emissions themselves will not give rise to significant air quality effects from vehicular emissions. With the implementation of mitigation measures no significant local air quality effects are predicted.
Landscape	Cultural Heritage	The proposed development will form a new feature in the environment and potentially affect the setting of sites which are of archaeological, architectural and cultural heritage importance, some of which will be prominent landscape features and may contain important views or prospects. These include Bective Abbey, Teltown, Brittas Estate and the Fair of Muff. It will also potentially affect the perception of the time depth of the wider landscape character.

Subject	Interaction With-	Interactions / Interrelationships
	Human Beings	There is a negative impact on population which arises from the visual impact, where dwellings are located in close proximity to the proposed development with no intervening vegetation or topography The tourism industry often relies on the character of landscape and new development can affect landscape character. Therefore, the proposed development could potentially affect a visitor experience if: • a particular tourist destination is affected to a degree that a sensitive aspect of the landscape character is significantly changed, • if the general landscape character is changed in such a way as to alter characteristics that are promoted by the tourist industry, • if the proposed development adversely affects an appreciation of the landscape's time depth. The OHL will be visible from some short sections of the Boyne Valley Driving Route, from Bective Bridge and within and the Blackwater Valley. This may be perceived as reducing the attractiveness of these areas for tourism and amenity purposes, although the adverse effects are localised.
	Flora and Fauna	The proposed development can impact on vegetation and habitat at construction and operational stages and therefore on landscape character and visual amenity in the immediate vicinity of the proposed development. This can include removal or trimming of trees and hedgerows and soil compaction. The highest impacts occur where mature trees or woodland are located within the safety clearance distances along the alignment. Swan flight diverters increase the discernibility of the earth wires and conductors at close distance.
	Noise and Vibration	Noise from high voltage OHLs can impact on landscape character in the immediate vicinity of the proposed development.

Subject	Interaction With-	Interactions / Interrelationships
	Water	Changes to drainage patterns can impact on landscape character.
	Soils, Geology and Hydrogeology	Changes to soils and geology can impact on landscape character. This is most likely at construction stage where soil compaction and changes to ground profile can occur.
	Material Assets General	Aviation markers increase the discernibility of the OHL conductor at close distances.
Material Assets - General	Landscape & Flora and Fauna	The use of aviation marker spheres on the line between Towers 355 and 357 may increase the visual impact of the alignment, refer to Chapter 11 Landscape of **Volume 3D** of the EIS. This location corresponds with one of the most sensitive locations identified along the alignment of the proposed development, where towers are visible from Bective Bridge looking along the River Boyne. The use of aviation marker spheres on the line between Towers 355 and 357 will negate the need for swan diverters on this section of the OHL, refer to Chapter 6 Flora and Fauna, of **Volume 3D** of the EIS.
Material Assets - Traffic	Air – Noise & Vibration	In addition to the impact on the road network, road vehicles also have an associated impact on other environmental factors such as air pollution, dust generation, noise and vibration. During the operational phase this will be minimal due to the low volumes of traffic that will be generated, however, during the construction phase these impacts, although temporary in nature, will prove more significant. Traffic has also the potential to impact on several other environmental factors dependent on circumstances. This likelihood for such impacts would increase when vehicles leave the public road network. These potential
	Air – Climate & Air Quality	
	Landscape	
	Cultural Heritage	
	Flora & Fauna	
	Water	

Subject	Interaction With-	Interactions / Interrelationships
		impacts traffic may indirectly cause are as follows: • Landscape due to the laying of temporary access tracks (where required); • Cultural heritage due to potential damage due to vibrations caused by heavy vehicles operating near cultural heritage sites; • Flora and Fauna due to the removal of vegetation at access locations to accommodate vehicular access to construction sites; • Water quality due to potential fuel or fluid leaks reaching groundwater.
Cultural Heritage	Landscape	The proposed development will form a new feature in the environment and impact visually on sites which are of archaeological, architectural and cultural heritage importance, some of which will be prominent landscape features and may contain important views or prospects.
	Human Beings - Tourism	Some of the more prominent archaeological, architectural or cultural heritage sites, structures, monuments or features may also be tourist attractions. The proposed development may be perceived as reducing the attractiveness of these sites by having an impact on their setting.
	Flora and Fauna	The proposed development may impact on demesne boundaries or planted landscape features within a demesne resulting in the removal of vegetation. This may also be perceived as reducing the attractiveness of these sites by having an impact on their setting.
	Noise and Vibration	Noise from high voltage OHLs can impact on the setting of archaeological, architectural or cultural heritage sites, structures, monuments or features. This may be perceived as reducing the attractiveness of the setting of these sites. It is noted that Chapter 9 of **Volumes 3C** and **3D** of the EIS concludes that it is not expected that noise arising will cause annoyance.

10.5 CONCLUSIONS

59 In conclusion, no likely significant cumulative effects on particular receptors / sources are predicted to arise as a result of the proposed development in combination with other developments (including those which have not yet been constructed).

60 In addition, while there is potential for the impacts described to interact, it is unlikely, as a result of the mitigation measures proposed, that any of these interactions will result in significant additional impacts that are not already anticipated by each environmental topic.

11 SUMMARY OF MITIGATION MEASURES

1 The evaluation of likely significant impacts of the proposed development as described throughout this Environmental Impact Statement (EIS) includes recommendations for specific measures to avoid, reduce and, if possible, offset the major adverse effects (i.e. mitigation measures). These measures are considered necessary to minimise environmental impacts associated with the proposed development during both its construction and operational phases. They are also referred to in this EIS as a Schedule of Mitigation Measures or Schedule of Environmental Commitments.

2 **Table 11.1** provides a collective summary of the proposed mitigation measures for both the construction and operational phases of the proposed development. The table includes the following:

- Mitigation measure item number;
- Approximate location of mitigation measure;
- Mitigation objective and commitment;
- An outline of the mitigation measure;
- Timing of the mitigation measure; and
- Monitoring requirements.

3 As set out in **Table 11.1,** there may be a requirement for additional consultation to be carried out during the construction period with landowners and certain prescribed authorities, in particular to ensure (i) the effectiveness of mitigation measures in relation to the environmental effects and (ii) that landowners are aware of the specific works that will take place pursuant to the proposed development.

4 **Table 11.1** provides a brief summary of recommended mitigation measures. This table should be read in conjunction with individual chapters of the EIS for more detail or further explanation.

5 It should also be noted that any and all conditions attached to any approval which the Board may decide to grant, will be incorporated fully into the appointed contractors' scope of work. In this regard, an outline of the Construction and Environmental Management Plan (CEMP) is presented in **Appendix 7.1, Volume 3B Appendices** of the EIS, for information.

Table 11.1: Schedule of Commitments (Summary of Mitigation Measures from Chapters of the EIS)

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
CONSTRUCTION (CHAPTER 7, VOLUME **3B) – NOTE ALL OTHER MITIGATION MEASURES ARE ALSO RELEVANT TO CONSTRUCTION MITIGATION**					
1.1	General construction	Construction Management	In the event of approval being granted for the proposed development and prior to commencement of works, the contractor(s) which will be appointed by the Electricity Supply Board (ESB) will prepare a detailed *Construction and Environmental Management Plan* (CEMP). An outline CEMP is included as, **Appendix 7.1, Volume 3B Appendices** in the EIS for information. The scope of the final CEMP will detail *inter alia* the implementation and management of environmental controls and mitigation measures (detailed in the EIS and summarised below). Monitoring of the construction phase shall be carried out by an Environmental Manager, in association with an ecologist (Ecologist Clerk of Work (ECoW)) and archaeologist to ensure that all mitigation measures contained in the EIS and CEMP are implemented.	Pre-construction Phase	Yes. Detailed CEMP produced by contractor and agreed by ESB and subsequently with local and relevant prescribed authorities.
1.2	General construction	Construction Management – Client Engineer	A Client Engineer will be appointed and shall monitor and inspect the detailed designs, plant, material, and works including scheduling to ensure that these meet the requirements of the functional specification, designs and transmission standards.	Pre-construction Phase	Yes
1.3	General construction	Construction Management	Prior to construction, Notices and Schedules, as well as maps confirming the position of towers as approved by the Board, will be issued to landowners. EirGrid representatives will meet with landowners to deal with any queries the landowner may have following the issuing of the Notice.	Pre-construction Phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
1.4	General construction	Construction Management – working hours	Access to the site will be during daylight for all construction stages. It is not anticipated that construction works will be carried out on Sunday, or Bank Holidays or that any construction works will be carried out in hours of darkness.	Construction Phase	None
1.5	General construction	Landowner Liaison	Prior to commencing the works, discussions will take place between the appointed landowner agents and landowners to ensure awareness of the specific works that will take place pursuant to the proposed development. All landowners will be contacted prior to access being required on their lands and a date of commencement for the works will be provided to the landowner before any work begins. The detailed design of access routes and construction methodology to be used, chosen from the methodologies identified in the EIS, will be based on the condition of land at the time of construction will be discussed with the landowner prior to the commencement of works.	Pre-construction Phase	None
1.6	General construction	Construction Management	Prior to commencement of construction a full traffic management plan will be produced and implemented.	Pre-construction Phase	None
1.7	General construction	Construction Management	A Construction and Waste Management Plan (forming part of the CEMP) will be implemented to minimise waste and ensure correct handling and disposal of construction waste streams.	Pre-construction Phase	None
1.8	General construction	Reinstatement	Once all the works are complete, the land used for temporary access routes and construction areas around the overhead structures will be reinstated as close as possible to their original condition.	Post Construction Phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
HUMAN BEINGS – POPULATION & ECONOMIC (CHAPTERS 2 VOLUMES 3C and 3D) - No specific mitigation measures. Refer to other topics.					
HUMAN BEINGS – LAND USE (CHAPTERS 3 VOLUMES 3C and 3D)					
2.1	General construction	Construction Management	A method statement and work programme that shows the detailed phasing of work will be prepared prior to commencement of work.	Pre-construction Phase	None
2.2	General construction and operational maintenance works	Landowner Liaison	A wayleave agent will be appointed by the contractor to liaise with the landowners along the line route and ensure that their requirements for entry are met, so far as is possible. Land owners will be notified in advance of the commencement of any construction or maintenance works.	Construction Phase and Operation Phase	None
2.3	General construction	Comply with ESB / IFA agreement	All employees and contractors involved in the construction phase will receive adequate training – in particular in relation to issues relating to livestock safety and bio security on farms.	Construction Phase	None
2.4	General construction	Maintain access to agricultural land	The contractor will ensure that land owners have reasonable access to all parts of their farm during the construction phase.	Construction Phase	None
2.5	General construction	Minimise the risk of spreading animal and crop diseases	Disease protocols will be adhered to. The contractor will comply with any Department of Agriculture, Food & the Marine regulation pertaining to crops and livestock diseases.	Construction Phase	Yes

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
2.6	N/A – general construction	Fencing of construction areas to prevent disturbance	Where required, appropriate fencing will be erected to exclude livestock from sites of construction.	Construction Phase	None
2.7	General construction	Minimise impact of rock breaking or piling, if required	In the unlikely event that rock breaking or pilling are required, owners of livestock in adjoining fields will be notified in advance.	Construction Phase	None
2.8	General construction	Minimise impacts to soil	Where top soil is stripped back it will be replaced. All disturbed field surfaces will be re-instated. It will be the construction policy to minimise non-tracked vehicular access to sites in wet weather. Temporary access tracks (aluminium or panel tracks) will be laid in certain sites to avoid damage to soil. Vehicles which leak oil or fuel will not be allowed on construction or access sites. Any soil contaminated by fuel or concrete spillage will be removed from the site and dealt with appropriately as per legislative requirements.	Construction Phase	None
2.9	General construction	Minimise impacts to land drains	Affected land drains will be directed in a manner that maintains existing land drainage.	Construction Phase	None
2.10	General construction and operation phase	Ensure health and safety	ESB will provide safety information directly to all affected land owners e.g. *Guidelines for Safe Working near Overhead Electricity Lines in Agriculture* and *Code of Practice for Avoiding Danger from Overhead Electricity Lines*. These publications will enable farmers to fulfil their statutory requirements under	Construction Phase and Operation Phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			Health and Safety Regulations.		
2.11	General construction and operation phase	Minimise impact on livestock	Helicopter inspections will be announced in local newspapers and the Farmer's Journal.	Operation Phase	None
HUMAN BEINGS – TOURISM (CHAPTERS 4 VOLUMES 3C and 3D) – No specific mitigation measures. Refer to other topics.					
HUMAN BEINGS – EMF (CHAPTERS 5 VOLUMES 3C and 3D)					
3.1	MSA	Minimise EMF levels	The configuration of the phases (that is the spatial arrangement of the two sets of three vertically aligned electricity wires) on the existing double circuit towers will be optimised to ensure EMF levels are minimised.	Pre-construction	None
FLORA AND FAUNA (CHAPTERS 6 VOLUMES 3C and 3D)					
4.1	General	Minimising risks such as disturbance to wildlife and protection of water quality	The key approach for minimising risks such as disturbance to wildlife and protection of water quality is the appointment of an appropriately experienced Ecological Clerk of Works (ECoW) on site during construction, to monitor the effectiveness of proposed mitigation measures in relation to known environmental effects and mitigation measures proposed in the EIS: The role of the ECoW will include: • Supervision of construction works and ensure compliance with legislation;	Construction Phase and initial Operation Phase (5 years plus)	Yes. Monitored by ECoW.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			• Monitoring habitats and species during the course of construction works and effectiveness of mitigation; • Provision of advice regarding the avoidance and minimisation of potential disturbance to wildlife; • Provide recommendations on appropriate responses / actions to site specific issues (e.g. identification of previously unrecorded breeding sites during construction works); and • Liaison with NPWS, IFI and other prescribed authorities, when required. In addition to the construction phase, it is recommended that a site ecologist (ECoW) also be appointed during the pre-construction (landowner liaison stage) and post construction phases (up to 5 years) in particular to monitor mitigation measures regarding wintering birds.		
4.2	General	Construction Management	A CEMP will be implemented for the construction phase of the project with respect to all mitigation.	Construction Phase	Yes. Monitored by Environmental Manager
4.3	General	Construction Management	Work method statements will be developed by construction and site contractors, agreed with statutory authorities and ECoW (where appropriate), and implemented by construction crews for all construction activities.	Construction Phase	Yes. Monitored by Environmental Manager.
4.4	General	Protection aquatic ecology	As required, temporary silt screens will be installed in drains /small streams deemed to be at possible risk of water pollutant discharge. Where possible, towers (access routes, stringing areas and indicative works areas) have been	Construction Phase	Yes. Monitored by EcOW.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			located away from sites of ecological importance. Furthermore, where possible, access to tower locations will be via existing tracks that are regularly used by farm machinery. Existing field access points (e.g. gaps / farm gates) to local roads will be used to avoid creating additional hedgerow gaps.		
4.5	General	Minimise impacts to habitats	Semi natural habitats such as wetlands and hedgerows will be avoided.	Construction Phase	Yes. Monitored by EcOW.
4.6	General	Avoid the spread and introduction of invasive species and noxious weeds	Any invasive plant material noted on site will be removed off site and disposed of at appropriate licensed waste disposal facility. Any invasive species found to occur within 15m of working areas will require its eradication to avoid the spread of invasive species, to ensure compliance with the *European Communities (Birds and Natural Habitats) Regulations 2011* (S.I. No. 477 of 2011).	Construction Phase	Yes. Monitored by EcOW.
4.7	General	Maintenance of habitat connectivity	All landscaping / reconnection works must ensure that only native species are utilised. Non-native species will be avoided.	Construction Phase	Yes. Monitored by EcOW
4.8	General	To minimise impacts to habitats	Hedgerow, tree and scrub vegetation that are to be retained which are located in close proximity to working areas will be clearly marked and fenced off to avoid accidental damage during excavations and site preparation. No materials will be stored within 5 metres of hedgerows / trees / scrub.	Construction Phase	Yes. Monitored by Environmental Manager.
4.9	Towers located at field boundaries	To minimise impacts to habitats i.e. field boundaries comprised of	The vegetation will be removed to ground level. Works will be implemented in a manner to minimise soil disturbance and compaction outside of the tower foundations. Post construction a wooden fence will be installed around the tower base to prevent livestock access and replanting carried out with low growing	Construction Phase	Yes. Monitored by EcOW.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
		hedgerows	woody species of local provenance including Blackthorn, Hawthorn and Hazel. This will allow re-establishment of the hedgerow in the gap where the tower is located. It is expected that the hedgerows would be sufficiently robust within 5 years following construction that fencing could be removed. Where required, disturbed areas of grassland will be appropriately prepared and reseeded with a locally sourced grass mix, similar to that already occurring within the surrounding fields. Reseeding works will be undertaken within 3 weeks of construction works to avoid flushing of exposed soil downstream.		
4.10	General	To minimise impacts to habitat i.e. trees	Tree cutting and lopping in proximity to conductors will be undertaken in a manner which minimises the requirement for extensive tree lopping. Large mature trees will be pollarded by qualified foresters / tree surgeons so as to retain as much of the treeline / linear habitat structure and in a manner which retains ground flora species and which does not kill the tree. The trimming regime will involve a scalloping or profiling effect which will minimise the effect on vegetation. Overall, it will not change the structure and ecological function of these linear woodland features, and will not measurably affect associated fauna post construction.	Construction Phase	Yes. Monitored by EcOW / Environmental Manager.
4.11	General	To minimise impacts to habitats i.e. trees	Where construction work is required close to mature trees, the National Joint Utilities Group *Guidelines for the Planning Installation and Maintenance of Utility Services in Proximity to Trees* (NJUG 10) will be followed so as to minimise damage.	Construction Phase	Yes. Monitored by EcOW / Environmental Manager.
4.12	General	To minimise impacts to	Scrub, hedgerow or tree removal / trimming will be undertaken outside of the bird	Construction	Yes. Monitored

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
		breeding birds	nesting period, which begins on March 1st and continues until August 31st, in order to protect nesting birds. All birds and their nesting places are protected under the *Irish Wildlife Act 1976* (as amended 2000).	Phase	by EcOW / Environmental Manager.
4.13	General	Protection aquatic ecology	A drainage and sediment control plan will be implemented by contractors during site works. The plan will detail specific mitigation measures (taken from mitigation measures, outlined in Chapter 6 and 8 of this EIS) to address site specific issues.	Construction Phase	Yes. Monitored by Environmental Manager.
4.14	General	Protection aquatic ecology	Potential impacts caused by spillages, drip and or spills during the construction phase will be reduced by the maintenance of an adequate supply of spill kits and hydrocarbon adsorbent packs at labelled stations at all working areas, with all vehicles on-site carrying spill kits. All personnel will be fully trained in the use of the equipment. Any used spill kits will be disposed of appropriately off-site.	Construction Phase	Yes. Monitored by Environmental Manager.
4.15	General	Protection aquatic ecology	A 24 hour, 7 day per week Emergency Response protocol for leaks / spill of hydrocarbons and / or chemicals will be drawn up and implemented. This must be implemented in the unlikely event of an accidental spillage of chemicals, hydrocarbons or release of protection aquatic ecology sediment to the surface or ground water system.	Construction Phase	Yes. Monitored by Environmental Manager.
4.16	General	Protection aquatic ecology and sensitive habitats	Excavated materials from construction works will be deposited within the works area where there is no significant risk of runoff into local watercourses.	Construction Phase	Yes. Monitored by EcOW / Environmental Manager.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
4.17	General	Protection aquatic ecology water	As part of their environmental and works requirements, the contractor will establish a maintenance schedule and operational procedure / method statement for silt and pollution control measures during the construction period. This will be monitored for effectiveness by the contractor and ECoW.	Construction Phase	Yes. Monitored by Environmental Manager.
4.18	General	Protection aquatic ecology Compliance with best practice	Oil, petrol and other fuel containers will be double-skinned and bunded to be able to contain 110% volume. Bund specification will conform to the current best practice for oil storage such as Enterprise Ireland's *Best Practice Guide BPGCS005 Oil Storage* Guidelines.	Construction Phase	Yes. Monitored by Environmental Manager.
4.19	General	Protection aquatic ecology Compliance with best practice	Pouring of concrete will only take place in designated locations and concrete washings will be treated off site following current best practice guidelines including *Pollution Prevention Guidelines for Northern Ireland and Scotland*. Concrete washings will not be discharged to surface water and poured concrete will be allowed to cure for a minimum of 48 hours in the dry.	Construction Phase	Yes. Monitored by Environmental Manager.
4.20	General	Protection aquatic ecology	Raw or uncured waste concrete or similar will be disposed of by removal to approved / licensed disposal site. It is noted that there will be a concrete truck wash out at the batching plant area. This washout will be directed to the three bay water recycler provided at this location.	Construction Phase	Yes. Monitored by Environmental Manager.
4.21	General	Protection aquatic ecology	Water courses which have been identified as potentially at risk of pollution from construction activities (e.g., drains and smaller streams linked to the River Boyne and Blackwater) will have appropriately designed silt traps (based on drain and potential runoff characteristics) installed in consultation with IFI (where	Construction Phase	Yes. Monitored by Environmental Manager.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			necessary). Refer to **Chapter 8** in Volumes 3C and 3D for details.		
4.22	General	Protection aquatic ecology	Refuelling of machinery, will be carried out on level, hard surfaced designated areas where possible, at least 20m from watercourses and drainage ditches. In the event that refuelling is required outside of this area, fuel will be transported in a mobile double skinned tank and a spill tray will be employed during refuelling operations.	Construction Phase	Yes. Monitored by Environmental Manager.
4.23	General	Protection habitats and aquatic ecology	All machinery will be regularly maintained and checked for leaks. Services will not be undertaken within 50m of aquatic features, including dry drainage ditches. Servicing must be undertaken on level, hard surfaced designated areas where possible.	Construction Phase	Yes. Monitored by Environmental Manager.
4.24	General – Construction	Protection aquatic ecology	Construction materials such as hydrocarbon, cement and grout will be stored in bunded areas or silos which will be regularly inspected by the site manager.	Construction Phase	Yes. Monitored by Environmental Manager.
4.25	General – construction	Protection aquatic ecology	Weather conditions will be taken into account when planning construction activities to minimise risk of extreme run off from works areas.	Construction Phase	Yes. Monitored by Environmental Manager.
4.26	General – construction	To minimise impacts to bats	Given the likely timescale (likely to be greater than 2 years) between planning and actual site clearance and construction, confirmatory bat verification surveys / monitoring of specific mature trees identified for felling will be undertaken by a bat specialist prior to tree cutting. In order to proceed with the felling of trees that may be identified as bat roosts, it will be necessary to acquire a derogation	Pre-construction Phase and Construction	Yes. Monitored by EcOW.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			licence from NPWS. NRA, (2006) *Guidance in relation to tree felling and hedgerow removal* will be followed throughout the site clearance phase of the project.	Phase	
4.27	General – construction	To minimise impacts to Otters	Pre-construction surveys to confirm the conditions which are anticipated to be encountered in this EIS will be undertaken at watercourses and adjacent habitats that occur in close proximity to tower locations and tree felling areas to confirm presence / absence of Otter breeding sites. Details of the pre-construction verification / monitoring methodology and the approach to be taken will be outlined in the CEMP that is to be drawn up for the construction phase of the development with reference to relevant guidance documents. No direct impacts are expected to arise as works will require an agreed method statement and be monitored by the ECoW.	Pre-construction Phase and Construction Phase	Yes. Monitored by EcOW.
4.28	General – construction.	To minimise impacts to Kingfishers	Given the likely timescale between planning and actual site clearance and construction, pre-construction surveys to validate the conditions which are anticipated to be encountered will be undertaken at watercourses and adjacent habitats (linked to the River Boyne and Blackwater) that occur in close proximity to tower locations and tree felling areas to confirm presence / absence of Kingfisher breeding sites.	Pre-construction Phase and Construction Phase	Yes. Monitored by EcOW.
4.29	General – construction	To minimise impacts to Badgers	Surveys for Badger setts will be conducted at woody vegetation required for cutting. This is required to confirm that site clearance activities are in line with	Pre-construction	Yes. Monitored by EcOW.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			the receiving environment considered in this EIS. A buffer zone will be established around any known Badger setts through the erection of temporary posts and wires with —no entry" signs erected. No direct impacts are expected to arise as works will require an agreed method statement and be monitored by the ECoW.	Phase and Construction Phase	
4.30	General – Operational Phase	To minimise impacts on Whooper Swans	The key operational impacts identified are potential collision risks to Whooper swans. Mitigation by avoidance of feeding and roosting sites has been implemented as far as possible in the route selection for the alignment. Flight Diverters (Swan Flight Diverter markers constructed from high-impact grey PVC (UV stabilised) fitted at approximately 5m apart along each earthwire, are proposed at specific locations identified in the EIS. This line marking is proposed for the earth wire to increase visibility of the earth wire to flying birds.	Operational	See 4.34 below
4.31	General	Hedgerow re-growth and fence maintenance	Where poor or no hedgerow re-growth has occurred, replanting with similar native hedgerow species will be carried out so as to ensure linear habitats are retained / re-established. If new fencing is required or maintenance then this will be agreed and implemented with the landowner.	Post Construction	Yes. 2 years post construction.
4.32	General		Monitoring will be undertaken to determine the effectiveness of proposed flight diverter mitigation.	Post construction	Yes. Annually for 10 years.
4.33	General – During	During maintenance works, consideration will be given	Depending on the nature of the proposed maintenance works; there may be a requirement for risk assessments of potential impacts to surface waters and	Post construction	Yes. Ongoing (depending works

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
	maintenance works	to ensure ongoing protection of water quality.	appropriate mitigation will be implemented where a risk is identified.		requirements)
SOILS, GEOLOGY AND HYDROGEOLOGY (CHAPTERS 7 OF VOLUMES 3C AND 3D)					
5.1	Lemgare CGS, Altmush CGS, Galltrim CGS and the Boyne CGS	To mitigate potential impacts	The mitigation measures agreed with the GSI for site investigation works / construction of the towers include the following; • Continued consultation with the GSI; • Limiting excavation by only excavating the required footprint; • Maintaining an adequate distance from Lemgare pNHA, and Altmush Stream; and • The GSI will be notified about any significant new section / feature that is exposed within the tower footprint.	Construction Phase	None
5.2	General	Effective treatment of spoil material	Excavated soil and subsoil will be stored adjacent to the excavation area. Excavated material will be reused in situ where possible. In the event no material is suitable / wanted for reuse by landowners, subsoil will be disposed of in accordance with all applicable legislative requirements.	Construction Phase	None
5.3	General	Dealing with unexpected contaminated land	All excavated materials will be visually assessed for signs of possible contamination such as staining or strong odours. Should it be determined that any of the soil excavated is contaminated, this will be dealt with appropriately as per all applicable legislative requirements.	Construction Phase	Monitoring required during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
5.4	General	To minimise impact from material spillages	All oils and fuels used during construction will be stored on temporary proprietary bunded surface (i.e. contained bunded plastic surface). These will be moved to each tower location as construction progresses. Refuelling of construction vehicles and the addition of hydraulic oils or lubricants to vehicles will take place away from surface water gullies or drains. No refuelling will be allowed within 50m of a stream / river. Spill kits and hydrocarbon absorbent packs will be stored in this area and operators will be fully trained in the use of this equipment.	Construction Phase	None
5.5	General	Minimise impacts to soils	Controlling working practices by, for example, minimising land take, avoiding repetitive handling of soils, minimising vehicle movements off road and limiting the size of stockpiles will reduce the compaction and erosion of material. Soils will be reinstated at the towers and along the temporary access route.	Construction Phase	None
5.6	Tower Locations	Minimise impacts to existing wells and boreholes	Where it is necessary to dewater to construct the tower foundations in close proximity of wells, monitoring will be carried out of wells within 100m of the tower locations.	Construction Phase	Monitoring required during construction
5.7	General – construction	Minimise impacts to existing wells and boreholes. Protection of the quality of the receiving water system.	Water pumped from the excavations may contain suspended solids. Settlement may be required to reduce the suspended solids concentrations to protect the quality of the receiving water system. Settlement will be undertaken by a standard water filtration system to control the amount of sediment in surface water runoff. Direct discharge to streams or rivers will not be permitted.	Construction Phase	Monitoring required during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
5.8		Tara Mines	Liaison will be undertaken with Tara Mines during construction / operation phase to ensure no conflicts arise.		
WATER (CHAPTERS 8 OF VOLUMES 3C AND 3D)					
6.1	General Construction Phase	To prevent water pollution	All works will be undertaken with due regard to the guidance contained within CIRIA Document C650 *Environmental Good Practice on Site*.	Construction Phase	None
6.2	Where tree felling may be required	To prevent water pollution during felling of forestry	Consultation will be undertaken with Inland Fisheries Ireland (IFI) and NPWS before commencing felling operations in areas of importance to fisheries and wildlife. Sediment traps will be installed prior to felling and maintained on a daily basis throughout felling operations. Trees will be felled away from the aquatic zone. Machine extraction will not occur in the riparian zone. On sites where risk of erosion is high (steep slopes and / or adjacent to rivers), brash mats will be used to avoid soil damage, erosion and sedimentation. Brash mat renewal will take place when they become heavily used and worn. Provision will be made for brash mats along all off-road routes, to protect the soil from compaction and rutting. Felling will not occur during periods of high rainfall to prevent runoff. No refuelling or machinery maintenance will occur within 50m of an aquatic zone. Timber will be stored on dry areas away from the riparian zones. The forest felling effects of the overhead transmission line will be short term during construction phase.	Construction Phase	Monitoring required during Construction Phase.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
6.3	Near watercourses (including the River Boyne and Blackwater)	Protection of Watercourses	Silt barrier / silt curtains will be used where towers or works are undertaken near watercourses. In relation to the River Boyne and Blackwater the towers are located a minimum of 60m and 100m respectively from these rivers. However, notwithstanding this distance, it is proposed to use silt barriers / curtains for tower construction near those rivers.	Construction Phase	
6.4	General Construction	Minimise impacts on soils	Stockpiles will be graded to a <1:4 profile. Topsoil and subsoils will be stored separately. Stockpiles of mineral soils and peat will be <2m and <1m respectively. Geotechnical supervision in combination with monitoring will ensure that any peat encountered is stored in suitable areas.	Construction Phase	Monitoring required during construction
6.5	Near watercourses	Protection of Watercourses	Where it would be necessary to dewater to construct the tower foundations precautions will be taken to ensure there is no adverse effects on nearby watercourses including the resultant water being filtered before discharge.	Construction Phase	Yes on the discharge water quality.
6.6	Near watercourses	Protection of Watercourses	Precautions will be taken to avoid spillages. These include: • Use of secondary containment, e.g. bunds around oil storage tanks; • Use of drip trays around mobile plant; • Supervising all deliveries and refuelling activities; and • Designating and using specific impermeable refuelling areas isolated from surface water drains.	Construction Phase	Yes during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
6.7	Near watercourses	Protection of Watercourses	With regard to on site storage facilities and activities, any raw materials and fuels, will be stored within bunded areas, if appropriate to guard against potential accidental spills or leakages. All equipment and machinery will have regular checking for leakages and quality of performance.	Construction Phase	Yes - equipment
6.8	Near watercourses	Protection of Watercourses	All site personnel will be trained and aware of the appropriate action in the event of an emergency, such as the spillage of potentially polluting substances. Spill kits are retained to ensure that all spillages or leakages are dealt with immediately and staff are trained in their proper use. Any servicing of vehicles will be confined to designated and suitably protected areas. Any pollution incident or spill will be reported to the regulator and remediated to their original condition.	Construction Phase	Ongoing monitoring required during construction
6.9	Near watercourses	Protection of Watercourses	Wash down and washout of concrete transporting vehicles will not be permitted at the location of construction. Such wash down and washout activities will take place at an appropriate facility offsite.	Construction Phase	Ongoing monitoring required during construction
6.10	Temporary Access Tracks and Tower Foundations	Protection of watercourses	At certain locations where very poor soft ground is encountered, Type 2 temporary access track may have to be laid. Generally temporary access tracks use rubber or aluminium road panels. Temporary access tracks will be up to 4m wide and routed away from drains where possible. In sensitive locations silt barriers will be used to prevent direct	Construction Phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			runoff to local watercourses.		
6.11	Temporary Access Routes and Tower Foundations	Protection of water quality	Preventative measures will ensure that input suspended solids concentrations will be minimised at source. This will be achieved by ensuring that all silt / clay and topsoil is properly stored during the construction phase of the development.	Construction Phase	Ongoing Monitoring required during construction.
6.12	Construction-Temporary Access Routes and Tower Foundations	Protection of Water Quality	Water quality monitoring will be undertaken prior to the commencement of construction to confirm baseline data and ensure there is no deterioration in water quality. This will be targeted on watercourses considered to be at a higher risk of pollution (i.e. towers where there are watercourses within 20m of the construction works). Water quality monitoring will include daily inspection of adjacent watercourses.	Prior to and during the Construction Phase	Ongoing Monitoring, observing and sampling required during construction.
6.13	Construction-Material Storage Yard	Protection of Water Quality	The surface water drainage system at the construction material storage yard will take into account the recommendations of the CIRIA C468 and utilises SuDs (sustainable urban drainage) devices where appropriate. Runoff from site will be limited to greenfield runoff rates. Runoff will pass through a silt trap, oil interceptor and settlement lagoon before being discharge to the surface water.	Prior to and during the Construction Phase	Ongoing observing and sampling required during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
6.14	Woodland Substation	Protection of Water Quality	Implementing the design standards of the GDSDS, the surface water drainage system at Woodland takes into account the recommendations of the GDSDS and utilises SuDs (sustainable urban drainage) devices where appropriate. Runoff from hardstand areas at Woodland Substation will be limited to greenfield runoff rates.	Prior to and during the Construction Phase	Ongoing observation required
AIR – NOISE & VIBRATION (CHAPTER 9 OF VOLUMES 3C AND 3D)					
7.1	Construction Phase	To ensure compliance with appropriate European Standards	The contractor appointed will have to ensure that all plant items used during the construction phase will comply with standards outlined in European Communities (*Construction Plant and Equipment) (Permissible Noise Levels) Regulations* (1990). The contractor will make reference to BS5228: *Noise Control on Construction and Open Sites* (2009), which offers detailed guidance on the control of noise from construction activities.	Construction Phase	None
7.2	Construction Phase	To ensure the adoption of appropriate practices during construction	It is proposed that various practices be adopted including: • Night time working will typically not occur; however, there may be a necessity to continue to operate generator, pumps or other equivalent machinery at a number of locations, where the digging of foundations and erection of towers may cause activity to remain in one location for a longer period of time; • On these infrequent occasions screening and enclosures can be utilised. For maximum effectiveness, a screen should be positioned as close as possible to either the noise source or receiver. The screen should be constructed of material with a mass of > 7kg/m2 and should	Construction Phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			have no gaps or joints in the barrier material. This can be used to limit noise impact to 45dB (A) Leq (BS 5228 acceptable night time level) at any noise sensitive receptors, if required by agreement with the local authority; • Appoint a site representative responsible for matters relating to noise; and • Establishing channels of communication between the contractor / developer, local authority and resident i.e. for notification of requirement of night works, should this be required.		
7.3	Construction Phase	Use of appropriate noise control measures during construction	Furthermore, it is envisaged that a variety of practicable noise control measures will be employed, these may include: • Selection of plant with low inherent potential for generation of noise and / or vibration; • Erection of temporary barriers around items such as generators or high duty compressors. For maximum effectiveness, a barrier should be positioned as close as possible to either the noise source or receiver. The barrier should be constructed of material with a mass of > 7kg/m2 and should have no gaps or joints in the barrier material, • As a rough guide, the length of a barrier should be 5 times greater than its height. A shorter barrier should be bent around the noise source, to ensure no part of the noise source is visible from the receiving location; and • Positioning of noisy plant as far away from sensitive receptors, as permitted	Construction Phase	Ongoing monitoring required during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			by site constraints.		
7.4	Construction Phase	Use of appropriate construction phase vibration mitigation	Any construction works that have the potential to cause vibration at sensitive receptors will be carried out in accordance with the limit values as set out in the EIS.	Construction Phase	Ongoing monitoring required during construction
7.5	Operational Phase	Use of appropriate operational phase noise mitigation measures	It is not expected that noise arising from the proposed development will cause significant noise impact. Corona noise may be audible under certain weather conditions and in close proximity to the line. Corona noise is caused predominantly by items of transmission line hardware, other than conductors, e.g. clamps, and can be mitigated by replacement of individual items of hardware. Aeolian noise very rarely occurs on 400 kV lines and is not expected to arise on the proposed development. Recommended mitigation measures for Aeolian noise include the fitting of air flow spoilers on conductors and the fitting of composite insulators.	Operational Phase	Ongoing monitoring required during construction
7.6	Unknown at time of writing	To minimise noise impact to sensitive receptors	Use of temporary noise barriers around rock breaking activity if noise impact to sensitive receptors is deemed likely.	For duration of localised rock breaking	Noise monitoring of closest sensitive receptor or representative location.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
AIR - QUALITY AND CLIMATE (CHAPTER 10 OF VOLUME 3C AND 3D)					
8.1	General Development wide – construction phase	Protection of properties from significant dust nuisance	Mitigation measures will be employed on a site-specific basis based on a review of the construction activities involved and their proximity to nearby receptors in each location. The site specific mitigation measures will be employed to ensure that properties within 50m of the construction locations will not be subject to significant dust nuisance.	Construction Phase	Ongoing monitoring required during construction (in the context the CEMP).
LANDSCAPE CHAPTER 11 OF VOLUMES 3C AND 3D)					
9.1	Development wide – construction phase	Minimise physical landscape effects on vegetation	The key mitigation measures described in the Flora and Fauna section (section 4 of this table) will serve to minimise physical landscape effects arising from disturbance to vegetation and soils. The key mitigation measures as described in the Flora and Fauna section in relation to landscape effects are; using existing access routes and gaps in hedgerows, reinstatement of hedgerows and ground vegetation (with similar or better quality planting), protection of retained vegetation, sensitive vegetation pruning methods including pollarding of mature trees to retain hedgerow lines, monitoring of vegetation establishment over 24 months, and replanting in the event of any reinstatement failures. Hedgerows will be maintained to ensure no vegetation is tall enough to potentially interfere with the conductors.	Construction and Operational Phase	Ongoing monitoring required by a qualified Landscape Architect during construction and inspection of reinstated planting over a 24 month period

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
9.2	Development wide – construction phase	Minimise physical landscape effects on soil	The mitigation measures in section 5 – Soils, Geology and Hydrogeology will serve to minimise physical landscape effects on soil and subsequent vegetation establishment. The key mitigation measures as described in this section in relation to landscape effects are; correct removal, storage and reinstatement of subsoil and topsoil, avoidance of soil compaction and removal and disposal of soil where not required for reinstatement.	Construction and Operational Phase	Ongoing monitoring required by a qualified Landscape Architect during construction and inspection of earthworks over a 24 month period
9.3	Blackwater Valley	To mitigate landscape character and visual impact in a valley landscape	Micro mitigation is possible through the retention or enhancement of trees and hedgerows in key locations	Construction phase	Ongoing monitoring required by a qualified Landscape Architect during construction and inspection of reinstated planting over a 24 month period

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
9.4	Brittas Estate	To reduce the potential impact on a historic designed landscape	The clearance of existing vegetation will be minimised in this area and in consultation with the landowner appropriate screening could be planted on either side of the entrance road and other locations within the estate to limit the views towards the proposed development.	Construction phase	Ongoing monitoring required by a qualified Landscape Architect during construction and inspection of reinstated planting over a 24 month period
9.5	Boyne Valley	To mitigate landscape character and visual impact in a valley landscape, on a protected viewpoint and on a view from Bective Abbey	Micro mitigation is possible through the retention or enhancement of trees and hedgerows in key locations.	Construction phase	Ongoing monitoring required by a qualified Landscape Architect during construction and inspection of reinstated planting over a 24 month period.=

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
MATERIAL ASSETS – GENERAL (CHAPTER 12 OF VOLUMES 3C AND 3D)					
10.1	Development wide - General	To minimise impacts on electricity, telecoms & gas	A pre-construction survey for utilities such as gas, electricity, telecoms etc. will be undertaken during the construction phase, including ground investigations, to validate the conditions which are anticipated to be encountered in the EIS.	Prior to construction	None
10.2	At the crossing of OHL and telecoms services is necessary	To minimise disruption to existing electricity & telecoms services during construction	Certain obstacles along a straight have to be guarded such as road / railway crossings and other transmission or distribution lines by way of temporary guard poles.	Construction phase	None
10.3	Development Wide General – Construction Phase	To comply with Best Practice Guidelines on the *Preparation of Waste Management Plans for Construction & Demolition Projects* (2006)	Waste management will be carried out in accordance with *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction & Demolition Projects* (2006) produced by the Department of Environment, Community and Local Government. A Construction Waste Management Plan (which will form part of the CEMP) will be implemented to minimise waste and ensure correct handling and disposal of construction waste streams. The key principles underlying the plan will be to minimise waste generation and to segregate waste at source.	Construction Phase	None
10.4	Development wide General –	To ensure the appropriate recovery / disposal of operational waste (such as	A negligible amount of light waste generated in the operational phase of the proposed development arising in maintenance and cleaning operations, replacement of lighting units as required, oils arising from occasional	Operational Phase	Monitoring required during Operational

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
	Operational Phase	packaging etc.) arising from occasional maintenance activities	maintenance activities and packaging materials will be removed off site by licensed contractors for appropriate recovery / disposal at licensed facilities.		Phase (during maintenance)
10.5	Development wide General - Operational Phase	To ensure safe aviation activity at Trim Airfield	Landing aircraft using Runway 28 would need to be visually aware of where the towers are located and a formal approach procedure of *„visual contact of towers / cables required before starting field approach"* should be introduced. The OHLs will be below the obstacle limitation surfaces for Trim Airfield, but making them more conspicuous through the fitting of marker spheres should be considered between Towers 355 and 357. The landscape consultants propose fitting 60cm diameter spheres at 30 metre intervals alternating orange and white	Operational Phase	None
10.6	Development wide General - Operational Phase	To ensure safe Ballooning activity in the vicinity of the proposed development	The potential presence of the proposed development will have to be considered by the balloon pilots as part of their flight planning. The power line will have to be considered by the balloon pilots for launching and landing, but as stated by the IAA balloon pilots are allowed fly over power lines.	Operational Phase	None
MATERIAL ASSETS – TRAFFIC (CHAPTER 13 OF VOLUMES 3C AND 3D)					
11.1	Development Wide General – Construction Phase	The preparation and implementation of a Construction Traffic Management Plan. The objective of this plan will be	It shall be a requirement of the contractor appointed to construct the project to prepare a detailed Construction Traffic Management Plan prior to the commencement of construction operations. As a minimum, the mitigation measures should include the following: • Development of a detailed construction programme aimed at	Prior to the commenceme nt of the construction	Monitoring of roads used during construction stage required.

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
		to minimise the impact caused by the construction stage of the project.	minimising peaks in traffic volumes on specific roads; • Continuous monitoring of the roads used for construction; • Identification of traffic management measures with respect to road closures; • Measures for continuous liaison with local authorities and other relevant stakeholders; • Identification of traffic management measures at site entrances; and • Measures for accommodating emergency response vehicles along the haul routes.	phase. Continuous updating throughout the construction stage.	
CULTURAL HERITAGE (CHAPTER 14 OF VOLUMES 3C AND 3D)					
12.1	General – Construction	To mitigate against potential impacts during the construction phase	In areas where it has been identified that there is the potential that archaeological, architectural or cultural heritage site, structures, monuments or features could be impacted on during the construction phase, one or more of the following mitigations measures have been recommended: • Archaeological monitoring – in areas of moderate archaeological potential, excavations associated with construction works and / or facilitating access to the construction site and / or stringing areas will be monitored by a suitably qualified archaeologist. In the event that archaeological deposits are discovered, work in the area will cease immediately and the archaeologist will liaise with the National Monuments Service of the DAHG and the National Museum of Ireland.	Prior to the construction phase and throughout construction	Ongoing assessment, testing and monitoring

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			• Archaeological testing – best practice in areas of high archaeological potential demands caution, to ensure that archaeological deposits are identified as early as possible, thereby ensuring that any loss from the archaeological record is minimised. Under a monitoring remit, an archaeologist will observe normal construction works, usually undertaken with a toothed excavator bucket. During archaeological testing a licensed eligible archaeologist supervises excavations undertaken with a toothless grading bucket, under licence to the National Monuments Service of the DAHG, thereby ensuring the early identification of archaeological deposits and minimal loss to the archaeological record. Undertaking this confirmatory surveying will ensure that sufficient time can be allowed within the construction schedule for the excavation of any archaeological deposits discovered. • Demarcation – where it has been identified that there is the potential that an archaeological, architectural or cultural heritage site, structure or monument or could be impacted upon in gaining access to construct the proposed development then demarcation has been recommended to prevent any inadvertent damage. A suitably qualified archaeologist will access the site prior to the commencement of construction works in the area and demarcate a buffer around the site, structure or monument that will remain in place throughout any construction works in the vicinity. • Confirmation of temporary access routes – at a number of locations confirmation of the proposed construction temporary access routes will		

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
			take place, in consultation with the construction team and prior to commencement of construction works, to ensure that the surviving historic fabric of buildings is not impacted on in gaining access for construction activities. To this end the temporary access routes may be revised, sensitive features highlighted and demarcated or different construction machinery or methods used that can access the site without impacting on the historic fabric. • Monitoring of tree surgery – in a couple of instances there is dense vegetation that will have be to be trimmed in the vicinity of upstanding remains of buildings that are indicated on historic mapping. This work will be monitored by a suitably qualified archaeologist to ensure that the historic fabric of the buildings is not impacted upon by the works.		
12.2	Development Wide General – Construction Phase	To ensure the implementation of the mitigation measures during the construction phase	It is recommended that a suitably qualified cultural heritage consultancy / consultant be appointed to oversee the effective implementation of the mitigation measures recommended in this EIS for the construction phase of the proposed development. The consultancy / consultant should maintain continuing liaison with the National Monuments Service of the DAHG throughout the construction phase of the development.	Construction phase	None
12.3	Development wide general	To comply with the Code of Practice Between the National Monuments Service of the DoEHLG (now DAHG) and ESB	In line with the Code of Practice Between the National Monuments Service of the DoEHLG (now DAHG) and ESB Networks (2009), a project archaeologist will be appointed to oversee the effective implementation of the recommended archaeological mitigation during the proposed works.	Construction phase	None

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
		Networks (2009)			
12.4	Teltown Zone of Archaeological Amenity (ZAA)	To mitigate impact on Teltown ZAA	A regime of archaeological testing under licence to the National Monuments Service of the DAHG will be undertaken to confirm whether, in accordance with the predicted impacts set out in the EIS, there are archaeological deposits that could be impacted upon by the construction of towers and guarding in the ZAA. In the event that archaeological deposits are discovered then the National Monuments Service will be notified immediately and time allocated within the construction schedule to allow for excavation of any archaeological material in full consultation with the National Monuments Service of the DAHG and the National Museum of Ireland.	Construction phase	None
12.5	Various Locations	To mitigate against potential impacts during the construction phase of tower locations and associated temporary access tracks.	Refer to summary of mitigation measures as listed in Chapter 14, **Volumes 3C** and **Volume 3D**.	Construction phase	Monitoring required during construction
12.6	Brittas House (RPS No. MH005-105)	To reduce the potential impact on the setting of entrance avenue to Brittas House (RPS No. MH005-105), Co Meath	The clearance of existing vegetation will be minimised in this area and in consultation with the landowner appropriate screening will be planted on either side of the lane to limit the views towards the proposed development.	Construction phase	Monitoring required during construction

Item	Location (along the proposed route)	Mitigation Objective and Commitment	Mitigation Measure	Timing of Mitigation Measure	Monitoring to Ensure Effectiveness of Mitigation
12.7	Development wide – operational	To mitigate against potential impacts during the operational phase	Potential impacts on archaeological, architectural or cultural heritage sites, monuments, structures or features during maintenance works that may be required during the operational phase of the proposed development are best mitigated through ongoing liaison with the National Monuments Service and the Architectural Heritage Advisory Unit at the DAHG and local heritage and conservation officers within the County Councils.	During maintenance or upgrade works that may be required during the operational phase	Ongoing monitoring required during the operational phase (during upgrading / maintenance works).

BIBLIOGRAPHY

CHAPTER 1 INTRODUCTION

EirGrid (May 2011). *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.1**, **Volume 3B Appendices,** of the EIS.

EirGrid (2012). *Approach to the Development of Electricity Lines* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EirGrid (February 2012). *Ecology Guidelines for Electricity Transmission Project – A Standard Approach to Ecological Impact Assessment of High Voltage Transmission Projects*. Available: http://www.eirgrid.com

EirGrid (May 2012). *Grid25 Implementation Programme (IP) 2011-2016* and associated *Strategic Environmental Assessment (SEA).* Available: http://www.eirgrid.com. Included on a disc with this volume of the EIS.

EirGrid (April 2013). *North-South 400 kV Interconnection Development Final Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.2**, **Volume 3B Appendices,** of the EIS.

EirGrid (July 2013). *North-South 400 kV Interconnection Development Preferred Project Solution Report* (PPSR). Available: http://www.eirgridprojects.com. Included as **Appendix 1.3**, **Volume 3B Appendices,** of the EIS.

EirGrid and SONI (2014). *The Need for a Second North-South Electricity Interconnector.* Available: http://www.eirgridprojects.com. Included as **Appendix 2.1**, **Volume 3B Appendices,** of the EIS.

European Commission (May 1999). *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions.* Available: http://www.ec.europa.eu.

European Commission (June 2001). *Guidance on EIA Scoping*. Available: http://www.ec.europa.eu.

European Commission (June 2001). *Guidance on EIA Screening*. Available: http://www.ec.europa.eu.

European Commission (April 2013). *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment*. Available: http://www.ec.europa.eu.

European Commission (May 2013). *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects.* Available: http://www.ec.europa.eu.

European Community (2000). S.I. No. 445/2000, European Communities (*Internal Market in Electricity) Regulations* (2000). Available: http://www.irishstatutebook.ie.

European Community (2005). S.I. No. 60/2005, European Communities *(Internal Market in Electricity) Regulations* (2005). Available: http://www.irishstatutebook.ie.

European Community (2009). S.I. No. 59/2009, European Communities *(Internal Market in Electricity) (Amendment) Regulations* (2009). Available: http://www.irishstatutebook.ie.

EU Directive No.79/409/EC and 2009/147/EC *On the conservation of the wild birds.* Available: http://ec.europa.eu/environment/nature/legislation/birdsdirective/.

EU Directive No. 85/337/EEC *On the assessment of the effects of certain public and private projects on the environment.* Available: http://eur-lex.europa.eu.

EU Directive No. 92/43/EEC *On the conservation of natural habitats and of wild fauna and Flora.* Available: http://ec.europa.eu/environment/nature/legislation/habitatsdirective.

EU Directive 96/92/EC *Concerning common rules for the internal market in electricity.* Available:http://ec.europa.eu/energy/electricity/publications.

EU Directive No. 97/11/EC amending Directive 85/337/EEC *On the assessment of the effects of certain public and private projects on the environment.* Available: http://eur-lex.europa.eu.

EU Directive No. 2003/35/EC *Providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC.* Available: http://eur-lex.europa.eu.

EU Directive No. 2003/54/EC *Concerning common rules for the internal market in electricity and repealing Directive 96/92/EC.* Available: http://eur-lex.europa.eu.

EU Directive No. 2003/92/EU *Common rules for the internal market in electricity*. Available: http://eur-lex.europa.eu.

EU Directive No. 2009/31/EC *On the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC,* *2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.* Available: http://eur-lex.europa.eu.

EU Directive 2009/72/EC *Concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.* Available: http://eur-lex.europa.eu.

EU Directive No. 2011/92/EU *On the assessment of the effects of certain public and private projects on the environment.* Available: http://eur-lex.europa.eu.

EU Regulation No. 347/2013_of the European Parliament and of the Council of 17 April 2013 on *Guidelines for Trans-European Energy Infrastructure* and repealing Decision No. 1364/2006/EC and amending Regulations (EC) No. 713/2009, (EC) No. 714/2009 and (EC) No. 715/2009. Available: http://eur-lex.europa.eu.

Environmental Protection Agency (EPA) (March 2002). *Guidelines on the information to be contained in Environmental Impact Statements.* Available http://www.epa.ie.

Environmental Protection Agency (EPA) (September 2003). *Advice Notes on Current Practice (in Preparation of Environmental Impact Statements).* Available http://www.epa.ie.

Department of Communications, Energy and Natural Resources (DCENR) (July 2012). *Government Policy Statement on the Strategic Importance of Transmission and Other Energy Infrastructure*. Available: http://www.dcenr.gov.ie.

Department of the Environment, Community and Local Government (March 2013). *Guidelines for Planning Authorities and An Bord Pleanála on Carrying out Environmental Impact Assessment*. Available: http://www.environ.ie.

International Expert Commission (IEC) (January 2012). *Meath- Tyrone Report Review by the International Expert Commission* August – November 2011*. (A review of the case for, and cost of undergrounding all or part of the Meath-Tyrone 400 kV Interconnection Development*.) Available: http://www.dcenr.gov.ie.

Irish Government (1999). *Electricity Regulation Act 1999.* Available: http://www.irishstatutebook.ie.

Irish Government (2000 as amended). *Planning and Development Act 2000 (as amended).* Available: http://www.irishstatutebook.ie.

Irish Government (2001 as amended). *Planning and Development Regulations 2001 (as amended).* Available: http://www.irishstatutebook.ie.

Irish Government (2006). *Planning and Development (Strategic Infrastructure) Act 2006.* Available: http://www.irishstatutebook.ie.

National Roads Authority (NRA) (2009). *Guidelines for Assessment of Ecological Impacts of National Road Schemes.* Available: http://www.nra.ie.

The Electricity (Northern Ireland) Order (1992). Available: http://www.legislation.gov.uk.

CHAPTER 2 STRATEGIC NEED

Commission for Energy regulation (CER) and Northern Ireland Authority for Energy Regulation (NIAER) Joint Report for the Case for a Second North-South Interconnector. Available:www.eirgrid.com.

Department of Enterprise, Trade and Investment (UK), Department of Communications, Marine Resources, Northern Ireland Authority for Energy Regulation (NIAER) Commission for Energy regulation (CER) (November 2004). *All-Island Energy Market*. Available: www.dcenr.gov.ie.

EirGrid and SONI (2013). *All Island Generation Capacity Statement 2013-2022*. Available:www.eirgrid.com. Included on a disc with this volume of the EIS.

ESB National Grid (ESBNG) and NIE (2005). *Additional Interconnection between Northern Ireland and the Republic of Ireland Selection of Preferred Option.* Available:www.eirgridprojects.com. Included on a disc with this volume of the EIS.

European Community (2000). S.I. No. 445/2000, European Communities *(Internal Market in Electricity) Regulations (2000).* Available: http://www.irishstatutebook.ie.

EU Directive 2009/28/EC *On the promotion of the use of energy from renewable sources.* Available: http://www.energy.eu/directives.

EU Directive (2009/72/EC) *Common Rules for the Internal Market in Electricity*. Available: http://europa.eu.

CHAPTER 3 SCOPING THE EIS

Department of Communications, Energy and Natural Resources (DCENR) (July 2012). *Government Policy Statement on the Strategic Importance of Transmission and Other Energy Infrastructure*. Available: http://www.dcenr.gov.ie.

EirGrid (May 2011). *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.1, Volume 3B Appendices,** of the EIS.

EirGrid (April 2013). *North-South 400 kV Interconnection Development Final Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.2**, **Volume 3B Appendices,** of the EIS.

EirGrid (July 2013). *North-South 400 kV Interconnection Development Preferred Project Solution Report* (PPSR). Available: http://www.eirgridprojects.com. Included as **Appendix 1.3**, **Volume 3B Appendices,** of the EIS.

Environmental Protection Agency (EPA) (March 2002). *Guidelines on the information to be contained in Environmental Impact Statements.* Available http://www.epa.ie.

Environmental Protection Agency (EPA) (September 2003). *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements).* Available http://www.epa.ie.

European Commission (May 1999). *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions.* Available: http://www.ec.europa.eu.

European Commission (June 2001). *Guidance on EIA - EIS Review*. Available: http://www.ec.europa.eu.

European Commission (June 2001). *Guidance on EIA Screening*. Available: http://www.ec.europa.eu.

European Commission (June 2001). Guidance on EIA Scoping. Available: http://www.ec.europa.eu.

EU Directive No.79/409/EC and 2009/147/EC *On the conservation of the wild birds.* Available: http://ec.europa.eu/environment/nature/legislation/birdsdirective/.

International Expert Commission (IEC) (January 2012). *Meath- Tyrone Report Review by the International Expert Commission* August – November 2011. *(A review of the case for, and cost of* *undergrounding all or part of the Meath-Tyrone 400 kV Interconnection Development*.) Available: http://www.dcenr.gov.ie.

Irish Government (2000). *Planning and Development Act (as amended) 2000.* Available: http://www.irishstatutebook.ie.

CHAPTER 4 CONSIDERATION OF ALTERNATIVES – TECHNOLOGY

Askon (2008). *Study on the Comparative Merits of Overhead Lines and Underground Cables as 400 kV Transmission Lines for the North-South Interconnector Project*. Commissioned by North East Pylon Pressure (NEPP). Available: http://www.dcenr.gov.ie.

Cavan County Council (2008). *Cavan County Development Plan 2008 – 2014*. Available: www.cavancoco.ie.

Cigré (2009). *Update of Service Experience of HV Underground and Cable Systems, ISBN 978 -2-85873-066-7.* Available: http://www.cigre.org, on request.

DCENR (July 2012). *Government Policy Statement on the Strategic Importance of Transmission and Other Energy Infrastructure.* Available: http://www.dcenr.gov.ie.

Department of the Environment, Community and Local Government (March 2013). *Guidelines for Planning Authorities and An Bord Pleanála on Carrying out Environmental Impact Assessment*. Available: http://www.environ.ie.

Dublin Regional Authority and Mid East Regional Authority (2010). *The Regional Planning Guidelines for the Greater Dublin Area.* Available: http://www.rpg.ie.

Ecofys (2008) on behalf of the DCENR. *Study on the Comparative Merits of Overhead Electricity Transmission Lines versus Underground Cables.* Available: http://www.dcenr.gov.ie.

EirGrid (2008*). Grid25 – A Strategy for the Development of Ireland‟s Electricity Grid for a Sustainable and Competitive Future.* Available: http://www.eirgrid.com/media/Grid. Included on a disc with this volume of the EIS.

EirGrid (April 2008). *Policy on the Use of Overhead Line and / or Underground Cable*. Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EirGrid (2009). *Meath-Tyrone 400 kV Interconnection Development Environmental Impact Statement,*. Available: http://www.eirgridprojects.com.

EirGrid (July 2009). *Cavan-Tyrone and Meath-Cavan 400 kV Power Lines – Considerations in Relation to Locating 400 kV Cables in or adjacent to Rail Beds.* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EirGrid and NIE (October 2009). *Meath-Tyrone 400 kV Interconnection Development: Tower Outline Evaluation and Selection Report.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EirGrid (May 2011). *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.1**, **Volume 3B Appendices,** of the EIS.

EirGrid (2012). *Transmission Development Plan 2012-2022.* Available: http://www.eirgrid.com. Included on a disc with this volume of the EIS.

EirGrid (May 2012). *Grid25 Implementation Programme (IP) 2011-2016.* Available: http://www.eirgrid.com/media/Grid. Included on a disc with this volume of the EIS.

EirGrid (April 2013). *North-South 400 kV Interconnection Development Final Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.2**, **Volume 3B Appendices,** of the EIS.

EirGrid (July 2013). *North-South 400 kV Interconnection Development Preferred Project Solution Report* (PPSR). Available: http://www.eirgridprojects.com. Included as **Appendix 1.3**, **Volume 3B Appendices,** of the EIS.

Elinfrastrukturudvalget (April 2008). *Technical report on the future expansion and undergrounding of the electricity transmission grid- Summary*. Available http://www.atvinnuvegaraduneyti.is/media.

Environmental Protection Agency (EPA) (March 2002). *Guidelines on the information to be contained in Environmental Impact Statements.* Available http://www.epa.ie.

Environmental Protection Agency (EPA) (September 2003). *Advice Notes on Current Practice (in the preparation of Environmental Impact Statements).* Available http://www.epa.ie.

ESB National Grid (ESBNG) and NIE (2006). *Additional Interconnection between Northern Ireland and the Republic of Ireland – Selection of Preferred Option.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

ENTSO-E (European Network of Transmission System Operators for Electricity) (2010). *Ten Year Network Development Plan 2010-2020*. Available: https://www.entsoe.eu. Included on a disc with this volume of the EIS.

ENTSO-E and Europacable (December 2010). Joint Paper - *Feasibility and Technical Aspects of Partial Undergrounding of Extra High Voltage Power Transmission Lines.* Available: http://ec.europa.eu/energy. Included on a disc with this volume of the EIS.

ENTSO-E (2012). *Ten Year Network Development Plan 2012.* Available: https://www.entsoe.eu. Included on a disc with this volume of the EIS. Included on a disc with this volume of the EIS.

International Expert Commission (IEC) (January 2012). *Meath- Tyrone Report Review by the International Expert Commission* August – November 2011*. (A review of the case for, and cost of undergrounding all or part of the Meath-Tyrone 400 kV Interconnection Development*). Available: http://www.dcenr.gov.ie. Included on a disc with this volume of the EIS.

Irish Government (2001). *Planning and Development Regulations* (as amended) 2001. Available: http://www.irishstatutebook.ie.

Irish Government (2002). *National Spatial Strategy 2002-2020.* Available: http://www.irishspatialstrategy.ie.

Irish Government (2007). *The National Development Plan 2007-2013*. Available: http://www.ndp.ie.

Meath County Council (2013). *Meath County Development Plan 2013–2019*. Available: www.meath.ie.

Monaghan County Council (2013). *Monaghan County Development Plan 2013-2019.* Available: www.monaghancoco.ie.

Parsons Brinckerhoff (February 2008). *Island of Ireland Cavan- Tyrone and Meath- Cavan 400 kV projects Preliminary Briefing Note Overhead and Underground Energy Transmission Options.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

Parsons Brinckerhoff (February 2009) for NIE and EirGrid. *Cavan – Tyrone and Meath – Cavan 400 kV Transmission Circuits. Comparison of High Voltage Transmission Options: Alternating Current*

Overhead and Underground and Direct Current Underground. Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

Parsons Brinckerhoff (April 2013). *Comparison of High Voltage Transmission Options: Alternating Current Overhead and Underground and Direct Current Underground*. [This is an addendum to the 2009 PB Power Study and should be read in conjunction with that 2009 report]. Available: http://www.eirgridprojects.com.

Parsons Brinckerhoff in association with Cable Consulting International Ltd (January 2012 with Errata April 2012). *Electricity Transmission Costing Study.* An Independent Report Endorsed by the Institution of Engineering & Technology. Available: http://www.theiet.org/factfiles/transmission-report.cfm. Included on a disc with this volume of the EIS.

Parsons Brinckerhoff (July 2013). *Cavan- Tyrone & Meath- Cavan 400 kV Transmission Circuits Technology and Costs Update. Addendum to the 2009 Report and Supplementary Report.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

The Border Regional Authority (2010). *The Border Regional Authority Planning Guidelines 2010-2022*. Available: http://www.border.ie.

RPS Group et al, (April 2012) for the Scottish Government. *Irish-Scottish Links on Energy study (ISLES).* Available: http://www.islesproject.eu/.

Secretary General of UCTE (2008). *Letter from the Secretary General of UCTE to APG (the Austrian Power Grid Company).* Available: http://http://www.eirgridprojects.com.

Tokyo Electric Power Company (TEPCO) (November 2009). *Assessment of the Technical Issues relating to Significant Amounts of EHV Underground Cable in the All-island Electricity Transmission System.* Available: www.eirgrid.com/media/TEPCO. Included on a disc with this volume of the EIS.

TransGrid Solutions Inc (October 2009) for EirGrid. *Investigating the Impact of HVDC Schemes in the Irish Transmission Network.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

CHAPTER 5 CONSIDERATION OF ALTERNATIVES – ROUTING

CIGRE (1999). *High Voltage Overhead Lines Environmental Concerns, Procedures, Impacts and Mitigations.* Available on request from www.cigre.org.

EIA Directive 85/337/EU *on the assessment of the effects of certain public and private projects on the environment.* Available http://www.environ.ie.

EirGrid (2009). *Meath-Tyrone 400 kV Interconnection Development Environmental Impact Statement.* Available. http://www.eirgridprojects.com.

EirGrid (July 2009). *Cavan-Tyrone and Meath-Cavan 400 kV Power Lines – Considerations in Relation to Locating 400 kV Cables in or adjacent to Rail Beds.* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EirGrid (May 2011). *North-South 400 kV Interconnection Development Preliminary Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.1**, **Volume 3B Appendices,** of the EIS.

EirGrid (April 2013). *North-South 400 kV Interconnection Development Final Re-evaluation Report.* Available: http://www.eirgridprojects.com. Included as **Appendix 1.2**, **Volume 3B Appendices,** of the EIS.

EirGrid (July 2013). *North-South 400 kV Interconnection Development Preferred Project Solution Report* (PPSR). Available: http://www.eirgridprojects.com. Included as **Appendix 1.3**, **Volume 3B Appendices,** of the EIS.

Energinet.DK (March 2009). *Cable Action Plan 132 – 150 kV grids.* Available: http://energinet.dk.

Environmental Protection Agency (EPA) (March 2002). *Guidelines on the information to be contained in Environmental Impact Statements.* Available http://www.epa.ie.

Environmental Protection Agency (EPA) (September 2003). *Advice Notes on Current Practice (in Preparation of Environmental Impact Statements).* Available http://www.epa.ie.

ESB International (2002) for EirGrid. *North East 220 kV Reinforcement Project – Initial Feasibility Study– Final.* Available: http://www.eirgridprojects.com. Included on a disc with this volume of the EIS.

ESBNG / NIE (2004). A*rva–Drumkee 275 kV Feasibility Study.* Available: www.eirgridprojects.com.

ESBNG (2005). *Louth-Tandragee 275kV Feasibility Study (South of the Border).* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS. Included on a disc with this volume of the EIS.

ESB National Grid (ESBNG) and NIE (2005). *Additional Interconnection between Northern Ireland and the Republic of Ireland Selection of Preferred Option.* Available:www.eirgridprojects.com. Included on a disc with this volume of the EIS. Included on a disc with this volume of the EIS.

ESBNG / NIE (2005). *Drumkee–Kingscourt 275 kV Feasibility Study (South of the Border).* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

ESBI and AOS Planning (September 2007) for EirGrid. *Route Constraints Report*. Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS. Included on a disc with this volume of the EIS.

ESBI and AOS Planning (May 2008) for EirGrid. *Route Constraints Report (September 2007) Addendum Report*. Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

EU (1999). Council Recommendation 1999/519/EC *(on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)).* Available: http://europa.eu/legislation_summaries/public_health/health_determinants_environment. Included on a disc with this volume of the EIS.

Euronorm EN 50341. *Overhead Electrical Lines exceeding 1 kV and the associated National Normative Aspects (NNA) for Ireland as defined by the Electro Technical Council of Ireland.*

Northern Ireland Electricity and ESBNG (2005). *Additional Interconnection between Northern Ireland and Republic of Ireland – Part 1 – Studies April 2001-2004.* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

Northern Ireland Electricity (March 2005). *Tandragee–Louth 275kV Feasibility Study.* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

Northern Ireland Electricity and ESB National Grid (March 2005). *Drumkee-Kingscourt 275kV Feasibility Study.* Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

Parsons Brinckerhoff (February 2009). *Cavan-Tyrone and Meath-Cavan 400 kV Transmission Circuits Comparison of High Voltage Transmission Options: Alternating Current Overhead and Underground, and Direct Current Underground.* Available: www.nie.co.uk.

Socoin and TOBIN Consulting Engineers (July 2007) for EirGrid. *Kingscourt to Woodland Constraints Report Volume 1.* Available: www.eirgrid.com. Included on a disc with this volume of the EIS.

Socoin and Tobin (September 2007) for EirGrid. *Constraints Report 1 - Addendum Report.* Available: www.eirgrid.com. Included on a disc with this volume of the EIS.

Socoin and TOBIN Consulting Engineers (May 2008) for EirGrid. *Kingscourt to Woodland 400 kV Powerline Addendum Report.* Available: www.eirgrid.com. Included on a disc with this volume of the EIS.

Socoin and TOBIN (December 2008) for EirGrid. *Response to An Bord Pleanála – Kingscourt to Woodland Route Comparison Report.* Available: www.eirgridprojects.com . Included on a disc with this volume of the EIS.

RPS Planning and Environment (2008) for EirGrid. *Tyrone-Cavan Interconnector & Meath Cavan Transmission Circuit – Corridor Evaluation Document*. Available: www.eirgridprojects.com. Included on a disc with this volume of the EIS.

UK National Grid (2012). Our *Approach to the Decision and Routing of New Electricity Transmission* Lines. Available: http://www.nationalgrid.com.

CHAPTER 7 CONSTRUCTION

Department of the Environment (1996). *Traffic Signs Manual*.

Irish Government (1996). *Waste Management Act 1996* (as amended). Available: www.irishstatutebook.ie.

Department of the Environment, Community and Local Government (2006). *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Waste Projects*. Available www.environ.ie.

CHAPTER 8 EMF – GENERAL

[**NOTE** - Chapter 8 was prepared by an American author. The references set out below are American academic References.]

Adair RK. *Constraints of thermal noise on the effects of weak 60-Hz magnetic fields acting on biological magnetite*. Proc Natl Acad Sci 91:2925-2929, 1994.

Advisory Group on Non-ionising Radiation (AGNIR). *Health Effects from Radiofrequency Electromagnetic Fields.* Report of the Independent Advisory Group on Non-ionising Radiation. London, England: Health Protection Agency, 2012.

Ahlbom A, Day N, Feychting M, Roman E, Skinner J, Dockerty J, Linet M, Michealis J, Olsen JH, Tynes T, Verkasalo PK. *A pooled analysis of magnetic fields and childhood leukemia*. Br J Cancer 83:692-8, 2000.

Ahlbom A, Feychting M, Gustavsson A, Hallqvist J, Johansen C, Kheifets L, Olsen JH. *Occupational magnetic field exposure and myocardial infarction incidence*. Epidemiology 15:403-408, 2004.

Akdag MZ, Dasdag S, Ulukaya E, Uzunlar AK, Kurt MA, Taskin A. *Effects of extremely low frequency magnetic field on caspase activities and oxidative stress values in rat brain*. Biol Trace Elem Res 138:238-249, 2010.

Al-Akras M-A, Darmani H, Elbetieha A. *Influence of 50 Hz magnetic field on sex hormones and other fertility parameters of adult male rats*. Bioelectromagnetics 27:127-131, 2006.

American Conference of Government Industrial Hygienists (ACGIH). *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 7th edition. Publication No. 0100. Cincinnati, OH: American Conference of Government Industrial Hygienists, 2001.

Anderson LE, Boorman GA, Morris JE, Sasser LB, Mann PC, Grumbein SL, Hailey JR, McNally A, Sills RC, Haseman JK. *Effect of 13 week magnetic field exposures on DMBA-initiated mammary gland carcinomas in female Sprague-Dawley rats*. Carcinogenesis 20: 1615-1620, 1999.

Astridge PS, Kaye GC, Whitworth S, Kelly P, Camm AJ, Perrins EJ. *The response of implanted dual chamber pacemakers to 50 Hz extraneous electrical interference*. Pacing Clin Electrophysiol 16:1966-1974, 1993.

Aydin M, Cevik A, Kandemir FM, Yuksel M, and Apaydin AM. *Evaluation of hormonal change, biochemical parameters, and histopathological status of uterus in rats exposed to 50-Hz electromagnetic field.* Toxicol Ind Health 25:352-158, 2009.

Babbitt JT, Kharazi AI, Taylor JMG, Bonds CB, Mirell SG, Frumkin E, Zhuang D, Hahn TJ. *Hematopoietic neoplasia in C57BL/6 mice exposed to split-dose ionizing radiation and circularly polarized 60 Hz magnetic fields*. Carcinogenesis 21: 1379-89, 2000.

Bailey WH and Wagner ME. IARC evaluation of EMF magnetic fields: Public understanding of the 0.4-T exposure metric. J Exposure Sci Environ Epidemiol 18:233-35, 2008.

Bankoske JW, Graves HB, McKee GW. *The Effects of High Voltage Electric Fields on the Growth and Development of Plants and Animals.* In Proceedings of the first national symposium on environmental concerns in rights-of-way management. Tillman R (Ed.) pp.112-123, 1976.

Barth A, Ponocny I, Ponocny-Seliger E, Vana N. Winker R. *Effects of extremely low-frequency magnetic field exposure on cognitive functions: results of a meta-analysis*. Bioelectromagnetics 31:173-179, 2010.

Baum A, Mevissen M, Kamino K, Mohr U, Löscher W. *A histopathological study on alterations in DMBA-induced mammary carcinogenesis in rats with 50 Hz, 100 muT magnetic field exposure*. Carcinogenesis 16:119-125, 1995.

Begall S, Červený J, Neef J, Voljtěch O, Burda H. Magnetic alignment in grazing and resting cattle and deer. PNAS 105:13451-13455, 2008.

Bernabò N, Tettamanti E, Russo V, Martelli A, Turri M, Mattoli M, Barboni B. *Extremely low frequency electromagnetic field exposure affects fertilization outcome in swine animal model.* Theriogenology 73:1293-1305, 2010.

Bernard N, Alberdi AJ, Tanguy ML, Brugere H, Helissey P, Hubert C, Gendrey N, Guillosson JJ, Nafziger J. *Assessing the potential Leukemogenic effects of 50 Hz and their harmonics using an animal leukemia model.* Journal of Radiation Research, 49:565-577, 2008.

Bevelhimer MS, Cada GF, Fortner AM; Schweizer PE; Riemer KP. *Laboratory Studies of the Short-term Responses of Freshwater Fish to Electromagnetic Fields.* Oak Ridge National Laboratory, 2013.

Bindokas VP, Gauger JR, Greenberg B. *Exposure schemes separates effects of electric shock and electric field for honey bees*, Apis mellifera L. Bioelectromagnetics 9:275-284, 1988a.

Bindokas VP, Gauger JR, Greenberg B. *Mechanism of biological effects observed in honey bees (Apis mellifera, L.) hived under extra-high-voltage transmission lines: Implications derived from bee exposure to simulated intense electric fields and shocks*. Bioelectromagnetics 9: 285-301, 1988b.

BioInitiative Working Group. BioInitiative: *A Rationale for a Biologically-based Exposure Standard for Electromagnetic Radiation*. August 2007.

BioInitiative Working Goup. Sage C and Carpenter DO (Eds.). *BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation* at www.bioinitiative.org, December 31, 2012.

Bohannon J. *Who‟s afraid of peer review?* Science 342:60-65, 2013.

Bonneville Power Administration (BPA). *Corona and Field Effects Computer Program*, 1991.

Boorman GA, Anderson LE, Morris JE, Sasser LB, Mann PC, Grumbein SL, Hailey JR, McNally A, Sills RC, Haseman JK. *Effects of 26-week magnetic field exposure in a DMBA initiation-promotion mammary glands model in Sprague-Dawley rats*. Carcinogenesis 20:899-904, 1999a.

Boorman GA, McCormick DL, Findlay JC, Hailey JR, Gauger JR, Johnson TR, Kovatch RM, Sills RC, Haseman JK. *Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in F344/N rats*. Toxicologic Pathology 27:267-78, 1999b.

Bunch KJ, Keegan TJ, Swanson J, Vincent TJ, Murphy MF. *Residential distance at birth from overhead high-voltage powerlines: childhood cancer risk in Britain 1962-2008*. Br J Cancer 110: 1402-1408, 2014.

Burchard JF, Monardes H, Nguyen DH. *Effect of 10 kV, 30 mT, 60 Hz electric and magnetic fields on milk production and feed intake in nonpregnant dairy cattle*. Bioelectromagnetics 24:557-563, 2003.

Burchard JF, Nguyen DH, Monardes HG, Petitclerc D. *Lack of effect of 10 kV/m 60 Hz electric field exposure on pregnant dairy heifer hormones.* Bioelectromagnetics 25:308-312, 2004.

Burchard JF, Nguyen DH, Monardes HG. *Exposure of pregnant dairy heifer to magnetic fields at 60 Hz and 30 uT.* Bioelectromagnetics 28:471-476, 2007.

Burda H, Begall S, Červený J, Neef J, Němec, P. *Extremely low-frequency electromagnetic fields disrupt magnetic alignment of ruminants.* PNAS 106:5708-5713, 2009.

Burdak-Rothkamm S, Rothkamm K, Folkard M, Patel G, Hone P, Lloyd D, Ainsbury L, Prise KM. *DNA and chromosomal damage in response to intermittent extremely low frequency magnetic fields.* Mut Res 672:82-89, 2009.

Brulfert A, Miller MW, Robertson D, Dooley DA, Economou P. *A cytohistological analysis of roots whose growth is affected by a 60-Hz electric field.* Bioelectromagnetics 6:283-291, 1985.

California Department of Health Services (CDHS). Neutra RR, Delpizzo V, Lee GM. *An Evaluation of The Possible Risks From Electric And Magnetic Fields (EMFs) from Power Lines, Internal Wiring, Electrical Occupations And Appliances.* Oakland, CA: California EMF Program, 2002.

Chu LY, Lee JH, Nam YS, Lee YJ, Park WH, Lee BC, Kim D, Chung YH, Jeong JH. *Extremely low frequency magnetic field induces oxidative stress in mouse cerebellum*. Gen Physiol Biophys 30: 415-421, 2011.

Chung M-K, Kim Y-B, Ha C-S, Myung S-H. *Lack of a co-promotion effect of 60 Hz rotating magnetic fields on n-ethyl-n-nitrosourea induced neurogenic tumors in F344 rats.* Bioelectromagnetics 29:539-48, 2008.

Ciejka E and Gorąca A. *The influence of low-frequency magnetic field on plasma antioxidant capacity and heart rate.* Wiad Lek 62:81-86, 2009.

Ciejka E, Kleniewska P, Skibska B, Goraca A. *Effects of extremely low frequency magnetic field on oxidative balance in brain of rats.* J Physiol Pharmacol 62: 657-661, 2011.

Conti R, Nicolini P, Cerretelli P, Margonato V, Veicsteinas A, Floris C. *Enel‟s research activity on possible biological effects of 50 Hz electromagnetic fields – results and plans of a large research programme.* Alta Frequenza 4: 395-402, 1989.

Costanzo E. *The influence of an electric field on the growth of soy seedlings.* J Electrostat 66:417-420, 2008.

Davies MS. *Effects of 60 Hz electromagnetic fields on early growth in three plant species and a replication of previous results*. Bioelectromagnetics 17:154-161, 1996.

Di Lazzaro V, Capone F, Apollonio F, Borea PA, Cadossi R, Fassina L, Grassi C, Liberti M, Paffi A, Parazzini M, Varani K, Ravazzani P. *A consensus panel review of central nervous system effects of the exposure to low-intensity extremely low-frequency magnetic fields*. Brain Stimul 6: 469-476, 2013.

De Souza A, Sueiro L, Garcia D, Porras E. *Extremely low frequency non-uniform magnetic fields improve tomato seed germination and early seedling growth.* Seed Sci Technol 38:61-72, 2010.

Department of Communications, Marine and Natural Resources (DCMNR). *Expert Group on Health Effects of Electromagnetic Fields.* March 2007. http://www.dcmnr.gov.ie/NR/rdonlyres/9E29937F-1A27-4A16-A8C3-F403A623300C/0/ElectromagneticReport.pdf.

de Vocht F, Hannam K, Baker P, Agius R. *Maternal residential proximity to sources of extremely low frequency electromagnetic fields and adverse birth outcomes in a UK cohort*. Bioelectromagnetics 35: 201-209, 2014.

Dimbylow, P. *Development of the female voxel phantom, NAOMI, and its application to calculations of induced current densities and electric fields from applied low frequency magnetic and electric fields.* Phys Med Biol 50:1047-1070, 2005.

Draper G, Vincent T, Kroll ME, Swanson J. *Childhood cancer in relation to distance from high voltage power lines in England and Wales: a case-control study*. BMJ 330: 1290, 2005.

Dundar B, Cesur G, Comlekci S, Songur A, Gokcimen A, Sahin O, Ulukut O, Yilmaz HR, Sutcu R, Caliskan S. *The effect of the prenatal and post-natal long-term exposure to 50 Hz electric field on growth, pubertal development and IGF-1 levels in female Wistar rats.* Toxicol Ind Health 25:479-487, 2009.

Dyrda K and Khairy P. *Implantable rhythm devices and electromagnetic interference: myth or reality?* Expert Rev Cardiovasc Ther 6:823-832, 2008.

Elliott P, Shaddick G, Douglass M, de Hoogh K, Briggs DJ, Toledano MB. *Adult cancers near high-voltage overhead power lines.* Epidemiology 24: 184-190, 2013.

European Committee for Electrotechnical Standardization (CENELEC). *European Standard EN 50527-1:2010 – Procedure for the assessment of the exposure to electromagnetic fields of workers bearing active implantable medical devices – Part 1: General.* Brussels: CENELEC, 2010.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN). *Report on the Analysis of Risks Associated to Exposure to EMF: In Vitro and In Vivo (Animals) Studies.* Milan, Italy: European Health Risk Assessment Network on Electromagnetic Fields Exposure, 2010.

European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN). *Risk Analysis of Human Exposure to Electromagnetic Fields (Revised). Report D2 of the EFHRAN Project.* Milan, Italy: European Health Risk Assessment Network on Electromagnetic Fields Exposure, 2012.

European Union (EU). *Council Recommendation of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz).* Off J Eur Comm L1999/59, 1999.

European Union (EU). *Implementation report on the Council Recommendation limiting the public exposure to electromagnetic fields (0 Hz and 300 GHz),* 2002.

European Union (EU). *Directive 2004/40/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic field) entered into force in the European Union.* Off J Eur Union L184:1-9, 2004.

European Union (EU). *Directive 2013/35/EU of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC.*

Fam WZ and Mikhail EL. *Lymphoma induced in mice chronically exposed to very strong low-frequency electromagnetic-field*. Cancer Lett 105:257-269, 1996.

Fedrowitz M, Kamino K, Löscher W. *Significant differences in the effects of magnetic field exposure on 7,12-dimethylbenz(a)anthracene-induced mammary carcinogenesis in two substrains of Sprague-Dawley rats.* Cancer Res 64: 243-251, 2004.

Fedrowitz M and Löscher W. *Gene expression in the mammary gland tissue of female Fischer 344 and Lewis rats after magnetic field exposure (50 Hz, 100 muT) for 2 weeks*. Int J Radiat Biol 88: 425-429, 2012.

Fedrowitz M, Hass R, Löscher W. *Effects of 50 Hz mangetic field exposure on the stress marker α-amylase in the rat mammary gland.* Int J Radiat Biol 88: 556-564, 2012.

Fews AP, Henshaw DL, Keitch PA, Close JJ, Wilding RJ. *Increased exposure to pollutant aerosols under high voltage power lines.* Int J Radiat Biol 75: 1505-1521, 1999.

Foliart DE, Pollock BH, Mezei G, Iriye R, Silva JM, Ebi KL, Kheifets L, Link MP, Kavet R. *Magnetic field exposure and long-term survival among children with leukaemia*. Br J Cancer 94:161-164, 2006.

Frahm J, Mattsson MO, Simkó M. *Exposure to ELF magnetic field modulate redox related protein expression in mouse macrophages.* Toxicol Lett 192:330-336, 2010.

Framm J and Lautner S. *Electrical signals and their physiological significance in plants.* Plant Cell Environm 30: 249-257, 2007.

Frei P, Poulsen AH, Mezei G, Pedersen C, Cronberg Salem L, Johansen C, Roosli M, Schuz J.

Residential distance to high-voltage power lines and risk of neurodegenerative diseases: a Danish population-based case-control study. Am J Epidemiol, 2013.

Girgert R, Gründker C, Emons G, Hanf V. *Electromagnetic fields alter the expression of estrogen receptor cofactors in breast cancer cells.* Bioelectromagnetics 29:169-176, 2008.

Girgert R, Emons G, Hanf V, Gründker C. *Exposure of MCF-7 breast cancer cells to electromagnetic fields up-regulates the plasminogen activator system*. Int J Gynecol Canc 19:334-338, 2009.

Girgert R, Hanf V, Emons G, Gründker C. *Signal transduction of the melatonin receptor MT1 is disrupted in breast cancer cells by electromagnetic fields*. Bioelectromagnetics 31:237-245, 2010.

Goraca A, Ciejka E, Piechota A. *Effects of extremely low frequency magnetic field on the parameters of oxidative stress in heart*. J Physiol Pharmacol 61:333-338, 2010.

Gottwald E, Sontag W, Lahni B, Weibezahn K-F. *Expression of HSP72 after ELF-EMF exposure in three cell lines.* Bioelectromagnetics 28:509-518, 2007.

Graham C, Sastre A, Cook MR, Kavet R, Gerkovich MM, Riffle DW. *Exposure to strong ELF magnetic fields does not alter cardiac autonomic control mechanisms.* Bioelectromagnetics 21: 413-421, 2000a.

Graham C, Sastre A, Cook MR, Kavet R. *Heart rate variability and physiological arousal in men exposed to 60 Hz magnetic fields.* Bioelectromagnetics 21: 480-482, 2000b.

Greenberg B, Bindokas VP, Gauger JR. *Biological effects of a 765-kV transmission line: Exposures and thresholds in honeybee colonies.* Bioelectromagnetics 2:315-328, 1981.

Greene RW. *60 Hz ultra-high voltage electric field effect on onion root mitotic index: a lack of impact.* Environ Exp Bot 23:355-360, 1983.

Greenland S, Sheppard AR, Kelsh MA, Kaune WT. *A pooled analysis of magnetic fields, wire codes, and childhood leukemia*. Epidemiology 11:624-634, 2000.

Halgamuge MN. *Pineal melatonin level disruption in humans due to electromagnetic fields and ICNIRP limits*. Radiat Prot Dosimetry 154: 405-416, 2013.

Harris AW, Basten A, Gebski V, Noonan D, Finnie J, Bath ML, Bangay MJ, Repacholi MH. *A test of lymphoma induction by long-term exposure of E mu-Pim1 transgenic mice to 50 Hz magnetic fields.* Radiat Res 149:300-307, 1998.

Health Council of the Netherlands (HCN). *Health Council of the Netherlands; Reports 2008*. Publication No. A09/02. The Hague: Health Council of the Netherlands., 2009.

Hert J, Jelinek L, Pekarek L, Pavlicek A. *No alignment of cattle along geomagnetic field lines found*. J Comp Physiol A 197:677-682, 2011.

Health Protection Agency (HPA). *Electricity Substations and Power Lines,* March, 2004. http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1158934607796?p=1158934607796.

Hefeneider SH, McCoy SL, Hausman FA, Christensen HL, Takahashi D, Perrin N, Bracken TD, Shin JY, Hall AS. *Long-term effects of 60-Hz electric vs. magnetic fields on IL-1 and IL-2 activity in sheep.* Bioelectromagnetics 22:170-177, 2001.

Heikkinen P, Kosama VM, Huuskonen H, Komulainen H, Kumlin T, Penttila I, et al. *Effects of 50 Hz magnetic fields on cancer induced by ionizing radiation in mice.* Int J Radiat Biol 77:483-495, 2001.

Hilson DW, Noggle JC, Burns ER. *Effects of Electric Field on Plants Growing Under High Voltage Transmission Lines. Office of Natural Resources*, Air Quality Branch. Chattanooga, Tennessee: Tennessee Valley Authority, 1983.

Hodges TK, Mitchell CA, Heydt G. *Effect of Electric Fields from 765-kV Transmission Lines on Plant Growth.* A report by Purdue University for Indiana and Michigan Electric Company, a Subsidiary of American Electric Power, 1975.

Hodges TK, Mitchell CA, Heydt G. *Effect of Electric Fields from 765-kV Transmission Lines on Plant Growth.* A report by Purdue University for Indiana and Michigan Electric Company, a Subsidiary of American Electric Power, 1975.

Hodges TK, Mitchell CA. *Influence on High Intensity Electric Fields on Yield of Sweet Corn and Dent Corn-1982.* A report for the American Electric Power Service Corporation. North Liberty, Indiana. 1984.

Hours M, Khati I, Hamelin J. *Interference between active implanted medical devices and electromagnetic field emitting devices is rare but real: results of an incidence study in a population of physicians in France*. Pacing Clin Electrophysiol 37: 290-296, 2014.

Huang H-H and Wang S-R. *The effects of inverter magnetic fields on early seed germination of mung beans.* Bioelectromagnetics 29: 649-657, 2008.

Huss A, Spoerri A, Egger M, Röösli M, for the Swiss National Cohort Study. *Residence near power lines and mortality from neurodegenerative diseases: longitudinal study of the Swiss population.* Am J Epidemiol 169:167-175, 2009.

International Agency for Research on Cancer (IARC). *IARC monographs on the evaluation of carcinogenic risks to humans.* Volume 80: static and extremely low-frequency (ELF) electric and magnetic fields. Lyon, France: IARC Press, 2002.

Institute of Electrical and Electronics Engineers (IEEE). *IEEE guide for the design, construction, and operation of electric power substations for community acceptance and environmental compatibility .* IEEE Std. 1127-1998, 2004.

International Electrotechnical Commission (IEC). *Measurement of low-frequency magnetic and electric field with regard to exposure of human beings.* Special requirements for instruments and guidance for measurements. IEC Standard 61786.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).* Health Phys 74:494-522, 1998.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). *Exposure to Static and Low Frequency Electromagnetic Fields, Biological Effects and Health Consequences (0-100 kHz) – Review of the Scientific Evidence on Dosimetry, Biological Effects, Epidemiological Observations, and Health Consequences Concerning Exposure to Static and Low Frequency Electromagnetic Fields (0-100 kHz).* Matthes R, McKinlay AF, Bernhardt JH, Vecchia P, Beyret B (eds.). International Commission on Non-Ionizing Radiation Protection, *2003.*

International Commission on Non-ionizing Radiation Protection (ICNIRP): *Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz).* Health Phys 99(6):818-836, 2010.

International Committee on Electromagnetic Safety (ICES). *IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields 0 to 3 kHz C95. 6-2002*. Piscataway, NJ: IEEE, 2002, Reaffirmed 2007.

Ioannidis JP, Tarone R, McLaughlin JK. *The false-positive to false-negative ratio in epidemiologic studies.* Epidemiology 22:450-456, 2011.

Ivancsits S, Diem E, Pilger A, Rüdinger HW, Jahn O. *Induction of DNA strand breaks by intermittent exposure to extremely-low-frequency electromagnetic fields in human diploid fibroblasts.* Mutat Res 519:1-13, 2002.

Ivancsits S, Diem E, Jahn O, Rüdiger HW. *Age-related effects on induction of DNA strand breaks by intermittent exposure to electromagnetic fields.* Mech Ageing Dev 124:847-850, 2003a.

Ivancsits S, Diem E, Jahn O, Rüdiger HW. *Intermittent extremely low frequency electromagnetic fields cause DNA damage in a dose-dependent way*. Int Arch Occup Environ Health 76:431-436, 2003b.

Jian W, Wei Z, Zhiqiang C, Zheng F. *X-ray-induced apoptosis of BEL-7402 cell line enhanced by extremely low frequency electromagnetic field in vitro.* Bioelectromagnetics 30:163-165, 2009.

Jiménez-Garcia MN, Arellanes-Robledo J, Aparicio-Bautista DI, Rodriguez-Segura MA, Villa-Trevino S, Godina-Nava JJ. *Anti-proliferative effect of extremely low frequency electromagnetic field on preneoplastic lesions formation in the rat liver.* BMC Cancer 10: 159, 2010.

Johansen C, Feychting M, Moller M, Amsbo P, Ahlbom A, Olsen JH. *Risk of sever cardiac arrhythmia in male utility workers: a nationwide Danish cohort study.* Am J Epidemiol 156:857-861, 2002.

Joosten S, Pammler K, Silny J. *The influence of anatomical and physiological parameters on the interference voltage at the input of unipolar cardiac pacemakers in low frequency electric fields*. Phys Med Biol 54:591-609, 2009.

Juutilainen J, Kumlin T, Naarala J. *Do extremely low frequency magnetic fields enhance the effects of environmental carcinogens? A meta-analysis of experimental studies*. Int J Radiat Biol 82:1-12, 2006.

Juutilainen J. *Do electromagnetic fields enhance the effects of environmental carcinogens?* Radiat Prot Dosimetry 132:228-231, 2008.

Kabacik S, Kirschenlohr H, Raffy C, Whitehill K, Coster M, Abe M, Brindle K, Badie C, Sienkiewicz Z, Bouffler S. *Investigation of transcriptional responses of juvenile mouse bone marrow to power frequency magnetic fields.* Mutat Res 745-746: 40-45, 2013.

Kavet R, Dovan T, Reilly JP. *The relationship between anatomically correct electric and magnetic field dosimetry and published electric and magnetic field exposure limits.* Radiat Prot Dosimetry 152: 279-295, 2012.

Khaki AA, Zarrintan S, Khaki A, Zahedi A. *The effects of electromagnetic field on the microstructure of seminal vesicles in rat: a light and transmission electron microcope study.* Pak JBiol Sci 11:692-701, 2008.

Kheifets L, Monroe J, Vergara X, Mezei G, Afifi A. *Occupational electromagnetic fields and leukemia and brain cancer: An update to two meta-analyses.* JOEM 50:677-88, 2008.

Kheifets L, Ahlbom A, Crespi CM, Draper G, Hagihara J, Lowenthal RM, Mezei G, Oksuzyan S, Schüz J, Swanson J, Tittarelli A, Vincenti M, Wunsch Filho V. *Pooled analysis of recent studies on magnetic fields and childhood leukaemia.* Br J Cancer 103:1128-1135, 2010a.

Kheifets L, Ahlbom A, Crespi CM, Feychting M. Johansen C, Monroe J, Murphy MFG, Oksuzyan S, Preston-Martin S, Roman E, Saito T, Savitz D, Schüz J, Simpson J, Swanson J, Tynes T, Merkasalo V, Mezei G*. A pooled analysis of extremely low-frequency magnetic fields and childhood brain tumors.* Am J Epidemiol 172:752-761, 2010b.

Kim Y-W, Kim H-S, Lee J-S, Kim Y-J, Lee S-K, Seo J-N, Jung K-C, Kim N, Gimm Y-M. *Effects of 60 Hz 14 μT magnetic field on the apoptosis of testicular germ cell in mice.* Bioelectromagnetics 30: 66-72, 2009.

Kiray A, Tayefi H, Kiray M, Bagriyanik HA, Pekcetin C, Ergur BU, Ozogul C. *The effects of exposure to electromagnetic field on rat myocardium*. Toxicol Ind Health 29: 418-425, 2013.

Kirschenlohr H, Ellis P, Hesketh R, Metcalfe J. *Gene expression profiles in white blood cells of volunteers exposed to a 50 Hz electromagnetic field.* Radiat Res 178: 138-149, 2012.

Kirschvink JL, Padmanabha S, Boyce KC, Ogelsby J. *Measurement of the threshold sensitivity of honeybees to weak, extremely low-frequency magnetic fields*. J Exp Biol 200:1363-1368, 1997.

Koeman T, van den Brandt PA, Slottje P, Schouten LJ, Goldbohm RA, Kromhout H, Vermeulen R. *Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort.* Cancer Causes Control 25: 203-214, 2014.

Koh EK, Ryu B-K, Jeong D-Y, Bang I-S, Nam MH, Chae K-S. *A 60-Hz sinusoidal magnetic field induces apoptosis of prostate cancer cells through reactive oxygen species.* Int J of Radiat Biol 84:945-955, 2008.

Korpinen L, Kuisti H, Elovaara J, Virtanen V. *Cardiac pacemakers in electric and magnetic fields of 400-kV power lines.* PACE 35: 422-430, 2012.

Korpinen L and Paakkonen R. *Examples of occupational exposure to electric and magnetic fields at 110-kV gas-insulation (GISs).* Radiat Prot Dosimetry 2014 Jun 25 [Epub ahead of print].

Krizaj D and Valencic V. *The effects of ELF magnetic fields and temperature on differential plant growth.* J Bioelectricity 8:159-165, 1989.

Lee JM and Clark CF. *Ecological Effects of EHV and UHV Transmission Lines Current Issues.* In: CIGRE Symposium on Transmission Lines and the Environment, pp. 223-307. June 23-25. Stockholm, Sweden. 1981.

Lee JM, Stormshak F, Thompson JM, Thinesen P, Painter LJ, Olenchek EG, Hess DL, Forbes R, Foster DL. *Melatonin secretion and puberty in female lambs exposed to environmental electric and magnetic fields.* Biol Reprod 49:857-864, 1993.

Lee GM, Neutra RR, Hristova L, Yost M, Hiatt RA: *A nested case-control study of residential and personal magnetic field measures and miscarriages.* Epidemiology 13:21-31, 2002.

Li DK, Odouli R, Wi S, Janevic T, Golditch I, Bracken TD, Senior R, Rankin R, Iriye R: *A population-based prospective cohort study of personal exposure to magnetic fields during pregnancy and the risk of miscarriage*. Epidemiology 13:9-20, 2002.

Li W, Ray RM, Thomas DB, Yost M, Davis S, Breslow N, Gao DL, Fitzgibbons ED, Camp JE, Wong E, Wernli KJ, Checkoway H. *Occupational exposure to magnetic fields and breast cancer among women textile workers in Shanghai, China*. Am J Epidemiol 178: 1038-1045, 2013.

Löscher W and Mevissen M. *Linear relationship between flux density and tumor co-promoting effect of prolonged magnetic field exposure in a breast cancer model*. Cancer Lett 96:175-180, 1995.

Löscher W, Mevissen M, Lehmacher W, Stamm A. *Tumor promotion in a breast cancer model by exposure to a weak alternating magnetic field.* Cancer Lett 71:75-81, 1993.

Löscher W, Wahnschaffe U, Mevissen M, Lerchl A, Stamm A. *Effects of weak alternating magnetic fields on nocturnal melatonin production and mammary carcinogenesis in rats.* Oncology 51:288-295, 1994.

Löscher W, Mevissen M, Haussler B. *Seasonal influence on 7,12-dimethylbenz[a]anthracene-induced mammary carcinogenesis in Sprague-Dawley rats under controlled laboratory conditions.* Pharmacol Toxicol 81:265-270, 1997.

Mahmoud AA, Zimmerman DR. *High voltage transmission and environmental effects.* Right-of-way December 15-19, 1983.

Mahmoud AA, Zimmerman DR. *Reproductive performance of pigs exposed to high voltage electric field: Second generation (Draft).* Presented at the Summer Meeting of the American Society of Agricultural Engineers, 1984.

Mandeville R, Franco E, Sidrac-Ghali S, Paris-Nadon L, Rocheleau N, Mercier G, Desy M, Gaboury L. *Evaluation of the potential carcinogenicity of 60 Hz linear sinusoidal continuous-wave magnetic fields in Fisher F344 rats*. FASEB J 11:1127-1136, 1997.

Mandeville R, Franco E, Sidrac-Ghali S, Paris-Nadon L. Rocheleau N, Mercier G, et al. *Evaluation of the potential promoting effect of 60 Hz magnetic fields on N-ethyl-N-nitrosourea induced neurogenic tumors in female F344 rats.* Bioelectromagnetics 21:84-93, 2000.

Mariucci G, Villarini M, Moretti M, Taha E, Conte C, Minelli A, Aristei C, Ambrosini MV. *Brain DNA damage and 70-kDa heat shock protein expression in CD1 mice exposed to extremely low frequency magnetic fields.* Int J Radiat Biol 86:701-710, 2010.

Markkanen A, Juutilainen J, Naarala J. *Pre-exposure to 50 Hz magnetic fields modifies menadione-induced DNA damage response in murine L929 cells*. Int J Radiat Biol 84:742-751, 2008.

Martínez-Sámano J, Torres-Durán PV, Juárez-Oropeza MA, Elías-Viñas D, Verdugo-Díaz L. *Effects of acute electromagnetic field exposure and movement restraint on antioxidant system in liver, heart, kidney and plasma of Wistar rats:* A preliminary report. Int J Radiat Biol 86:1088-1094, 2010.

Martinez-Samano J, Torres-Duran PV, Juarez-Oropeza MA, Verdugo-Diaz L. *Effect of acute extremely low frequency electromagnetic field exposure on the antioxidant status and lipid levels in rat brain*. Arch Med Res 43: 183-189, 2012.

McCormick DL, Ryan BM, Findlay JC, Gauger JR, Johnson TR, Morrissey RL, Boorman GA. *Exposure to 60 Hz magnetic field and risk of lymphoma in PIM transgenic and TSG-p53 (p53 knockout) mice.* Carcinogenesis 19:1649-1653, 1998

McCormick DL, Boorman GA, Findlay JC, Hailey JR, Johnson TR, Gauger JR, Pletcher JM, Sills RC, Haseman JK. *Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F1 mice.* Toxicol Pathol 27:279-85, 1999.

McCoy SL, Hefeneider SH. *Effect of 60 Hz electric and magnetic fields from a 500 kV transmission line on interleukin 1 production and antibody response by ewe lamb, pp. 633-636.* In: Electricity and Magnetism in Biology and Medicine, Blank M (Eds). San Francisco, CA: San Francisco Press, Inc., 1993.

McKee GW, Knievel DP, Poznaniak DT, Bankoske JW. *Effects of 60 Hz high intensity electric fields on living plants.* IEEE Trans Power App Sys 97:1177-1181, 1978.

McLean J, Stuchly MA, Mitchel RE, Wilkinson D, Yang H, Goddard M, et al. *Cancer promotion in a mouse-skin model by a 60 Hz magnetic field.* 2. Tumor-development and immune response. Bioelectromagnetics 12:273-287, 1991.

McLean J, Thansadote A, Lecuyer D, Goddard M, Tryphonas L, Scaiano JC, et al. *A 60-Hz magnetic field increases the incidence of squamous cells carcinomas in mice previously exposed to chemical carcinogens.* Cancer Lett 92:121-125, 1996.

Mevissen M, Stamm A, Buntenkotter S, Zwingelberg R, Wahnschaffe U, Löscher W. *Effects of magnetic fields on mammary tumor development induced by 7,12-dimethylbenz(a)anthracene in rats.* Bioelectromagnetics 14:131-143, 1993a.

Mevissen M, Wahnschaffe U, Löscher W, Stamm A, Lerchl A. *Effects of AC magnetic field on DMBA-induced mammary carcinogenesis in Sprague-Dawley rats.* In Electricity and Magnetism in Biology and Medicine. Blank M (ed), pp. 413-415. San Francisco: San Francisco Press, 1993b.

Mevissen M, Lerchl A, Löscher W. *Study on pineal function and DMBA-induced breast cancer formation in rats during exposure to a 100-mG, 50 Hz magnetic field.* J Toxicol Environ Health 48:169-185, 1996a.

Mevissen M, Lerchl A, Szamel M, Löscher W. *Exposure of DMBA-treated female rats in a 50-Hz, 50-µT magneticfield: effects on mammary-tumor growth, melatonin levels, and T-lymphocyte activation.* Carcinogenesis 17:903-910, 1996b.

Mevissen M, Haussler M, Lerchl A, Löscher W*. Acceleration of mammary tumorigenesis by exposure of 7,12-dimethylbenz[a]anthracene-treated female rats in a 50-Hz, 100-microT magnetic field: replication study.* J Toxicol Environ Health A 53:401-418, 1998.

Mezei G, Kheifets L, Nelson L, Miklls K, Iriye R, Kelsey J. *Household appliance use and residential exposure to 60-Hz magnetic fields.* J Expo Anal Environ Epidemiol 11:41-49, 2001.

Mezei G, Bracken TD, Senior R, Kavet R. *Analyses of magnetic-field peak-exposure summary measures.* J Expo Sci Environ Epidemiol 16:477-85, 2006.

Mihai R, Cogalniceanu G, Brezeanu, A. *Control of nicotiana tabacum callus growth by alternating and pulsed electric field.* Electro- and Magnetobiology 13:195-201, 1994.

Miller MW, Carstensen EL, Kaufman GE, Robertson D. *60-Hz electric field parameters associated with* *the perturbation of a eukaryotic system.* In. Biological effects of extremely low frequency electromagnetic fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium at Richland, Washington, October 16-18, 1978.

Miyakoshi Y, Kajihara C, Shimizu H, Ynagisawa H. *Tempol suppresses micronuclei formation in astrocytes of newborn rats exposed to 50-Hz, 10-mT electromagnetic fields under bleomycin administration.* Mut Res Gen Toxicol Environ Mutagen 747: 183-141, 2012.

Napp A, Joosten S, Stunder D, Knackstedt C, Zink M, Bellmann B, Marx N, Schauerte P, Silny J. *Electromagnetic interference with implantable cardioverter-defibrillators at power frequency: an in vivo study.* Circulation 129: 441-450, 2014.

National Radiological Protection Board (NRPB). *Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 GHz).* Volume 15, No 3. Chilton: National Radiological Protection Board, 2004.

National Institute of Environmental Health Sciences (NIEHS). *Assessment of health effects from exposure to power-line frequency electric and magnetic fields: working group report.* NIH Publication No. 98-3981. Research Triangle Park, NC: National Institute of Environmental Health Sciences of the U.S. National Institutes of Health, 1998.

National Institute of Environmental Health (NIEHS). *EMF Electric and Magnetic Fields Associated with the use of Electric Power: Questions and Answers.* Research Triangle Park, NC: National Institute of Environmental Health Sciences of the U.S. National Institutes of Health, 2002.

National Research Council (NRC). *Risk Assessment in the Federal Government Managing the Process.* Washington, D.C.: National Academy Press, 1983.

Naziroğlu M, Tokat S, Demirci S. *Role of melatonin on electromagnetic radiation-induced oxidative stress and Ca2+ signaling molecular pathways in breast cancer.* J Recept Signal Transduct Res 32: 290-297, 2012.

Negishi T, Imai S, Shibuya K, Nishimura I, Shigemitsu T. *Lack of promotion effects of 50 Hz magnetic fields on 7,12-dimethylbenz(a)anthracene-induced malignant lymphoma/lymphatic leukemia in mice.* Bioelectromagnetics 29:29-38, 2008.

Normandeau, Exponent, T. Tricas, and A. Gill. 2011. *Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species.* U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Okudan N, Celik I, Salbacak A, Cicekcibasi AE, Buyukmumcu M, Gokbel H. *Effects of long-term 50 Hz magnetic field exposure on the micronucleated polychromatic erythrocyte and blood lymphocyte frequency and argyrophilic nucleolar organizer regions in lymphocytes of mice.* Neuroendocrinol Lett 31:208-214, 2010.

Otaka Y, Chida T, Yamagishi Y, Kitamura S. *Carcinogenicity test in B6C3F1 mice after parental and prenatal exposure to 50 Hz magnetic fields*. Bioelectromagnetics 23:216-213, 2001.

Parsch LD, Norman MD. *Impact of power lines on crop yields in eastern Arkansas.* Arkansas Farm Research. September-October: 4, 1986.

Parsons Brinckerhoff and Associates. *Comparison of High Voltage Transmission Options: Alternating Current Overhead and Underground and Direct Current Undergound – Final Report,* Prepared for Northern Ireland Electricity and EirGrid. February 2009.

Pedersen C, Raaschou-Nielsen O, Rod NH, Frei P, Poulsen AH, Johansen C, Schüz J. *Distance from residence to power line and risk of childhood leukemia: a population-based case-control study in Denmark.* Cancer Causes Control 25: 171-177, 2014.

Polaniak R, Buladk R, Karon M, Birkner K, Kukla M, Zwirsak-Korczala K, Birkner E. *Influence of an extremely low frequency magnetic field (ELF-EMF) on antioxidative vitamin E properties in AT478 murine squamous cell carcinoma culture in vitro*. Int J Toxicol 29:221-230, 2010.

Poole C. *Invited commentary: Evolution of epidemiologic evidence on magnetic fields and childhood cancers.* Am J Epidemiol 143: 129-132, 1996.

Preece AW, Kaune WT, Grainger P, Golding J. *Assessment of human exposure to magnetic fields produced by domestic appliances.* Rad Protect Dosimetry. 83:21-28, 1999.

Rajaei F, Borhani N, Sabbagh-Ziarani F, Mashayekhi F. *Effects of extremely low-frequency electromagnetic field on fertility and heights of epithelial cells in pre-implantation stage endometrium and fallopian tube in mice.* J Chinese Integr Med 8:56-60, 2010.

Rannug A, Holmberg B, Mild KH. *A study on skin tumour formation in mice with 50 Hz magnetic field exposure.* Carcinogenesis 14: 573-578, 1993a.

Rannug A, Holmberg B, Ekstrom T, Mild KH. *Rat-liver foci study on coexposure with 50 Hz magnetic-fields and known carcinogens*. Bioelectromagnetics 14:17-27, 1993b.

Reed DD, Jones EA, Mroz GD, Liechty HO, Cattelino PJ, Jurgensen MF. *Effects of 76 Hz electromagnetic fields on forest ecosystems in northern Michigan: tree growth*. Int J Biometeorol 37:229-234, 1993.

Repacholi M. *Concern that "EMF" magnetic field from power lines cause cancer.* Sci Total Environ 426: 454-458, 2012.

Richardson N, McCleave J, Albert E. *Effect of extremely low frequency electric and magnetic fields on locomotor activity rhythm of Atlantic salmon (Salmo Salar) and American eels (Anguilla Rostrata).* Environ Pollut 10: 65-76, 1976.

Rodriguez M, Petitclerc D, Nguyen DH, Block E, Burchard JF. *Effect of electric and magnetic fields (60 Hz) on production, and levels of growth hormone and insulin-like growth factor 1, in lactating, pregnant cows subjected to short days.* J Dairy Sci. 85:2843-2849, 2002.

Rodriguez M, Petitclerc D, Burchard JF, Nguyen DH, Block E, Downey BR. *Responses of the estrous cycle in dairy cows exposed to electric and magnetic fields (60 Hz) during 8-h photoperiods.* Anim Reprod Sci 77:11-20, 2003.

Rodriguez M, Petitclerc D, Burchard JF, Nguyen DH, Block E. *Blood melatonin and prolactin concentrations in dairy cows exposed to 60 Hz electric and magnetic fields during 8 h photoperiods.* Bioelectromagnetics 25:508-515, 2004.

Rogers LE, Warren JL, Gano KA, Hinds NR, Fitzner RE, Gilbert RO. *Environmental Studies of a 1100-kV Prototype Transmission Line: An Interim Report.* Portland, Oregon: Batelle Pacific Northwest Laboratories for Bonneville Power Administration, 1980.

Rogers LE, Warren JL, Hinds NR, Gano KA, Fitzner RE, Piepel GF. *Environmental Studies of a 1100-kV Prototype Transmission Line: Annual report for the 1980 Study Period.* Portland, Oregon: Battelle Pacific Northwest Laboratories, 1981.

Rogers LE, Warren NR, Hinds KA, Gano RE, Fitzner RE, Peipel GF. *Environmental Studies of a 1100-kV Prototype Transmission Line: An Annual Report for the 1981 Study Period.* Portland, Oregon: Battelle Pacific Northwest Laboratories for Bonneville Power Administration, 1982.

Ruiz-Gomez MJ and Martinez-Morillo M. *Electromagnetic fields and the induction of DNA strand breaks.* Electromag Biol Med 28:201-214, 2009.

Russell KN, Ikerd H, Droege S. *The potential conservation value of unmowed powerline strips for native bees*. Biol Conserv 124:133-148, 2005.

Russell et al. *The Use of Transmission Line Easements for the Benefit of Native Bees.* Palo Alto, CA: EPRI, 2013.

Ruzic R, Jerman I, Jeglic A, Fefer D. *Electromagnetic stimulation of buds of Castanea sativa, mill. in tissue culture.* Electro- and Magnetobiology 11:145-153, 1992.

Sahl J, Mezei G, Kavet R, McMillan A, Silvers A, Sastre A, Kheifets L. *Occupational magnetic field exposure and cardiovascular mortality in a cohort of electric utility workers.* Am J Epidemiol 156: 913-918, 2002.

Sasser LB, Anderson LE, Morris JE, Miller DL, Walborg EF, Kavet R., et al. *Lack of a co-promoting effect of a 60 Hz mangetic field on skin tumorigenesis in SENCAR mice.* Carcinogenesis 19: 1617-1621, 1998.

Sastre A, Cook MR, Graham C. *Nocturnal exposure to intermittent 60 Hz magnetic fields alters human cardiac rhythm*. Bioelectromagnetics 19:98-106, 1998.

Savitz DA. *Magnetic fields and miscarriage*. Epidemiology 13:1-4, 2002.

Savitz DA, Herring AH, Mezei G, Evenson KR, Terry JW Jr, Kavet R. *Physical activity and magnetic field exposure in pregnancy*. Epidemiology. 17:222-225, 2006.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) for the Directorate-General for Health & Consumers of the European Commission. *Health Effects of Exposure to EMF.* January 2009.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) for the Directorate-General for Health & Consumers of the European Commission. *Memorandum on the use of the scientific literature for human health risk assessment purposes – weighing of evidence and expression of uncertainty.* March 2012.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). *Preliminary Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF).* Brussels, Belgium: European Commission, 2013.

Scholten A and Silny J. *The interference threshold of cardiac pacemakers in electric 50 Hz fields.* J Med Eng Technol 25:1-11, 2001.

Schüz J, Grell K, Kinsey MS, Link MP, Mezei G, Pollack BH, et al., *Extremely low frequency magnetic fields and survival from childhood acute lymphoblastic leukemia.* Blood Cancer J 2:e98; doi: 10.1038/bcj.2012.42, 2012.

Sermage-Faure C, Demoury C, Rudant J, Goujon-Bellec S, Guyot-Goubin A, Deschamps F, Hemon D, Clavel J. *Childhood leukaemia close to high-voltage power lines--the Geocap study, 2002-2007*. Br J Cancer 108: 1899-1906, 2013.

Slaby P, Tomanova K, Vacha M. *Cattle on pastures do align along the North-South axis, but the alignment depends on herd density*. J Comp Physiol A Neuroethol Sens Neural Behav Physiol 199: 695-701, 2013.

Smith SD, McLeod BR, Liboff AR. *Effects of CR-tuned 60 Hz magnetic fields on sprouting and early growth of Raphanus sativus*. Bioelectrochem Bioenerg. 32:67-76, 1993.

Sommer AM and Lerchl A. *50 Hz magnetic fields of 1 mT do not promote lymphoma development in AKR/J mice*. Radiat Res. 165:343-349, 2006.

Sorahan T. *Cancer incidence in UK electricity generation and transmission workers, 1973-2008.* Occup Med (Lond) 62: 496-505, 2012.

Sorahan T and Mohammed N. *Neurodegenerative disease and magnetic field exposure in UK electricity supply workers.* Occup Med (Lond) 64: 454-460, 2014.

Souques M, Magne I, Lambrozo J. *Implantable cardioverter defibrillator and 50-Hz electric and magnetic fields exposure in the workplace.* Int Arch Occup Environ Health 84:1-6, 2011.

Stevens RG. *Electric power use and breast cancer: A hypothesis.* Amer J. Epidiol. 154:556-561. 1987.

Stormshak F, Bracken TD, Carey M, Chartier V, Dickson L, Forbes R, Hall A, Havens P, Hess D, Krippaehne S, Lee J, Ogden B, Olenchek B, Painter L, Rowe K, Stearns R, Thinesen P, Thompson J. *Joint HVAC Transmission EMF Environmental Study: Final Report on Experiment 1.* Bonneville Power Adminstration, Contract # DE-B179-90BPO4293. May, 1992.

Svedenstål B-M and Holmberg B. *Lymphoma development among mice exposed to x-rays and pulsed magnetic fields.* Int J Radiat Biol 64:119-125, 1993.

Svendsen AL, Weihkopf T, Kaatsch P, Schuz J. *Exposure to magnetic fields and survival after diagnosis of childhood leukemia: a German cohort study.* Cancer Epidemiol Biomarkers Prev 16:1167-1171, 2007.

Swanson J and Kaune WT. *Comparison of residential power-frequency magnetic fields away from appliances in different countries.* Bioelectromagnetics 20: 244-254, 1999.

Swedish Radiation Protection Authority (SSI). Fifth annual report from SSI's Independent Expert Group on Electromagnetic Fields, 2007. SSI Rapport 2008:12. Stockholm, Sweden: Swedish Radiation Protection Authority 2008.

Swedish Radiation Safety Authority (SSM). Recent Research on EMF and Health Risks: *Seventh annual report from SSMs independent Expert Group on Electromagnetic Fields 2010.* Report Number: 2010:44. Stockholm, Sweden: Swedish Radiation Safety Authority, 2010.

Swedish Radiation Safety Authority (SSM). Research 2013:19. Eighth Report from SSM:s *Scientific Council on Electromagnetic Fields.* Stockholm, Sweden: Swedish Radiation Safety Authority, 2013.

Thompson JM, Stormshak F, Lee JM, Hess DL, Painter L. *Cortisol secretion and growth in ewe lambs chronically exposed to electric and magnetic fields of a 60-Hertz 500-Kilovolt AC transmission line.* J Anim Sci. 73:3274-3280, 1995.

Tiikkaja M, Aro AL, Alanko T, Lindholm H, Sistonen H, Hartikainen JEK, et al., *Electromagnetic interference with cardiac pacemakers and implantable cardioverter-defibrillators from low-frequency electromagnetic fields in vivo.* Europace 15: 288-394, 2013.

Touitou Y and Selmaoui B. *The effects of extremely low-frequency magnetic fields on melatonin and cortisol, two marker rhythms of the circadian system.* Dialogues Clin Neurosci 14: 381-399, 2012.

Toivonen L, Metso R, Valjus J, Hongisto M. *The influence of 50hz electric and magnetic fields on cardiac pacemakers.* Imatran Voima Oy: Research Reports; Helsinki, 1991.

Turner MC, Benke G, Bowman JD, Figuerola J, Fleming S, Hours M, Kincl L, Krewski D, McLean D, Parent ME, Richardson L, Sadetzki S, Schlaefer K, Schlehofer B, Schuz J, Siemiatycki J, Van Tongeren M, Cardis E. *Occupational exposure to extremely low frequency magnetic fields and brain tumour risks in the INTEROCC study.* Cancer Epidemiol Biomarkers Prev, 2014.

US Environmental Protection Agency (USEPA). *Guidelines for carcinogen risk assessment and supplemental guidance for assessing susceptibility from early-life exposure to carcinogens*. EPA/630/P-03/001F. Washington, DC: USEPA, 2005.

van der Mark M, Vermeulen R, Nijssen PC, Mulleners WM, Sas AM, van Laar T, Kromhout H, Huss A. *Extremely low-frequency magnetic field exposure, electrical shocks and risk of Parkinson's disease*. Int Arch Occup Environ Health, 2014.

Vergara X, Kheifets L, Greenland S, Oksuzyan S, Cho Y-S, Mezei G. *Occupational exposure to extremely low-frequency magnetic fields and neurodegenerative disease. A meta-analysis*. J Occup Environ Med 55:136-146, 2013.

Warren NR, Hinds KA, Gano RE, Fitzner RE, Piepel GF. *Environmental Studies of a 1100-kV Prototype Transmission Line: an Annual Report for the 1980 Study Period*. Portland, Oregon: Battelle Pacific Northwest Laboratories for Bonneville Power Administration, 1981.

Wertheimer N and Leeper E. *Electrical wiring configurations and childhood cancer*. Am J Epidemiol 109:273-84, 1979.

World Health Organization (WHO). *Electromagnetic fields and public health – Electromagnetic hypersensitivity*. December 2005. http://www.who.int/peh-emf/publications/facts/fs296/en/

World Health Organization (WHO). *Fact sheet No. 322: Electromagnetic Fields and Public Health – Exposure to Extremely Low Frequency Fields*. World Health Organization, June 2007a.

World Health Organization (WHO). *Environmental Health Criteria 238: Extremely Low Frequency (ELF) Fields.* Geneva, Switzerland: World Health Organization, 2007b.

World Health Organization (WHO). *What Are Electromagnetic Fields? Summary of Health Effects.* World Health Organization, 2013. Available from http://www.who.int/peh-emf/about/WhatisEMF/en/.

Yang Y, Jin X, Yan C, Tian Y, Tang J, Shen X. *Case-only of interactions between DNA repair genes (hMLH1, APEX1, MGMT, XRCC1 and XPD) and low-frequency electromagnetic fields in childhood acute leukemia.* Leuk Lymph 49: 2344-2350, 2008.

Yao K, YiBo Y, Wang KJ, Ye J, Lu D, Jiang H. *Absence of effect of power-frequency magnetic field exposure on mouse embryonic lens development.* Bioelectromagnetics 28:628-35, 2007.

Yasui M, Kikuchi T, Ogawa M, Otaka Y, Tsuchitani M, Iwata H. *Carcinogenicity test of 50 Hz sinusoidal magnetic fields in rats.* Bioelectromagnetics 18:531-540, 1997.

Zapotosky JE, Gauger JR, Haradem DP. *ELF Communications System Ecological Monitoring Program: Final Summary Report. Report No. D06214-6.* Washington, DC: Space and Naval Warfare Systems Command, 1996.

Zhao L, Liu X, Wang C, Yan K, Lin X, Li S, Bao H, Liu X. *Magnetic fields exposure and childhood leukemia risk: a meta-analysis based on 11,699 cases and 13,194 controls*. Leuk Res 38: 269-274, 2014.

Zhang C, Li Y, Wang C, Lv R, Song T. *Extremely low-frequency magnetic exposure appears to have no effect on pathogenesis of Alzheimer's disease in aluminum-overloaded rat.* PLoS One 8: e71087, 2013.

CHAPTER 9 TRANSBOUNDARY

Commission Delegated Regulation (EU) No. 1391/2013 of 14 October 2013 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council *on guidelines for trans-European energy infrastructure as regards the Union list of projects of common interest.* Available: http://eur-lex.europa.eu.

European Commission (May 2013). *Guidance on the Application of the Environmental Impact Assessment Procedure for Large-scale Transboundary Projects*. Available: http://ec.europa.eu.

EIA Directive 85/337/EU *on the assessment of the effects of certain public and private projects on the environment.* Available http://www.environ.ie.

EU Directive No. 2011/92/EU *On the assessment of the effects of certain public and private projects on the environment* (codification). Available: http://eur-lex.europa.eu.

EU Directive 2000/60/EEC establishing a framework for the community action in the field of water policy. (the EU Water Framework Directive). Available: http://ec.europa.eu/environment/water/water-framework.

Regulation EU/347/2013 *on guidelines for trans-European energy infrastructure [TEN-E regulation].* Available: http://eur-lex.europa.eu.

CHAPTER 10 CUMMULATIVE IMPACTS AND IMPACT INTERACTIONS

EirGrid (May 2012). *Grid25 Implementation Programme (IP) 2011-2016* and associated *Strategic Environmental Assessment (SEA).* Available: http://www.eirgrid.com/media/GRID. Included on a disc with this volume of the EIS.

European Commission (May 1999). *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions.* Available: http://www.ec.europa.eu.

EU Directive No. 2011/92/EU *On the assessment of the effects of certain public and private projects on the environment* (codification) Available: http://eur-lex.europa.eu.

Environmental Protection Agency (EPA) (March 2002). *Guidelines on the information to be contained in Environmental Impact Statements.*

Environmental Protection Agency (EPA) (September 2003). *Advice Notes on Current Practice (in Preparation of Environmental Impact Statements).*