The Great Grid Upgrade

Western Link 2

Strategic Options Report

June 2026

nationalgrid

Contents

Cyswllt Gorllewinol 2 (Western Link 2)
Document control

Version History

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Executive summary

Purpose of the Strategic Options Report

This Strategic Options Report (SOR) provides an overview of the options that National Grid Electricity Transmission plc (NGET) has identified and subsequently evaluated for the strategic siting optioneering of the AC6 Project, which is an integral part of the Cyswllt Gorllewinol 2 (Western Link 2) Project. The Western Link 2 (WL2) Project comprises of two new proposed transmission line projects: AC5 and AC6.

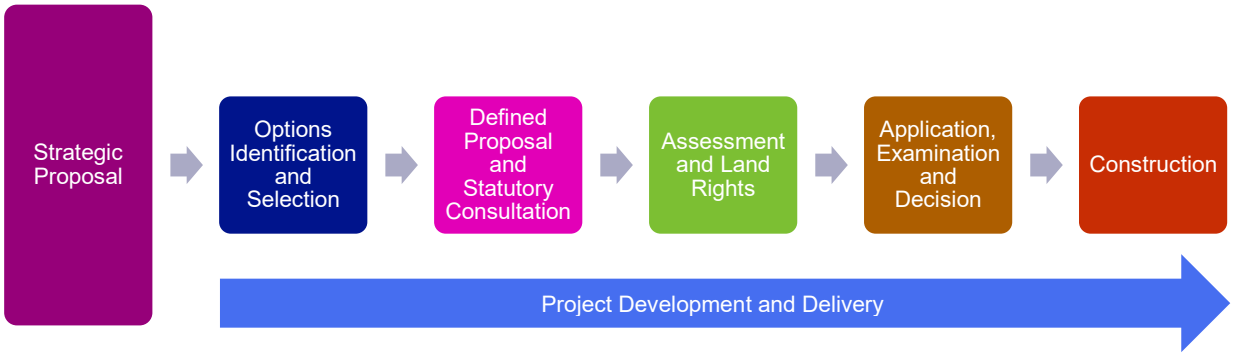
The AC5 Project is a new proposed transmission link between North Ayrshire, Scotland, and Central/South Ayrshire (T-point), Scotland. This project will be assessed and developed separately by Scottish Power Transmission, a subsidiary of Scottish Power Energy Networks (SPEN), who are responsible for the transmission of electricity in central and southern Scotland.

The AC6 Project, which is the focus of this document and is referred to as "the project" in this SOR, represents a new transmission link between Central/South Ayrshire (T-Point) and Wales. This AC6 Project aims to provide additional transmission capacity between Scotland, Wales, and England. It will be jointly developed by NGET and SPEN, with SPEN responsible for developing the assets in Scotland, while NGET will handle the assets in Wales and England. For all other UK jurisdictions related to this project, NGET and SPEN will collaborate to develop the necessary assets.

This SOR for the AC6 project presents NGET's assessment of routeing and landing the connection in Wales, while SPEN will be conducting their own assessment for the starting point of the project in the South of Scotland.

Figure A below, sets out the key development and delivery stages of NGET's process-based approach, when identifying transmission system works that would require additional consents and/or permissions, are shown below:

Figure A: NGET's approach to project development and delivery



This report forms part of the initial 'Strategic Proposal' stage.

How the electricity system is planned and operated

NGET is the owner of the transmission system in England and Wales and is regulated by the Office of Gas and Electricity Markets (Ofgem). NGET holds an electricity transmission licence permitting transmission ownership activities and requiring that it provide an efficient, economic, and co-ordinated transmission system. As part of this requirement, NGET must ensure that there is sufficient transmission capacity in order to meet demand and generator customer requirements, along with providing for wider transmission system needs that exist or are anticipated in the future. When planning changes to the transmission system, NGET must also have regard to the desirability of preserving amenity, in line with the duties under sections 9 and 38 of the Electricity Act 1989 ('the Electricity Act').

The National Energy System Operator (NESO) is a separate legal entity to NGET. NESO facilitates several roles on behalf of the electricity industry, including making formal offers to applicants requesting connection to the National Electricity Transmission System (NETS). NESO also makes investment recommendations to Transmission Owners (TOs), including NGET, through an annual network planning cycle and other periodic reviews. This indicates which areas of the transmission system require reinforcement.

The legislation, policy and regulatory framework that NGET work within

Legislation

In addition to the legal duty to maintain an efficient, economic, and co-ordinated energy transmission system, NGET is subject to a number of statutory duties in England and Wales when developing new infrastructure, including under the:

- Electricity Act 1989
- National Parks and Access to the Countryside Act 1949
- Countryside and Rights of Way Act 2000
- Natural Environment and Rural Communities Act 2006
- Wildlife and Countryside Act 1981

UK Energy Policy

In 2019, the UK Government committed to achieving net zero greenhouse gas emissions by 2050. In addition, in 2024 the UK Government has committed to achieving a clean electricity system by 2030.

These commitments require the UK to move away from fossil fuels and to increase and adopt alternative sources of renewable and low-carbon sources of energy to power homes, transport, and businesses, such as offshore wind, solar energy and nuclear generation. The Government has set out how it plans to deliver on these commitments within multiple strategies and plans including:

- Prime Minister's Ten Point Plan for a Green Industrial Revolution (November 2020);
- Energy White Paper: Powering our Net Zero Future (December 2020);
- Net Zero Strategy: Build Back Greener (October 2021);

- British Energy Security Strategy (BESS, April 2022); and
- Powering Up Britain and Powering Up Britain: Energy Security Plan (March 2023)
- Clean Power 2030 Action Plan: A new era of clean electricity (December 2024)

Consenting regimes

Terrestrial and Marine

The purpose of the project is to develop the electricity transmission system between Scotland and Wales, which will include terrestrial infrastructure in both countries. Due to the marine connection between these countries, cable infrastructure will need to be developed in the marine environment within Scotland, Wales, Northern Ireland, and the Isle of Man. This project will be subject to multiple statutory consents due to its type and scale.

The current intention is for this project to obtain its necessary consents from a variety of terrestrial and marine permissions and licences under appropriate statutory regimes. A compulsory purchase order (under the Electricity Act 1989) will also be required for elements of the project on the Welsh mainland (above mean low water).

There remains a possibility that certain elements of the Project (within Wales and Welsh territorial waters) could be consented (with powers of compulsory acquisition) pursuant to a single consent under the Infrastructure (Wales) Act 2024 (IWA). However, reliance upon the IWA regime would first require the Project to obtain a Section 22 Direction from the Welsh Ministers on the basis that the Ministers consider it to be a project of 'national significance to Wales'.

In addition, in the territories which are not subject to the requirement for a marine works licence under the Marine and Coastal Access Act 2009 (MaCAA), such as the Isle of Man, consent for development will be sought through a Marine Infrastructure Consent under the Marine Infrastructure Management Act 2016 (MIMA).

The NGET Project team is committed to ensuring the Project adheres to, and assists in meeting, where appropriate, the various legislative and political commitments made by the UK and devolved governments. Section 3.6 of this SOR outlines the various policies that the project team currently understands, at the time of writing, to be relevant to the Project, and will ensure that consideration of these policies is integrated into the Project as it is developed.

National planning policy

The Welsh Government, as a devolved power within the UK for the nation of Wales, established their net zero targets for the nation, which aims to be carbon neutral by 2050. The Welsh policy landscape is outlined in the following policy documents:

- Natural Resources Policy and Area Statements
- Welsh National Marine Plan
- Economic Action Plan
- Planning Policies Wales (including Energy)

- Welsh Government's Net Zero Strategic Plan
- The Well-being of Future Generations (Wales) Act 2015
- The Equalities Act 2010
- Future Wales: The National Plan 2040

In addition, the UK government is committed to decarbonise the grid, as highlighted by the Net Zero strategy and the National Policy Statements (NPS). To enable this transition to a decarbonised grid, development of new renewable energy infrastructure and energy transmission infrastructure, which the NPSs discuss. In particular, the relevant electricity transmission NPSs are:

- EN1 - National Policy Statements for Energy,
- EN3 - National Planning Policy Statement for Renewable Energy Infrastructure, and
- EN5 - the National Policy Statement for Electricity Networks Infrastructure, which is read in conjunction with EN1.

It is noted that the role of NPSs is to inform the determination of applications for development consent orders under the Planning Act 2008. However, nevertheless, they are a relevant statement of Government policy as to the provision of energy infrastructure and the importance of transmission projects within the UK decarbonisation agenda.

The need case for reinforcement to the transmission system

NGET must comply with Schedule 9 of the Electricity Act and Standard Condition D3 (Transmission System Security Standard and Quality of Service) of its Transmission Licence, which requires it to develop and maintain an efficient, coordinated and economical system of electricity transmission.

When required power flows are identified that would exceed the boundary capacity of the transmission system, NGET must resolve the capacity shortfall under the terms of its Transmission Licence.

Existing transmission network

The existing transmission system in Scotland, Wales, the Midlands and North of England and the B6a and B7 boundaries are shown in Figure B and Table A.

Figure B: The National Electricity Transmission System in Scotland, Wales, the Midlands and the North of England

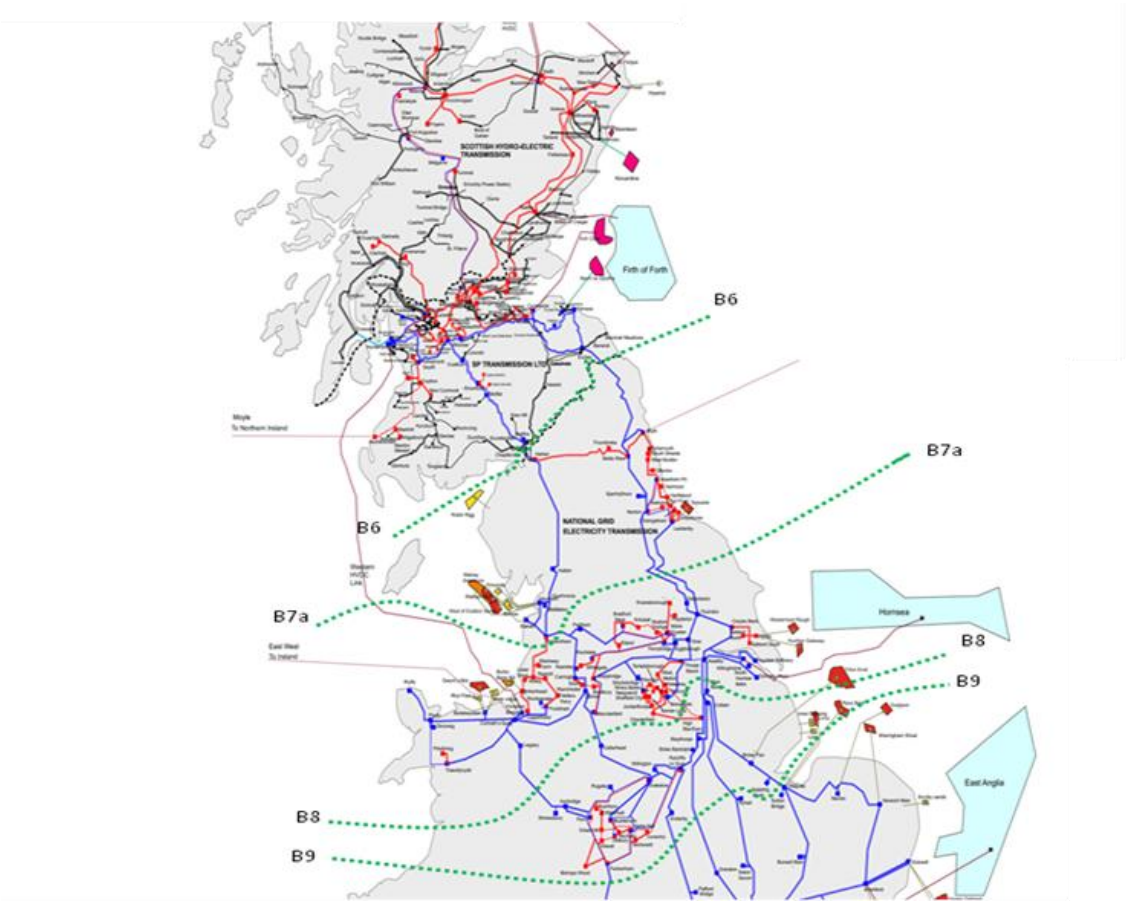


Table A: Existing boundary performance by 2035 and generation group capacity to last contract date

System Boundary Export or Generation Group required transfer		2035 Post Fault Capability	2035 Post Fault Capacity	Capability Deficit	Capacity Deficit	Secured Event Fault
B6 – 2035 (system boundary)	28,405 MW	16,800 MW	24,665 MW	-11,605 MW	-3,740 MW	New CMN3 Circuit
B7a – 2035 (system boundary)	25,203 MW	19,700 MW	23,805 MW	-5,503 MW	-1,398 MW	Norton – Osbaldwick Double Circuit

Boundary analysis results

NGET recognises that the deficits outlined in Table A need to be addressed. It is noted that a capability uplift would be expected to facilitate the required boundary transfers.

From 2035, further increases in boundary requirements are expected, and this is reflected in the existing contractual generation commitments. To address these needs, additional reinforcements to these boundaries are expected in Wales, Midlands and North of England, which will supplement these boundaries in the future. This will facilitate connections beyond 2035, when further increases in generation are expected across all regions. These will be subject to their own detailed needs case and options assessment.

Need case conclusion

Currently, the need for the Project to be delivered to meet the network requirements, as set out above, is summarised below:

- A need to provide Capacity Across the B6 and B7a boundaries with proposed 2 GW HVDC connections further reducing the deficit.
- Any options considering connections to Mid Wales would require further transmission works to connect proposed generation and HVDC options within this area.
- HVDC connections are considered post fault neutral in most circumstances as flow can be dropped to 0 MW for a local connection area fault at the NGET end.

How NGET identified and assessed strategic options

Once the need case is established, NGET considers the various ways in which they can meet that need. Before NGET undertake any detailed optioneering work, a technical compliance filter is applied to ensure that all potential strategic options will function on the network, rejecting any that do not meet technical standards or would not work in practice. In the early stages of optioneering, a key factor is to consider locations either at or close to existing or already planned NGET substations to minimise the required infrastructure. There are many ways to meet the identified need, so further network modelling is needed to better understand the issues. This initial identification is based on the network planning information available from NESO at the time of appraisal.

NGET then applied a “benefits filter” to the technically feasible options, which places focus on those that best meet the obligations to the environment and consumers.

The criteria for any potential strategic option to be considered further are any of the following:

- An environmental benefit:
- A technical system benefit;
- A capital and lifetime cost benefit, which includes the consideration of initial capital costs and long-term maintenance and operating costs; or
- A socio-economic benefit.

When the net benefits of options are closely aligned, each option is documented and included for appraisal. Following the application of the benefits filter, eleven options were identified as having comparable net benefits and potential technical compliance, warranting further evaluation. These options are listed in Table B below:

Table B: Proposed Strategic Options for Appraisal

Proposed strategic option title	Option description
Strategic Option AC6-1 – Pentir	288 km new offshore subsea transmission connection
Strategic Option AC6-2 – Wylfa South	252 km new offshore subsea transmission connection
Strategic Option AC6-3 – Bodelwyddan	306 km new offshore subsea transmission connection
Strategic Option AC6-4 – Pembroke	504 km new offshore subsea transmission connection
Strategic Option AC6-5 – South Wales West Connection Node C	552 km new offshore subsea transmission connection
Strategic Option AC6-6 – Carmarthen Bay (Llandyfaelog)	576 km new offshore subsea transmission connection
Strategic Option AC6-7 – Swansea North	612 km new offshore subsea transmission connection
Strategic Option AC6-8 – Baglan Bay	612 km new offshore subsea transmission connection
Strategic Option AC6-9 – South Wales West Connection Node B	630 km new offshore subsea transmission connection
Strategic Option AC6-10 – Connah’s Quay	330 km new offshore subsea transmission connection
Strategic Option AC6-11 – Bryncir	303 km new offshore subsea transmission connection

Summary of NGET's strategic options

An overview of the eleven strategic options that have been subject to environmental, socio-economic, cost and technical appraisal and the key findings will be presented in this section.

Strategic Option AC6-1 – Pentir:

Strategic Option AC6-1 is a 288 km majority subsea connection, configured as a High Voltage Direct Current (HVDC) circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the existing Pentir 400 kV substation in North Wales. NGET's starting presumption for further development of this option, should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the existing Pentir substation. Bay extensions and associated works at the existing Pentir substation would be required to accommodate the connection of the Project.

Strategic Option AC6-2 – Wylfa South:

Strategic Option AC6-2 is a 252 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the proposed Wylfa South 400 kV substation in North Wales. NGET's starting presumption for further development of this option, should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Wylfa South substation. Two bays at the proposed Wylfa South substation would be required to accommodate the connection of the Project.

Strategic Option AC6-3 – Bodelwyddan:

Strategic Option AC6-3 is a 306 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the existing Bodelwyddan 400 kV substation in North Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Bodelwyddan substation. Bay extensions at the existing Bodelwyddan substation would be required to accommodate the connection of the Project.

Strategic Option AC6-4 – Pembroke:

Strategic Option AC6-4 is a 504 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the existing Pembroke 400 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the Pembroke landfall to the converter station, which will be located in the vicinity of the Pembroke substation. Bay extensions at the existing Pembroke substation would be required to accommodate the connection of the Project.

Strategic Option AC6-5 – South Wales West Connection Node C:

Strategic Option AC6-5 is a 552 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the proposed South Wales West Connection Node C (SWCN C) 400 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the SWCN C substation. Bay extensions at the planned new SWCN C substation would be required to accommodate the connection of the Project.

Strategic Option AC6-6 – Carmarthen Bay:

Strategic Option AC6-6 is a 576 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the proposed Carmarthen 400 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Carmarthen substation. Two bays at the proposed Carmarthen substation would be required to accommodate the connection of the Project.

Strategic Option AC6-7 – Swansea North:

Strategic Option AC6-7 is a 612 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the existing Swansea North 400 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Swansea North substation. Bay extensions at the existing Swansea North substation would be required to accommodate the connection of the Project.

Strategic Option AC6-8 – Baglan Bay:

Strategic Option AC6-8 is a 612 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the existing Baglan Bay 275 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Baglan Bay substation. Bay extensions at the existing Baglan Bay substation would be required to accommodate the connection of the Project.

Strategic Option AC6-9 – South Wales West Connection Node B:

Strategic Option AC6-9 is a 630 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of South Wales West Connection Node B (SWCN B) 400 kV substation in South Wales. NGET's starting presumption for further development of this option should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the proposed SWCN B substation. Bay extensions at the planned new SWCN B substation would be required to accommodate the connection of the Project.

Strategic Option AC6-10 – Connah's Quay:

Strategic Option AC6-10 is a 330 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the proposed Connah's Quay 400 kV substation in North Wales. NGET's starting presumption for further development of this option, should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Connah's Quay substation. Two bays at the proposed Connah's Quay substation would be required to accommodate the connection of the Project.

Strategic Option AC6-11 – Bryncir:

Strategic Option AC6-11 is a 303 km majority subsea connection, configured as an HVDC circuit. Two converter stations would be required, one at the starting point in the Central/South Ayrshire (T-Point) and one in the vicinity of the proposed Bryncir 400 kV substation in North Wales. NGET's starting presumption for further development of this option, should it be selected, would be for a majority subsea HVDC connection. Onshore underground HVDC cables would be required from the landfall to the converter station, which will be located in the vicinity of the Bryncir substation. Two bays at the proposed Bryncir substation would be required to accommodate the connection of the Project.

Selection of a preferred option

NGET has determined that the preferred strategic option to best address the Project's Need Case and taken forward at this stage is Strategic Option AC6-1 (Pentir). The selection of AC6-1 as preferred option is justified by the following points, summarising the environmental and socio-economic, technical, and cost appraisal:

- From an environmental and socio-economic perspective, on the basis of the information currently available and assuming that appropriate mitigation is undertaken, together with sensitive routeing and siting, environmental and socio-economic factors are not considered to significantly constrain Strategic Option AC6-1. AC6-1 making landfall in Pentir has the least effect on the fewest number of marine designations in the area compared to the other options. Additionally, the option has the potential to appropriately mitigate onshore designations, due to the landfall options and reduced amount of sensitive receptors leading to the landfall substation. AC6-1 includes the second shortest circuit length, at 288 km, and

performs the best when considering environmental and socio-economic elements, avoiding significant designations such as Areas of Outstanding Natural Beauty (AONBs), National Parks, and Geoparks. It includes the least amount of marine designation-related receptors, requiring crossing the fewest number of marine ecology receptors and is characterised by suitable coastal width or depth, with no immediate constraints from a marine geology perspective. Furthermore, AC6-1 is the most preferred from an onshore perspective, considering landfall options and sensitive receptors.

- From a technical perspective, AC6-1 achieves the technical Needs Case, increasing capacity across the B6 and B7a boundaries. With regard to the technical performance of the eleven strategic options of the Project, NGET has noted that the main differentiating factors are the cable circuit length and the reinforcement works triggered by the Project. AC6-1 has the second shortest HVDC cable length and will not trigger notable reinforcement works to the local network.
- From a cost perspective, AC6-1 (Pentir), with HVDC as the recommended technology, has a capital cost of £2,582.4m and a lifetime circuit cost of £2,732m, hence, presenting the second lowest capital and lifetime costs across all options taken forward for detailed appraisal. The HVDC technology is well-established and does not add uncertainty or constructability risk to the Project.

Conclusions and next steps

This SOR presents the findings of NGET's strategic options appraisal process and is intended to provide a clear justification for NGET's preferred strategic option for the AC6 Project. This report demonstrates that NGET has utilised the Need Case to consider the potential ways in which the Project could be delivered by generating a number of potential strategic options.

To meet the need to increase capacity across the B6 and B7a boundaries, NGET's proposal at the current stage is to take forward Strategic Option AC6-1 as the preferred option for the Project. NGET will continue to review the work, including any notable changes in circumstances, and will have regard to consultation responses.

The selection of AC6-1 as the preferred option is justified above; reference can be made to the previous sections of the executive summary. The Project will now be taken forward to the next stage of development.

This involves preliminary routeing and siting work, identification of a preliminary preferred route corridor and siting choice for the converter station and preparation of a graduated swathe, which indicates a more likely location for the development. This will be consulted on at consultation to seek feedback from consultees and help shape the further development of the project.

Glossary

Acronym / Term	Definition
Ω	Ohm, the unit of electrical resistance
AC	Alternating Current
AC Cable	AC Underground Cable
ACS	Average Cold Spell
AIS	Air-Insulated Substation
AONB	Area of Outstanding Natural Beauty
AQMA	Air Quality Management Area
ASTI	Accelerated Strategic Transmission Investment
Availability Factor	The time a generator is able to produce electricity over a period of time divided by that period of time
AWI	Areas of Wildlife Interest
BESS	British Energy Security Strategy
CBA	Cost Benefit Analysis
CCC	Climate Change Committee
CEMP	Construction Environmental Management Plan
CION	Connection and Infrastructure Options Note
CMNC	The project code previously used for CMN3 before revision CMN3: The project code used to represent the North-South element of the CMN3/FSU1 connection. The CMN3 element is a transmission link between South East Scotland and North West England and FSU1 is the East-West element, representing the upgrading of the existing network to a higher voltage between Harker and Stella West
CNP	Critical National Priority
Conductor	Used to transport power
Constraint costs	Payments made to constrain generation, to manage power flows where forecast power flows would exceed the capability of the electricity transmission system
CSC	Current Source Converter
CSNP	Centralised Strategic Network Plan
CTMP	Construction Traffic Management Plan
DC	Direct Current

Acronym / Term	Definition
Dedicated Forest	Protected feature in Wales for sections of woodland/forest
DESNZ	Department for Energy Security and Net Zero, the ministerial department with primary responsibility for energy.
DND	Detailed Network Design
DNO	Distribution Network Operator
Double circuit	Two transmission circuits, each consisting of three conductors (one for each phase of the three phase circuits), carried on two sides of a single pylon
EcIA	Ecological Impact Assessment Report
Economy Planned Transfer Assessment	Modelling approach for the Economy Planned Transfer Assessment is set out in NETS SQSS Appendix E
EGL 1	Eastern Green Link 1 Project
EGL 2	Eastern Green Link 2 Project
EIAR	Environmental Impact Assessment Report
EISD	Earliest in service date, the earliest date at which the network will be ready for the connection.
Electricity Act	The Electricity Act 1989
EN-1	Overarching National Policy Statement for Energy
EN-3	National Policy Statement for Renewable Energy Infrastructure
EN-5	National Policy Statement for Electricity Network Infrastructure
EN-6	National Policy Statement for Nuclear Power Generation
ESO	Replaced by NESO (See below): Was the Operator of National Electricity Transmission System, the National Grid Electricity System Operator
ETYS	Electricity Ten Year Statement sets out the Electricity System Operator's view of future transmission requirements and where the capability of the transmission network might need to be addressed over the next decade.
EV	Electric Vehicle
FES	Future Energy Scenarios represent different credible scenarios for the transition to a cleaner greener energy future by 2050.
FLO	Fisheries Liaison Officer
FRA	Flood Risk Assessment
GB	Great Britain

Acronym / Term	Definition
GHG	Greenhouse gases
GIL	Gas Insulated Lines
GIS	Geographical Information Systems
GtW	Grimsby to Walpole – a new primarily overhead line connection between Grimsby West substation to new Walpole via Lincolnshire Connection substation(s).
GW	Gigawatt
ha	hectare
HDD	Horizontal Directional Drilling
HND	Holistic Network Design, a publication by ESO issued in July 2022 setting out a single integrated transmission network design that supports the large-scale delivery of electricity generated from offshore wind by 2030
HND FUE	Holistic Network Design Follow Up Exercise, an updated publication of the HND.
HRA	Habitats Regulation Assessment
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IBA	Important Bird Area
ICE	Internal Combustion Engine
ICO	Infrastructure Consent Order
IET, PB/CCI Report	An independent report endorsed by the Institution of Engineering and Technology by Parsons Brinckerhoff in association with Cable Consulting International
Insulators	Used to safely connect conductors to pylons
IWA	Infrastructure Wales Act (2024)
IROPI	Imperative Reasons of Overriding Public Interest
km	kilometre
kV	Kilovolt
LNR	Local Nature Reserve
MAS	Marine Area Statements
MaCAA	Marine and Coastal Access Act 2009
MCZ	Marine Conservation Zone

Acronym / Term	Definition
MCZA	MCZ Assessment
MEEB	Measures of Equivalent Environmental Benefit
MITS	Main Interconnected Transmission System
ML	Marine Licence
MPA	Marine Protected Area
MPS	Marine Policy Statements
MVA	Mega Volt Amperes
Mvar	Megavolt Ampere Reactive
MW	Megawatt
NESO	National Energy System Operator The ESO is transitioning to becoming the NESO
NETS	National Electricity Transmission System
Net zero	UK Government's commitment to reduce greenhouse gas emissions to net zero by 2050 as per the Climate Change Act 2008 (2050 Target Amendment) Order 2019. Net zero means any emissions that cannot be avoided would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere.
NETS SQSS	National Electricity Transmission System Security and Quality of Supply Standard
NGET	National Grid Electricity Transmission plc
NIdMP	Northern Ireland draft Marine Plan
NMPF	National Marine Planning Framework
NNR	National Nature Reserve
NOA	Network Options Assessment
NPS	National Policy Statements
NPPF	National Planning Policy Framework 2024
NPR	Network Planning Review
NPV	Net Present Value
NSIP	Nationally Significant Infrastructure Project
N&V	Noise and Vibration
NZMR	Net Zero Market Reform
Ofgem	The Office of Gas and Electricity Markets

Acronym / Term	Definition
OHL	Overhead Line
OTNR	Offshore Transmission Network Review
Planned Transfer	The amount of power which will flow out of a region at ACS peak. The Planned Transfers for a region of the NETS is calculated using the modelling approach set out in the NET SQSS.
PLSS	Preliminary Landfall and Siting Study assessment
(the) Policy	National Grid's Stakeholder, Community and Amenity Policy
PPW	Planning Policy Wales
PRoW	Public Right of Way
Pylons	Used to support conductors
REMA	Review of Electricity Market Arrangements
RESPs	Regional Energy Strategic Planners
RIBA	Royal Institute of British Architects
RLOSI	Registered Landscapes of Outstanding and of Special Interest
RSPB	Royal Society for the Protection of Birds
SAC	Special Areas for Conservation
SF_6	Sulphur Hexafluoride (gas used to provide electrical insulation)
SGT	Super-Grid Transformer
SM	Scheduled Monument
SMP	Scottish Marine Plan
SOR	Strategic Options Report
Span length	Distance between adjacent pylons
SPA	Special Protection Areas
SPEN	SP Transmission plc is a wholly owned subsidiary of ScottishPower (SP) Energy Networks responsible for the transmission of electricity in central and southern Scotland.
SQSS	Security and Quality of Supply Standard. This sets out the criteria and methodology for planning and operating the transmission system.
SSEN	Scottish and Southern Electricity Networks (SSEN) Transmission is the trading name for Scottish Hydro Electric Transmission responsible for the electricity transmission network in the north of Scotland

Acronym / Term	Definition
SSEP	Strategic Spatial Energy Plan
SSSI	Sites of Special Scientific Interest
STC	System Operator – Transmission Owner Code
Strategic Options Appraisal	A robust and transparent process used to compare options and to assess the positive and negative effects they may have across a wide range of criteria including environmental, socioeconomic, technical and cost factors.
Study area	A defined geographic area used for the purpose of strategic option appraisal
Substation	Transmission substations are found where electricity enters the power grid to convert generator outputs to a level that suits its means of transmission
SWCN B	South Wales West Connection Node B
SWCN C	South Wales West Connection Node C
S4NPF	Scotland's fourth National Planning Framework
TAAP	Transmission Accelerated Action Plan
TANs	Technical Advice Notes
TCPA	Town & Country Planning Act (1990)
TEC	Transmission Entry Capacity
TO	Transmission Owner
T-pylon	Monopole pylon design developed by National Grid
Transmission Licence	Licence granted under Section 6(1)(b) of the Electricity Act
UG	Underground
Volt (V)	The electrical unit of potential difference 1 kilovolt (kV) = 1,000volts
Volt-ampere (VA)	The SI unit of apparent power 1 kVA = 1,000 VA 1 MVA = 1,000 kVA
Volt-ampere-reactive (VAR or Var)	The SI unit of reactive power 1 kVAR = 1,000 VAR 1 MVAR = 1,000 kVAR
VSC	Voltage Source Convertors
Watt (W)	The SI unit of power 1 kilowatt (kW) = 1,000 watts

Acronym / Term	Definition
	1 megawatt (MW) = 1,000 kW 1 gigawatt (GW) = 1,000 MW
WNMP	Welsh National Marine Plan
Watt-hour (Wh or Whr)	A unit of work/energy which is equivalent to the power of one Watt operating over the course of one hour
WHS	World Heritage Site
XLPE	Cross Linked Polyethylene (solid material used to provide electrical insulation)

1. Introduction

1.1 Purpose of the Strategic Options Report

1.1.1 This Strategic Options Report (SOR) has been prepared by National Grid Electricity Transmission plc (NGET) as part of the ongoing strategic options appraisal and decision-making process involved in promoting a new transmission project from South of Scotland to Wales. It presents the findings of NGET's options appraisal process and is intended to provide a clear justification and evidence for the decision-making of a preferred strategic option for the AC6 Project, which is an integral part of the Cyswllt Gorllewinol 2 (Western Link 2) Project.

1.1.2 The Western Link 2 (WL2) Project comprises of two new transmission line projects: AC5 and AC6. The AC5 Project is a new proposed transmission link between North Ayrshire, Scotland, and Central/South Ayrshire (T-point), Scotland. This project will be assessed and developed separately by Scottish Power Transmission, a subsidiary of Scottish Power Energy Networks (SPEN), who are responsible for the transmission of electricity in central and southern Scotland.

1.1.3 The AC6 Project, which is the focus of this document, represents a new transmission link between Central/South Ayrshire (T-Point) and Wales. This project aims to provide additional transmission capacity between Scotland, Wales, and England. This SOR will focus specifically on the AC6 Project and has been prepared in accordance with NGET's (the Transmission Owner across England and Wales)- 'Our Approach to Consenting'[1].

1.1.4 In 2024, the UK Government has committed to achieving clean power by 2030, subject to the security of supply. The way electricity is generated in the UK is changing rapidly, with a transition to cheaper, cleaner, and more secure forms of energy like new offshore windfarms. NGET needs to make changes to the network of overhead lines (OHLs), pylons, cables, and other infrastructure that transports electricity around the country, so that everyone has access to the clean electricity from these new renewable sources. Details on the need for the Project are described in Chapter 4 of this report.

1.1.5 The consideration of strategic options forms part of the process to inform the selection of a preferred option. The Project is currently proposed to be consented through a combination of the Town and Country Planning Act 1990 ('TCPA') for terrestrial elements and Marine Licence ('ML') applications for marine infrastructure.

1.1.6 While TCPA remains the primary consenting route at this stage, the Infrastructure (Wales) Act 2024 ('IWA') regime is being actively monitored for onshore consenting in Wales and would be subject to an application via s22 Direction to Welsh Ministers.

1.1.7 The strategic options process will be influenced by considerations of other emerging energy projects and by evolving customer requirements.

[1] Our Approach to Consenting, National Grid, April 2022
www.nationalgrid.com/electricity-transmission/document/142336/download

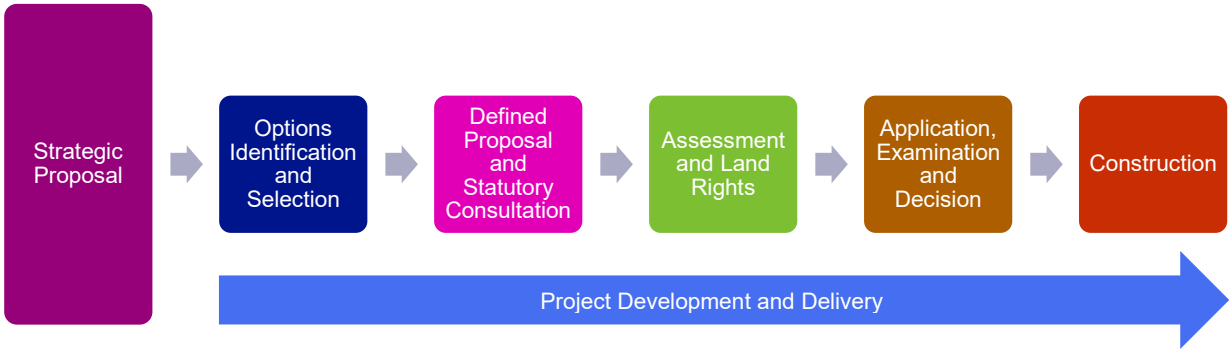
1.1.8 NGET also keeps strategic options under review as plans and proposal evolve, taking account of consultation feedback and any changes that might influence the appraisal of technical, environmental, socio-economic, and cost considerations.

1.1.9 Figure 1.1 shows the key stages in the project development and delivery process for major infrastructure projects:

- Strategic Proposal
- Options Identification and Selection
- Defined Proposal and Statutory Consultation
- Assessment and Land Rights
- Application
- Examination and Decision
- Construction

1.1.10 The identification of a strategic proposal establishes the scope of the project which commences with Options Identification and Selection. This document forms part of the "Strategic Proposal" and is at the very start of the process. This report provides information about scheme development, to support consultation on NGET's proposals.

Figure 1.1 – NGET's approach to project development and delivery



1.1.11 This report is a key output from the initial stage of NGET's approach to consenting process, and provides information about project development, to support consultation for major infrastructure projects.

1.1.12 As the Project proposals continue to evolve, strategic options will be kept under review, taking account of consultation feedback and any changes that might influence the appraisal of technical, environmental, socio-economic and cost considerations.

1.2 Structure of this Report

1.2.1 The report is structured as follows:

- Chapter 1: Introduction
- Chapter 2: How is the electricity transmission system is planned and operated
- Chapter 3: The legislative, policy and regulatory framework that NGET work within
- Chapter 4: The need case for reinforcement to the transmission system
- Chapter 5: Options identification and selection process
- Chapter 6: The results of NGET's appraisal of strategic options
- Chapter 7: Comparison of the appraisal of the strategic options
- Chapter 8: Conclusions and next steps

1.2.2 This document is also supported by a detailed set of appendices setting out NGET's obligations, technology assumptions and cost appraisal methodology as follows:

- Appendix A: Summary of National Grid Electricity Transmission Legal Obligations
- Appendix B: Energy Transmission Significant Infrastructure Supporting Policy
- Appendix C: Technology Overview
- Appendix D: Economic Appraisal
- Appendix E: Mathematical Principles used for AC Loss Calculation
- Appendix F: Beyond 2030 Publication
- Appendix G: Onshore Alternative Option

1.2.3 This SOR is part of an iterative process, investigating prospective opportunities. The conclusions of this report will, in due course, be supplemented by feedback from consultation exercises, along with other elements such as design evolution. In line with NGET's Approach to Consenting, NGET will continue to assess relevant technical, environmental, socio-economic and cost factors as part of the ongoing appraisals.

2. How the electricity transmission system planned and operated

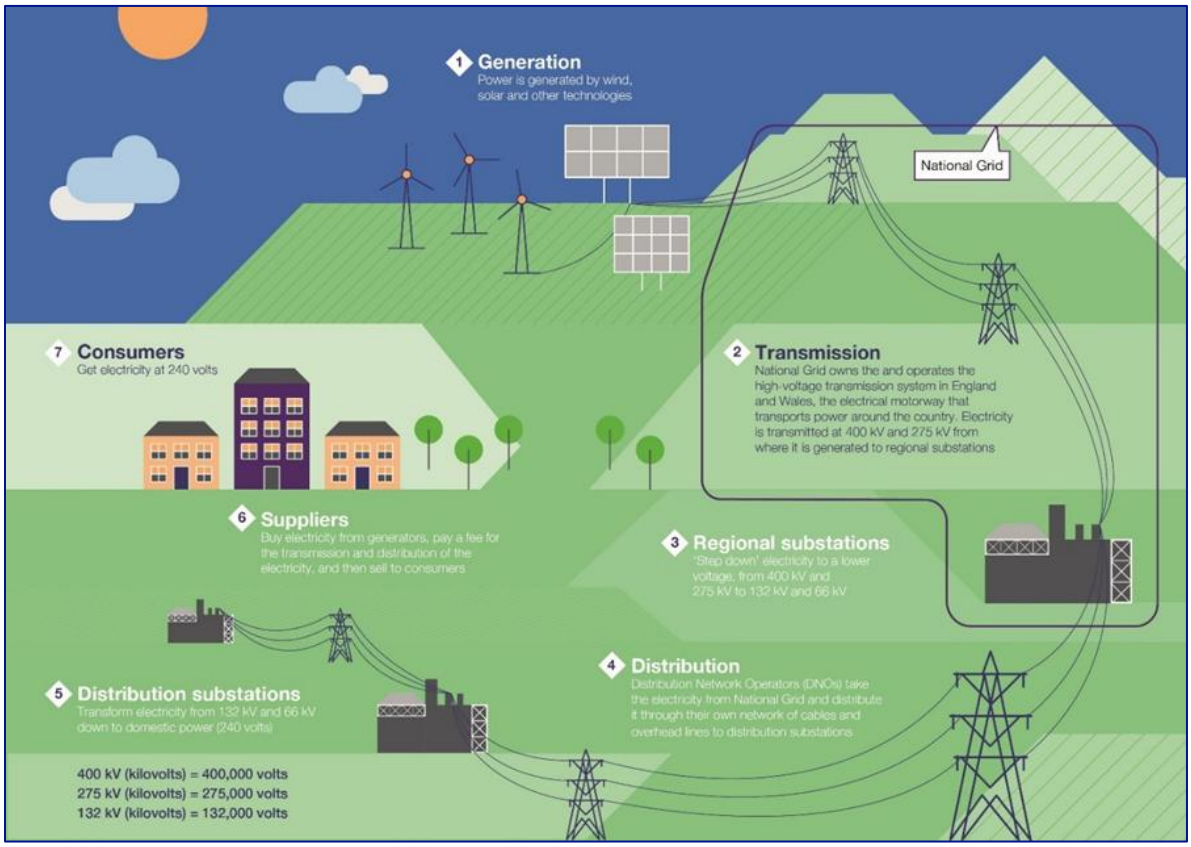
2.1 The transmission system

2.1.1 The electricity transmission system is a means of transmitting electricity around the country from where it is generated to where it is needed. The existing transmission system in Great Britain operates at voltage levels of 400 kV and 275 kV and transports bulk supplies of electricity from large generating stations to demand centres. These systems are typically the responsibility of the Transmission Owners (TOs). Lower voltage distribution systems operate at 132 kV and below in England and Wales and are mainly used to transport electricity from substations (interface points with the transmission system) to the majority of end customers. These systems are typically the responsibility of the Distribution Network Operator (DNO). The electricity system is illustrated in Figure 2.1.

What is demand?

Demand is electricity used by domestic and non-domestic consumers, for example the electricity used within the home or by businesses.

Figure 2.1 - The electricity system from generator to consumer



2.1.2 There are three Transmission Owners (TOs) for Great Britain's network. NGET is the TO for the transmission network in England and Wales. SPEN is the TO for Southern Scotland, and Scottish and Southern Electricity Networks (SSEN) is the TO for Northern Scotland and Scottish Islands Groups.

2.1.3 The generation directly connected to the electricity transmission system tends to be of two types: large low carbon energy (nuclear, wind farms, solar, hydro) and large fossil fuel powered generation. This is also supplemented by new storage technologies such as battery storage.

2.1.4 Substations provide points of connection to the transmission system for power generation stations, distribution networks, transmission connected demand customers (e.g., large industrial customers) and interconnectors. Circuits connect substations on the transmission system. The system is mostly composed of double-circuits (in the case of overhead lines carried on two sides of a single pylon) and single-circuits.

What are interconnectors?

Interconnectors are transmission links that connect the electricity networks in two countries to allow for the transfer of electricity across borders. Currently the Great Britain system has interconnectors with France, Netherlands, Belgium and other countries.

2.1.5 Much of the transmission system was originally constructed in the 1960s. Incremental changes to the transmission system have subsequently been made to meet increasing customer demand and to connect new power generation stations and interconnectors with other countries' transmission systems.

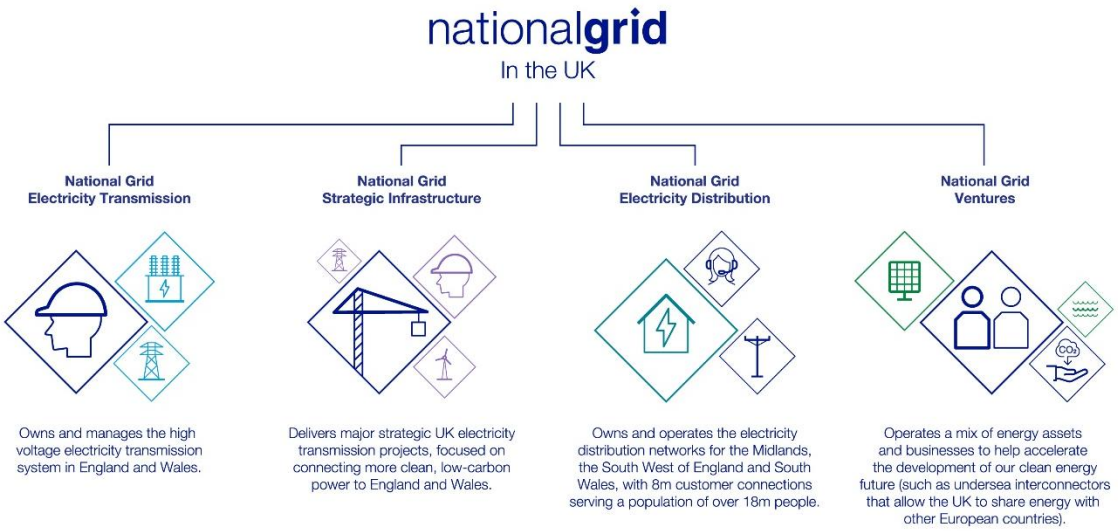
2.1.6 A single electricity market serves the whole of Great Britain. In this competitive wholesale market, generators and suppliers trade electricity on a half hourly basis. Generators produce electricity and sell it in the wholesale market. Suppliers purchase electricity in the wholesale market and supply to end customers.

2.1.7 Electricity can also be traded on the single market in Great Britain by generators and suppliers in other European countries. Interconnectors with transmission systems in France, Belgium, Denmark, the Netherlands and other countries are used to import electricity to and/or export electricity from Great Britain's transmission system.

2.2 Roles and responsibilities

2.2.1 Multiple parties are involved in maintaining and operating the electricity transmission system. The following sections provide an overview of the roles and responsibilities for the Department for Energy Security and Net Zero (DESNZ), the Office of Gas and Electricity Markets (Ofgem), NGET and the National Energy System Operator (NESO).

Figure 2.2 – Roles and Responsibilities within National Grid



2.3 The role of NGET

2.3.1 NGET, as the TO, owns, builds and maintains the high voltage transmission system in England and Wales and is part of the National Grid Group of companies.

2.3.2 NGET's transmission system is a vital component of the UK's energy infrastructure, consisting of overhead lines and underground cabling, operating at high voltages of 400 kV and 275 kV. This extensive network connects to numerous transmission substations, forming a highly interconnected system that ensures the efficient transport of electricity across the country.

2.3.3 In addition to these overhead and underground circuits, the transmission system also includes sub-sea cables. These sub-sea cables play a crucial role in linking the UK to neighbouring countries, facilitating the exchange of renewable energy and enhancing energy security. Overall, the National Grid is designed to support the growing demand for electricity while promoting the transition to a cleaner, more sustainable energy future.

2.3.4 Transmission of electricity in Great Britain requires permission by a licence granted under Section 6(1)(b) of the Electricity Act 1989[2] (as amended) (the Electricity Act). NGET has been granted a transmission licence[3] (the Transmission Licence) and is therefore bound by legal obligations, which are primarily set out in the Electricity Act and the Transmission Licence.

2.3.5 NGET's legal obligations include duties under Section 9, Section 38 and Schedule 9 of the Electricity Act. In summary, NGET is required to:

- Develop and maintain an efficient, co-ordinated, and economical system of electricity transmission.
- Invest in upgrading the electricity transmission system, delivering new infrastructure such as overhead lines and substations that will connect increasing amounts of low carbon power as required to meet future demand and supply as well as wider Energy Policy.
- Collaborate with NESO to facilitate the connection of large energy projects to the transmission system, ensuring electricity can reach homes and businesses.

2.3.6 When formulating proposals for the installation of electric line or the execution of any other works for or in connection with the transmission or supply of electricity, have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and

2.3.7 When formulating such proposals, do what it reasonably can, to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects.

A more detailed consideration of NGET's legal duties is set out in Appendix A.

[2] Electricity Act 1989
https://www.legislation.gov.uk/ukpga/1989/29/contents

[3] Licences and licence conditions, Ofgem
https://www.ofgem.gov.uk/energy-policy-and-regulation/industry-licensing/licences-and-licence-conditions

2.4 The role of the Department for Energy Security and Net Zero

2.4.1 The Department for Energy Security and Net Zero (DESNZ) is the ministerial department with primary responsibility for energy. It sets the policy landscape for the United Kingdom in the form of National Policy Statements. Details of the Government energy policy are described in Chapter 3.

What is net zero?

UK Government's commitment to reduce greenhouse gas emissions to net zero by 2050 as per the Climate Change Act 2008 (2050 Target Amendment) Order 2019.Net zero means any emissions that cannot be avoided would be balanced by schemes to offset an equivalent amount of greenhouse gases from the atmosphere.

2.5 The role of the Welsh Government

2.5.1 The Welsh Government, as a devolved power within the UK for the nation of Wales, established their net zero targets for the nation, which aims to be carbon neutral by 2050. The Welsh policy landscape is outlined in the following policy documents:

- Natural Resources Policy and Area Statements[4]
- Welsh National Marine Plan[5]
- Economic Action Plan[6]
- Planning Policies Wales (including Energy)[7]
- Welsh Government's Net Zero Strategic Plan[8]
- The Well-being of Future Generations (Wales) Act 2015[9]; and
- Future Wales: The National Plan 2040 [10]

[4] National Resources Policy Statement
https://www.gov.wales/sites/default/files/publications/2019-05/natural-resources-policy-statement.pdf

[5] Welsh National Marine Plan
https://www.gov.wales/sites/default/files/publications/2019-11/welsh-national-marine-plan-document_0.pdf

[6] Economic Action Plan
https://www.gov.wales/sites/default/files/publications/2019-02/prosperity-for-all-economic-action-plan.pdf

[7] Planning Policy Wales
https://www.gov.wales/sites/default/files/publications/2024-07/planning-policy-wales-edition-12.pdf

[8] Welsh Government's Net Zero Strategic Plan
https://www.gov.wales/sites/default/files/publications/2022-12/welsh-government-net-zero-strategic-plan.pdf

[9] The Well-being of Future Generations (Wales) Act 2015
https://futuregenerations.wales/wp-content/uploads/2017/01/WFGAct-English.pdf

[10] Future Wales: The National Plan 2040
https://www.gov.wales/sites/default/files/publications/2020-11/working-draft-national-development-framework-document-september-2020.pdf

2.6 The role of Ofgem

2.6.1 Ofgem (the Office of Gas and Electricity Markets) is the regulator for gas and electricity markets in Great Britain. It is a non-ministerial Government department and an independent National Regulatory Authority, whose role is to protect consumers as a greener, fairer, energy system is delivered.

2.6.2 Ofgem works with Government, industry, and consumer groups to help deliver net zero from an energy perspective at the lowest cost possible to consumers.

2.6.3 To deliver the investments proposed within the Holistic Network Design[11] (HND), Ofgem has introduced a regulatory framework known as Accelerated Strategic Transmission Investment[12] (ASTI). This aims to facilitate achieving Government targets by streamlining the regulatory approval and funding process for projects which require acceleration.

2.7 The role of the National Energy System Operator (NESO)

2.7.1 The National Energy System Operator (NESO) is the electricity system operator for Great Britain. NESO ensures electricity is always where it is needed, and the transmission network remains stable and secure in its operation.

2.7.2 As of 1 October 2024, NESO became a public body owned by the DESNZ. It was formerly part of National Grid PLC and called the Electricity System Operator (ESO).

2.7.3 NESO has been established to act as the independent organisation responsible for planning Great Britain's energy system, looking after and operating the electricity network and offering expert advice to the sector's decision-makers.

2.7.4 Generators apply to NESO when they wish to connect to the network and NESO leads, working with the TOs, to consider how the network may need to evolve to deliver a cleaner greener future. NESO is currently reforming their connection processes to meet the increasing number of projects wanting to connect to the transmission system.

2.7.5 NESO, in undertaking this role, engages with NGET for England and Wales as well as the two TOs in Scotland, SSEN and SP Energy Networks.

2.7.6 NESO and its predecessor ESO have been or – in the case of NESO - are responsible for multiple roles across the electricity system, including:

- **Electricity market balancing:** NESO ensures that electricity demand and supply is balanced on a second-by-second basis and manages any shortfalls in boundary capacity.

What is a boundary?

A boundary notionally splits the system into two parts, crossing critical circuit paths that carry power between the areas where power flow limitations may be encountered.

[11] Holistic Network Design, National Energy System Operator
https://www.neso.energy/publications/beyond-2030/holistic-network-design-offshore-wind

[12] Decision on accelerating onshore electricity transmission development, Ofgem
https://www.nationalgrideso.com/future-energy/pathway-2030-holistic-network-design

- **Future Energy Scenarios:** NESO undertakes an annual process to publish the Future Energy Scenarios13 (FES) which takes energy industry views as part of a consultation process and develops a set of possible energy growth scenarios to 2050. In developing FES, NESO takes into consideration the latest pipeline of connections as detailed within the Transmission Entry Capacity (TEC) Register. The TEC Register is essential for managing the UK's electricity transmission network, providing an overview of the capacity available for new connections. As customers apply to NESO for new or modified connections, the TEC Register helps assess the current and future capacity needs of the network. NESO annually publish the Electricity Ten Year Statement14 (ETYS) setting out the network performance and requirements for all transmission in Great Britain over the next 10 years based on the data from the FES. ESO used the ETYS to publish annually the Network Options Assessment[15] (NOA), which considered the economic case for options to reinforce the transmission system and makes economic recommendations. The NOA included a Cost Benefit Analysis (CBA) process to determine when would be appropriate to take forward options proposed by TOs to increase network capacity. This considers the capital costs of the proposal, delivery timescales and constraint costs (as explained in Chapter 5) avoided by delivering the proposal. This establishes when a proposed reinforcement becomes the most economical way to deliver value to Great Britain's energy consumers.
- **Network Planning Review (NPR):** The Pathway to 2030 Holistic Network Design [16] (HND) and the recommendations set out in the most recent Network Options Assessment (NOA) prepared by ESO were the first steps towards a more centralised, strategic network planning approach that is critical for delivering affordable, clean and secure power, with a view to achieving net zero.

  NESO is currently transitioning from the NOA to a more comprehensive approach, a Centralised Strategic Network Plan[17] (CSNP). The CSNP will aim to foster the holistic development of the NETS, marking a new era in network planning for NGET.
- **Connections:** NESO facilitates several roles on behalf of the electricity industry, including making formal offers to connection applicants, to the electricity transmission system. NGET is obligated to provide the physical connections to the elements of the electricity transmission system that NGET owns.

[13] Future Energy Scenarios 2024: NESO Pathways to Net Zero
https://www.nationalgrideso.com/future-energy/future-energy-scenarios

[14] Electricity Ten Year Statement (ETYS)
https://www.neso.energy/publications/electricity-ten-year-statement-etys

[15] Network Options Assessment 2021/22 Refresh, National Grid ESO, July 2022
https://www.neso.energy/document/262981/download

[16] The Pathway to 2030 Holistic Network Design, National Grid ESO
https://www.neso.energy/document/262681/download

[17] Decision on the initial findings of our Electricity Transmission Network Planning Review, Ofgem
https://www.ofgem.gov.uk/publications/decision-initial-findings-our-electricity-transmission-network-planning-review

2.7.7 The planning activities undertaken by NESO are currently being updated to support the delivery of the Government's net-zero commitment. In 2022, ESO published the HND setting out an integrated approach to transmission network design that supports the connection of 23 gigawatts (GW) of offshore wind to Great Britain by 2030.

2.7.8 In 2024, ESO published the findings from the HND Follow-Up Exercise (HND FUE) in a report entitled 'Beyond 2030' [18], which is a pivotal document outlining the strategic direction for the UK's electricity transmission network as it transitions towards a decarbonised future. This report provides an overview of the network design that will act as the pathway to a clean, secure, and affordable energy network, aligning with the Climate Change Committee's (CCC) Sixth Carbon Budget and Scotland's ScotWind leasing round to 2035. It is closely linked to the Transitional Centralised Strategic Network Plan 2 (tCSNP2), which serves as a framework for the necessary investments and infrastructure developments required to meet the ambitious targets set for 2030 and beyond.

2.7.9 The tCSNP2 provides a comprehensive roadmap for the evolution of the UK's transmission network, ensuring that the infrastructure is not only capable of meeting current demands but also adaptable for future energy needs. More detail on the 'Beyond 2030' report can be found in Appendix F.

[18] Beyond 2030, National Grid ESO
www.neso.energy/document/304756/download

3. The legislative, policy and regulatory framework that NGET work within

3.1 Overview

3.1.1 NGET is under a legal duty to maintain an efficient, economic, and co-ordinated electricity transmission system. This section of the report provides further detail of the legal duties and the wider policy context in which NGET operate within including Government energy policy and national planning policy. This includes ensuring that the delivery of energy is affordable, networks are resilient and enabling transition to a net zero carbon economy, while having regard to the environment and society in which NGET operates.

3.2 NGET's requirement to reinforce the transmission system

3.2.1 NGET's duties are determined by the Electricity Act and under the terms of its Transmission Licence. Those duties, and terms of particular relevance to the development of the proposed connection described in this report, are set out below.

3.2.2 As part of NGET's Transmission Licence requirements, the transmission infrastructure needs to be capable of providing and maintaining a minimum level of security and quality of supply and of transporting electricity from and to customers. NGET is required to ensure that the transmission system remains capable as customer requirements change.

3.2.3 Capacity refers to the theoretical maximum limit of a circuit, while capability denotes the practical limit imposed by physical and operational constraints. The capacity of the transmission system is determined by the physical ability of electrical circuits to carry power. Each circuit has a specific capacity, and the total capacity of the circuits within a region or across a boundary is the cumulative sum of the capacities of all individual circuits.

3.2.4 On the other hand, the capability of the transmission system represents the natural flow of energy that can occur within the network's infrastructure. Due to the inherent physical properties of the transmission system, this capability is often less than the theoretical capacity of the infrastructure. This distinction is crucial for understanding how effectively the transmission system can operate under real-world conditions.

3.2.5 The transmission system must accommodate changes in demand, generation, and interconnectors. Customers can apply to NESO for new or modified connections. Upon receiving applications, the relevant transmission owner uses the TEC Register to assess the generation group and determine if the transmission system can support the proposed changes. If capacity is available, NESO will extend a formal offer of connection.

3.2.6 Where power flows are constrained by the transmission system across a specific number of circuits, this is termed a 'boundary' by NESO. Such boundaries are used in the ETYS to identify constraints which may require changes to the transmission system in the next 10 years. Where the 'boundary capacity' is exceeded against the standards

of the Security and Quality of Supply Standard (SQSS), NGET must resolve the capacity shortfall.

3.2.7 Where capacity and capability of the transmission system are not sufficient, either from a generation group or across a boundary, NGET is required to reinforce the network. NGET does this by either modifying the existing network (if possible) and / or constructing additional transmission infrastructure to resolve the shortfall.

3.3 Security and Quality of Supply Standard (SQSS)

3.3.1 NGET must comply with Section 9 of the Electricity Act and Standard Condition D3 (Transmission system security standard and quality of service) of NGET's Transmission Licence. This means that where the boundary capacity of the Main Interconnected Transmission System (MITS) is exceeded against the standards, NGET must resolve the capacity shortfall under the terms of its Transmission Licence. The standards against which NGET assesses these shortfalls are set out in the "Design of the Main Interconnected Transmission System" section of the NETS SQSS.

What is the SQSS?

It is an industry standard that sets out the criteria and methodology for planning and operating the onshore and offshore electricity transmission system. It details the planning criteria for the connection of generation and demand groups onto the transmission system. It defines the performance required of the transmission system in terms of Quality and Security of Supply for secured events. This means that at all times:

- *Electricity system frequency should be maintained within statutory limits;*
- *No part of the National Electricity Transmission System (NETS) should be overloaded beyond its capability;*
- *Voltage performance should be within acceptable statutory limits; and*
- *The system should remain electrically stable.*

NESO is the code administrator of the SQSS and there is a panel made up of industry experts that are responsible for ensuring that the SQSS is up to date and manages any changes. Any changes to the SQSS are overseen by Ofgem.

3.3.2 The NETS SQSS also sets out in "Generation Connection Criteria applicable to the onshore transmission system" that connections to the transmission system must be secured to meet the identified requirements. Where the SQSS applies, the generator(s) are considered part of a "generation group" for assessment against these criteria.

What is a generation group?

A generation group consists of a number of existing generating stations and / or proposed generating stations connecting in a particular geographical area of the transmission system.

3.3.3 Generators apply to NESO for connections to the NETS in Great Britain. If the application is for an onshore generation connection, the applicant will indicate the specific location of the generating station, which will suggest the likely geographical connection to the transmission system, subject to NGET's review and optioneering appraisal. The TEC Register is used to assess the available capacity for these connections. If the application is for an offshore connection or impacts multiple TOs, NESO will coordinate the process known as Connection and Infrastructure Options Note (CION) / HND to determine their preferred connection option.

3.3.4 NESO also ensures that the relevant transmission owner conducts generation connection process studies and makes a connection offer to the customer, identifying the necessary infrastructure work. Once the offer is signed, the connection is recorded on the TEC Register, establishing a contractually binding connection location and timescale for the TO, such as NGET, to facilitate the connection.

3.3.5 A connection offer will normally be given in respect of a particular geographical area. Sometimes this leads to a presumption as to the connection point located on the existing transmission network. In other circumstances where there is no or little existing transmission infrastructure, this will require the provision of new infrastructure. The post connection offer assessment process enables further evaluation of the preferred connection option and refinement of the preferred overall transmission solution. This process continues, informed by evolving circumstances and consultation, until an application is submitted for consent in relation to a transmission project.

3.3.6 NGET assesses the adequacy of the project's transmission system in accordance with the methodology defined in the SQSS. This assessment requires evaluating power flows between regions of the transmission system, known as Planned Transfers. The Planned Transfer from a region is determined by considering the Average Cold Spell (ACS) Peak Demand in that region, alongside the generation capacity available, following the modelling procedures outlined in the SQSS.

3.3.7 The Planned Transfer represents the amount of power expected to flow out of the region during periods of ACS peak demand, which occurs when demand is higher due to increased energy consumption. These calculations are crucial as they account for power flows under peak demand conditions.

3.3.8 It is important to note that any transmission system is susceptible to faults that can interfere with the ability of transmission circuits to carry power. Most faults are temporary and often related to weather conditions, such as lightning or severe storms, with many circuits capable of being restored to operation automatically within minutes after a fault. However, some faults may persist for a longer duration and require repair or replacement of failed electrical equipment.

3.3.9 Whilst some of these faults may be more likely than others, faults may occur at any time, and it would not be acceptable to have a significant interruption to supplies as a result of specified fault conditions, including combinations of faults. The principle underlying the SQSS is that the NETS should have sufficient spare capability or "redundancy" such that fault conditions do not result in widespread supply interruptions. The level of security of supply has been determined to ensure that the risk of supply interruptions is managed to a level that maintains a minimum standard of transmission system performance. The faults needed to design the system to be compliant with are called "Secured Events".

3.4 NGET's Statutory Duties

3.4.1 This section includes the statutory duties most relevant to the development of new infrastructure. These duties are considered in NGET's approach to identifying options and the selection process. This is shown in NGET's review of potential strategic options and the application of the appraisal factors, as reported in Chapter 5 of this report.

3.4.2 The relevant statutory duties are:

- Electricity Act 1989
- National Parks and Access to the Countryside Act 1949
- Countryside and Rights of Way Act 2000
- Natural Environment and Rural Communities Act 2006
- Wildlife and Countryside Act 1981

Electricity Act 1989

3.4.3 When developing new infrastructure, NGET is required to comply with the following duties.

3.4.4 Schedule 9(2) of the Electricity Act (General duties of licence holders) states:

> "it shall be the duty of the holder of a licence authorising him to participate in the transmission of electricity: (a) to develop and maintain an efficient, co-ordinated and economical system of electricity transmission…;"

3.4.5 Section 38 and Schedule 9 of the Electricity Act state that:

> *"(1) In formulating any relevant proposals, a licence holder;*
>
> *- (a) shall have regard to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and*
>
> *- (b) shall do what he reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects."*

3.4.6 In November 2025, National Grid Electricity Transmission updated its Schedule 9 Statement (referred to the Stakeholder, Community and Amenity Policy[19]) setting out how we will meet our statutory duties under Schedule 9 of the Electricity Act.

National Parks and Access to the Countryside Act 1949

3.4.7 Section 11A (1A) of the National Parks and Access to the Countryside Act 1949 imposes a duty on certain bodies and persons in respect of National Parks. NGET, for the purpose of this provision, is a 'relevant authority' by virtue of being a 'statutory undertaker' such that the duty applies to it. The duty provides as follows:

[19] NGET Updated Schedule 9 Statement: the Stakeholder, Community and Amenity Policy

> *"*(1A) In exercising or performing any functions in relation to, or so as to affect, land in any National Park in England, a relevant authority other than a devolved Welsh authority must seek to further the purposes specified in section 5(1) and if it appears that there is a conflict between those purposes, must attach greater weight to the purpose of conserving and enhancing the natural beauty, wildlife and cultural heritage of the area comprised in the National Park."

3.4.8 Section 5 sets out the statutory purposes of the National Park, as follows:

> "(1) The provisions of this Part of this Act shall have effect for the purpose:
>
> (a) of conserving and enhancing the natural beauty, wildlife and cultural heritage of the areas specified in the next following subsection; and
>
> (b) of promoting opportunities for the understanding and enjoyment of the special qualities of those areas by the public.*"*

Countryside and Rights of Way Act 2000

3.4.9 Section 85 of the Countryside and Rights of Way Act 2000 imposes a duty on public bodies in respect of areas of outstanding natural beauty. NGET, for the purpose of this provision, is a 'relevant authority' by virtue of being a 'statutory undertaker', such that the duty applies to it. The duty provides as follows:

> *"(A1) In exercising or performing any functions in relation to, or so as to affect, land in an area of outstanding natural beauty in England, a relevant authority other than a devolved Welsh authority must seek to further the purpose of conserving and enhancing the natural beauty of the area of outstanding natural beauty."*

3.4.10 Areas of Outstanding Natural Beauty are now commonly referred to as "National Landscapes"; however, the statutory designation and terminology within the Countryside and Rights of Way Act 2000 remain unchanged.

3.4.11 Section 245 (Protected Landscapes) of the Levelling-up and Regeneration Act 2023 (LURA) amends the duty on relevant authorities in respect of their functions which affect land in National Parks, National Landscapes, and the Norfolk and Suffolk Broads (collectively referred to as Protected Landscapes) in England.

3.4.12 Relevant authorities must now 'seek to further' the statutory purposes of Protected Landscapes. This replaces the previous duty on relevant authorities to 'have regard to' their statutory purposes.

Natural Environment and Rural Communities Act 2006

3.4.13 Section 40 of the Natural Environment and Rural Communities Act 2006 imposes a duty in respect of biodiversity. NGET, for the purposes of this provision, is a 'public authority' by virtue of being a 'statutory undertaker' such that this duty applies to it. The duty provides as follows:

> *"(A1) For the purposes of this section "the general biodiversity objective" is the conservation and enhancement of biodiversity in England through the exercise of functions in relation to England.*

(1) A public authority which has any functions exercisable in relation to England must from time to time consider what action the authority can properly take, consistently with the proper exercise of its functions, to further the general biodiversity objective."

Wildlife and Countryside Act 1981

3.4.14 Section 28G of the Wildlife and Countryside Act 1981 imposes a duty on 'statutory undertakers' in respect of Sites of Special Scientific Interest (SSSI). The duty provides as follows:

> "(1) An authority to which this section applies (referred to in this section and in sections 28H and 28I as "a section 28G authority") shall have the duty set out in subsection (2) in exercising its functions so far as their exercise is likely to affect the flora, fauna or geological or physiographical features by reason of which a site of special scientific interest is of special interest.
>
> (2) The duty is to take reasonable steps, consistent with the proper exercise of the authority's functions, to further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which the site is of special scientific interest."

3.5 Government energy policy

3.5.1 In 2019, the UK Government committed to achieving net zero greenhouse gas emissions by 2050. In 2024 the UK Government also committed to achieving a clean electricity system by 2030.

3.5.2 These commitments require the UK to move away from fossil fuels and to adopt alternative sources of energy to power our homes, transport and businesses. The Government has set out how it plans to deliver on these commitments within multiple plans including:

- November 2020: Prime Minister's Ten Point Plan for a Green Industrial Revolution[20].
- December 2020: Energy White Paper: Powering our Net Zero Future[21].
- October 2021: Net Zero Strategy: Build Back Greener[22].
- April 2022: British Energy Security Strategy[23] (BESS). This document is built on the Net Zero Strategy and was published in response to the Russian invasion of Ukraine and the 2022 energy price crisis.

[20] The Ten Point Plan for a Green Industrial Revolution, HM Government, November 2020 https://assets.publishing.service.gov.uk/media/5fb5513de90e0720978b1a6f/10_POINT_PLAN_BOOKLET.pdf

[21] Energy White Paper: Powering our Net Zero Future, HM Government, December 2020 https://assets.publishing.service.gov.uk/media/5fdc61e2d3bf7f3a3bdc8cbf/201216_BEIS_EWP_Command_Paper_Accessible.pdf

[22] Net Zero Strategy: Build Back Greener, HM Government, October 2021 https://assets.publishing.service.gov.uk/media/6194dfa4d3bf7f0555071b1b/net-zero-strategy-beis.pdf

[23] British Energy Security Strategy, HM Government, April 2022

- March 2023: Powering Up Britain[24] and Powering Up Britain: Energy Security Plan[25]. This document provides an update of the strategy for secure, clean and affordable British energy for the long-term future.
- December 2024: Clean Power 2030 Action Plan: A new era of clean electricity[26]. This document provides the strategic initiative aimed at transitioning to cleaner energy sources and reducing carbon emissions. With regards to transmission infrastructure, the policy looks at the introduction of improved planning and consenting environment will accelerate the expansion and upgrade of transmission and distribution networks to better enable the introduction of renewables into the Grid.

3.5.3 Key ambitions contained within these plans to achieve net zero include:

- Up to 50 GW of offshore wind connected by 2030 including 5 GW of which will be offshore floating wind.
- Up to eight nuclear reactors being progressed with up to 24 GW to be achieved by 2050.
- Up to 10 GW of low carbon hydrogen production capacity by 2030, doubling the previous ambition.
- 600,000 heat pump installations a year by 2028 and improving housing stock insulation.

3.6 Consenting approach

3.6.1 The roles and responsibilities for the consenting of the marine and terrestrial elements of the scheme are proposed to be divided between SPEN and NGET:

- SPEN: lead the terrestrial and marine consenting within the Scottish territory,
- NGET: lead the terrestrial and marine consenting within the Welsh territory.
- The consenting of the other territories, which are anticipated to be only within the marine environment, would be led by NGET with appropriate support from SPEN.

3.6.2 This Project is currently programmed to seek consent, within the UK, via a combination of the Town and Country Planning Act 1990 with Compulsory Purchase Order (under the Electricity Act 1989) routes in onshore Wales and Marine Licence and Consents for offshore elements. At the same time, the Project is keeping open the option to seek consent via the Infrastructure Wales Act (2024). To follow this route, the Project would

https://assets.publishing.service.gov.uk/media/626112c0e90e07168e3fdba3/british-energy-security-strategy-web-accessible.pdf

[24] Powering up Britain, HM Government, March 2023
https://assets.publishing.service.gov.uk/media/642468ff2fa8480013ec0f39/powering-up-britain-joint-overview.pdf

[25] Powering up Britain: Energy Security Plan, HM Government, March 2023
https://assets.publishing.service.gov.uk/media/642708eafbe620000f17daa2/powering-up-britain-energy-security-plan.pdf

[26] Clean Power 2030 Action Plan: A new era of clean electricity, UK Government, December 2024
https://assets.publishing.service.gov.uk/media/677bc80399c93b7286a396d6/clean-power-2030-action-plan-main-report.pdf

need to be recognised by Welsh Ministers as being of National significance to Wales[27]. In addition, in the territories which are not subject to MaCAA, such as the Isle of Man, consent for development will be sought through a Marine Infrastructure Consent.

3.6.3 The marine route between the proposed landfalls is envisaged to traverse Scottish Territorial Seas (TS), Northern Irish Waters, the Isle of Man's Waters and Welsh TS. The location of the Welsh landfall does not alter the number of waters traversed.

3.6.4 As a result, routes to consent are outlined in the Table 3.1 below

Table 3.1: Consenting Regime Options by Territory

Terrestrial or Marine Environments	Consent Approach	Consenting Regime Options		
		A**	B***	C****
Terrestrial	Town and Country Planning Act (Wales)	✓	×	×
	Town and Country Planning Act (Scotland)	✓	✓	✓
	Infrastructure (Wales) Act (Terrestrial)*	×	✓	✓
Marine	Infrastructure (Wales) Act (Marine) (out to 12nm)*	×	×	✓
	Marine Licence (Wales*, Scotland & NI)	✓	✓	✓
	Marine Licence (Scotland & NI)	✓	✓	✓
	Marine Infrastructure Consent (IoM)	✓	✓	✓

**Note: for Wales, where there is an infrastructure consent sought under the Infrastructure (Wales) Act 2024 for the marine activities, this is only currently valid out to 12nm. Therefore, for the installation beyond 12nm, a marine licence from NRW would be required out to the extent of the Welsh exclusive economic zone.*

*** Consenting Regime Option A: Captures the currently available and relevant consenting routes across each of the territories the Project traverses. Across each of the consenting regime approaches, the potential route for consent in Scotland, Northern Ireland, and the Isle of Man does not change.*

**** Consenting Regime Option B: Represents the potential option for seeking an infrastructure consent for the terrestrial portion of the Project within Wales under the Infrastructure (Wales) Act 2024, should appropriate secondary legislation be introduced in a timely manner. Across each of the consenting regime approaches, the potential route for consent in Scotland, Northern Ireland, and the Isle of Man does not change.*

***** Consenting Regime Option C: Represents the potential option for seeking an infrastructure consent for the terrestrial and marine portions (out to 12nm) of the Project within Wales under the Infrastructure (Wales) Act 2024, should appropriate secondary legislation be introduced in a timely manner. For the offshore portion of the Project (beyond 12nm up to the EEZ), a marine licence would be sought. Across each of the consenting regime approaches, the potential route for consent in Scotland, Northern Ireland, and the Isle of Man does not change.*

[27] The Infrastructure (Wales) Act 2024 provides for a new consenting process that will enable the Welsh Ministers to determine applications for significant infrastructure projects. The Act contains the framework for the overall process, with the finer details in Regulations.

3.6.5 Across each of the options for route to consent presented in Table 3.1 above, the route to consent for the Project infrastructure proposed within Scotland, Northern Ireland, Isle of Man is anticipated to remain constant across all the options. Option A is proposed to be the consenting regime for the project at this point of time.

Summary of the relevant policy statements

3.6.6 A summary of the relevant policy statements is set out below and as the Project develops it will have regard to all national and relevant local policies.:

Scottish Government

National Planning Framework

3.6.7 Scotland's fourth National Planning Framework (S4NPF) sets out our spatial principles, regional priorities, national developments and national planning policy. It should be read as a whole and replaces NPF3 and Scottish Planning Policy.

3.6.8 This policy will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

Welsh Government

Natural Resources Policy and Area Statements

3.6.9 The Natural Resources Policy identifies the key priorities, risks, and opportunities to achieve the sustainable management of natural resources, including addressing the climate emergency and reversing biodiversity decline. Its objectives are to maintain and enhance the resilience of ecosystems and the benefits they provide. Planning Policy Wales outlines how the planning system should contribute towards these goals, and Future Wales builds on this policy by setting out specific policies that support them.

3.6.10 This policy will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

Welsh National Marine Plan

3.6.11 The Welsh National Marine Plan is the first of its kind for Wales and represents the start of a process of shaping our seas to support economic, social, cultural and environmental objectives. Marine planning will guide the sustainable development of our marine area by setting out how proposals will be considered by decision-makers. The Marine Plan has informed the preparation of Future Wales and, where relevant, it should inform Strategic and Local Development Plans and planning decisions. The timescales to produce the Marine Plan and Future Wales have overlapped, enabling the production of both plans to be joined up. This link will continue as both plans are implemented and reviewed.

Economic Action Plan

3.6.12 The Economic Action Plan supports the delivery of Prosperity for All – the national strategy for Wales. It sets out a vision for inclusive growth based on strong foundations, future industries and productive regions. It aims to build resilience and future proof the economy. The Plan focuses funding support on businesses which align with decarbonisation objectives, are innovative and entrepreneurial, seek to export and import, support skills development and high-quality employment, and support automation, research and development and digitalisation. The Plan identifies national thematic sectors and foundational sectors. Thematic sectors include high value manufacturing, tradable services (e.g. sale of online services), and enablers (key competitiveness drivers e.g. digital or renewable sectors). Whilst foundation sectors include tourism, food, retail and care. The Plan also introduces a new regionally focused model of economic development.

Planning Policies Wales (Including Energy)

3.6.13 The Welsh planning system manages the development and use of land for public interest, prioritising the long-term collective benefit for the people, with the aim of contributing to the improvement of economic, social, environmental and cultural well-being of Wales. To aid this, the Welsh Government established the Planning Policy Wales (PPW) document, which sets out land use planning policies, and is supplemented by the Technical Advice Notes (TANs), Welsh Government Circulars, and policy clarification letters.

Welsh Government's Net Zero Strategic Plan

3.6.14 The Welsh Government declaring a Climate Emergency in 2019 and have since outlined their commitment through their Net Zero Strategic Plan which aims to deliver collective net zero emissions within the public sector. The Net Zero Strategic Plan demonstrates NGET's delivery against the requirements of the Wellbeing of Future Generations (Wales) Act 2015, which directs us to consider long-term persistent problems such as poverty, health inequalities, and climate change. Depending on the consenting route, consideration of Local Authority(s) validation checklist requirements will be taken into account as part of the application preparation which will include Equalities assessment.

The Equalities Act 2010

3.6.15 The UK government established the Equalities Act, which requires decision makers to make strategic decisions about the exercise of their functions to have regard to the desirability of reducing socio-economic inequalities; to reform and harmonise equality law and restate the greater part of the enactments relating to discrimination and harassment related to certain personal characteristics; to enable certain employers to be required to publish information about the differences in pay between male and female employees; to prohibit victimisation in certain circumstances; to require the exercise of certain functions to be with regard to the need to eliminate discrimination and other prohibited conduct; to enable duties to be imposed in relation to the exercise of public procurement functions; to increase equality of opportunity; to amend the law relating to rights and responsibilities in family relationships; and for connected purposes.

3.6.16 The Welsh government has further ratified their statutory duties through The Equality Act 2010 (Statutory Duties) (Wales) Regulations 2011.

The Well-being of Future Generations (Wales) Act 2015

3.6.17 The Well-being of Future Generations (Wales) Act provides a legally-binding common purpose – the seven well-being goals – for national government, local government, local health boards and other specified public bodies to follow (e.g. local authorities, Welsh Ministers, Natural Resources Wales etc). It details the ways in which the specified public bodies must work and work together to improve the well-being of Wales.

3.6.18 Additionally, the Act puts in place a 'sustainable development principle' which tells organisations how to go about meeting their duty under the Act. In addressing the sustainable development principle, the public body must operate in a manner which seeks to ensure that the needs of the present are met without compromising the ability of future generations to meet their own needs. When making decisions, public bodies are required to ensure they consider the impact they could have on people living their lives in Wales in the future.

Future Wales: The National Plan 2040

3.6.19 This has development plan status. Policy 17 sets out that decision-makers must give significant weight to the need for Wales to meet international commitments as well as generating 70% of consumed electricity by renewable means by 2030. It also outlines a presumption in favour of large-scale wind energy development in certain areas. It also sets out that new transmission infrastructure should be designed to minimise visual impact on nearby communities. It sets out a commitment by Welsh Government to work with National Grid and DNOs, to transition to a multi-vector grid network and reduce the barriers to the implementation of new grid infrastructure.

3.6.20 These policies will be considered during the evolution of the AC6 Project to ensure that the project is designed to align with relevant national government requirements.

Summary of the relevant Marine Policy Statements

3.6.21 A summary of the relevant Marine Policy Statements is set out below, and as the Project develops it will have regard to all national and relevant local policies and where applicable how compliance is met:

United Kingdom Policy Guidance

Statutory guidance: Guidance to the UK Marine Policy Statement from 1 January 2021

3.6.22 The Statutory guidance: Guidance to the UK Marine Policy Statement from 1 January 2021 was published on behalf of all the UK Administrations by the Department of Environment, Food and Rural Affairs. It explains how references to EU law in the UK Marine Policy Statement (MPS) should be interpreted from 1 January 2021 following the UK's withdrawal from the EU.

UK Marine Policy Statement

3.6.23 The Marine Policy Statement (MPS) will facilitate and support the formulation of Marine Plans, ensuring that marine resources are used in a sustainable way in line with the high-level marine objectives. This policy will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

Wales

Marine Area Statements (MAS)

3.6.24 The Welsh Marine Area Statement derives from the Environment (Wales) Act 2016 [28] and covers the inshore waters of Wales extending out 12 nautical miles and making up 43% of the Welsh territory.

Marine Plans

3.6.25 The Welsh National Marine Plan (WNMP)[29] is the first marine plan for Wales, which is intended to be the start of a process of shaping the Welsh marine area (covering approximately 32,000 km^2 of sea) to support economic, social, cultural and environmental objectives. In line with the requirements for monitoring the marine environment within the UK outlined in and required by MaCAA, the WNMP denotes the Welsh Government's intentions to review the effects of the policies at least every three years.

3.6.26 These policies will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

[28] Environment (Wales) Act 2016
https://www.legislation.gov.uk/anaw/2016/3/contents

[29] The Welsh National Marine Plan (WNMP)
https://www.gov.wales/welsh-national-marine-plan

Scotland

Marine Plans

3.6.27 The Scottish Marine Plan (SMP) sets out some guidance specifically for regional planners, which includes legislative guidance on the following: Assessing the condition of the region; Summarising the significant pressures and impact of human activity; Keeping under review the physical, environmental, social, cultural and economic characteristics of the region; the purposes for which it is used; its communication, energy and transport systems; and the living resources which it supports; Setting economic, social, marine ecosystem and climate change objectives; Stating the contribution of MPAs and other designated areas to the protection and enhancement of the region; Stating policies for sustainable development of the region; and Developing a Statement of Public Participation and carrying out consultation.

3.6.28 This policy will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

Northern Ireland

Marine Plans

3.6.29 The Northern Ireland draft Marine Plan (NIdMP) sets out some guidance for the enablement of a healthy marine area which is managed sustainably for the economic, environmental and social prosperity of present and future generations. The NIdMP considers the Northern Irish Marine Area, which comprises all marine waters including seabed, subsoil, sea loughs and tidal rivers, so far as the tide flows at Mean High Water Spring Tide.

3.6.30 The current NIdMP is a draft version only and so not currently in effect. However, it is prudent to consider the policies outlined within the current document within project design evolution so that the appropriate allowances are made with respect to any development within the marine area of Northern Ireland.

3.6.31 This policy will be considered during the evolution of the Project to ensure the project is designed to align with relevant national government requirements.

Isle of Man

Marine Plans

3.6.32 No marine plans are currently enacted within the Isle of Man at time of writing. Instead, the Marine Infrastructure Management Act 2016 identifies the various requirements for consent various marine activities to gain consent.

4. The need case for reinforcement to the transmission system

4.1 Background to the needs case

4.1.1 The electricity industry in Great Britain is undergoing unprecedented change. Closure of fossil fuel power stations and end of life nuclear power stations means significant additional investment in new generating and interconnection capacity will be needed to ensure existing minimum standards of security and supply are maintained.

4.1.2 Growth in onshore green technologies, offshore wind power generation and interconnectors with Europe has seen a significant number of connections planned in Scotland, England and, significantly, in areas of the East Coast of England.

4.1.3 The Climate Change Act 2008 (as amended) now commits the UK Government to reducing greenhouse gas emissions by at least 100% from the 1990 baseline by 2050 (this is referred to as “Net Zero”), strengthening the likelihood of most of these connections progressing to delivery. This 2050 target is commonly known as 'Net Zero'.

4.1.4 To achieve Net Zero, there will need to be a substantial shift away from the use of unabated fossil fuel-based power generation. This has led to investment in onshore green technologies and offshore wind generation, which will increase further in the future.

4.1.5 Historically, the electricity transmission system was supplied largely by coal fired power generating stations. The increasing importance of low carbon generation has driven the closure of these generating stations, with the UK’s last coal fire power generating station having closed in 2024. This generating capacity is being replaced by low carbon generation which is geographically located away from the coal powered generating stations. The transmission system must be updated to reflect the location of the new generation capacity.

4.1.6 Electricity demand is especially concentrated in large urban areas, including urban areas in the M62 corridor, the M18 corridor, the Midlands, the M4 corridor and the Southeast. The transmission system carries bulk energy from the generators to points on the network where that power is taken onto the distribution networks for onward transmission to homes and businesses across England and Wales. As the country decarbonises, this national demand for energy will increase and new low carbon generation will replace fossil fuel generation.

4.2 National Electricity Transmission System Security and Quality of Supply Standard

4.2.1 NGET must comply with Schedule 9 of the Electricity Act and Standard Condition D3 (Transmission system security standard and quality of service) of its Transmission Licence. This means that where the boundary capacity of the Main Interconnected Transmission System (MITS) is exceeded against the standards, NGET must resolve the capacity shortfall under the terms of its Transmission Licence. The standards against which NGET assesses these shortfalls are set out in the "*Design of the Main*

Interconnected Transmission System" section of the National Electricity Transmission System Security and Quality of Supply Standard [30] (NETS SQSS).

4.2.2 The NETS SQSS also sets out in "*Generation Connection Criteria applicable to the onshore transmission system*" that connections to the transmission system must be secured to meet the identified requirements set out in the NETS SQSS. Where the NETS SQSS applies, the generator(s) are considered part of a "generation group" for assessment against these criteria.

4.2.3 Generators apply to National Energy System Operator (NESO) for connections to the NETS in Great Britain. If the application is for an onshore generation connection, the applicant will indicate the specific location of the generating station, which will indicate the likely geographical connection to the transmission system. If the application is for an offshore connection or impacts multiple transmission owners, the ESO will co-ordinate the process known as Connection and Infrastructure Options Note (CION)[31]/HND to determine the preferred connection option.

4.2.4 The NESO ensures that the relevant on-shore or off-shore transmission owner undertakes generation connection process studies via CION or HND and makes a connection offer to the customer for a connection point and identifies at a high level the relevant infrastructure work needed to make the connection. Once this offer is signed, the connection is recorded on the Transmission Entry Capacity (TEC) Register and forms a contractually binding connection location and timescale with the transmission owner, such as NGET. The transmission owner is then required to connect the generation customer or undertake the works to facilitate their connection.

4.2.5 A connection offer will normally be given in respect of a particular geographical area. Sometimes this leads to a connection point located on the existing transmission network. In other circumstances, there is no or little existing transmission infrastructure that is situated where the connection is required. In such a circumstance there will be a requirement to provide new infrastructure for the customer to connect to. The post connection offer assessment process enables further evaluation of the preferred connection option and refinement of the preferred transmission solution. This process continues, informed by evolving circumstances and consultation, until an application is submitted for a development consent in relation to a transmission project.

4.2.6 NGET assesses the adequacy of its transmission system in accordance with the method defined in the NETS Security and Quality of Supply Standard (SQSS). NGET is required to assess power flows between regions of the transmission system (Planned Transfers). The Planned Transfer from the region is calculated by taking the Average Cold Spell (ACS) Peak Demand in the region and the generation operating in the region then modelling the flow expected as set out in the NETS SQSS. The Planned Transfer is therefore the amount of power which will flow in or out of the region at ACS peak. Planned Transfer calculations will always consider the power flows for ACS peak demand conditions, as less generation will be entering the market when demand is lower in off peak conditions.

4.2.7 Any transmission system is susceptible to faults that interfere with the ability of transmission circuits to carry power. Most faults are temporary, many are related to weather conditions such as lightning or severe weather, and many circuits can be

[30] Security and Quality of Supply Standard (SQSS) | National Energy System Operator: https://www.neso.energy/industry-information/codes/security-and-quality-supply-standard-sqss

restored to operation automatically in minutes after a fault. Other faults may be of longer duration and would require repair or replacement of failed electrical equipment.

4.2.8 Whilst some of these faults may be more likely than others, faults may occur at any time, and it would not be acceptable to have a significant interruption to supplies as a result of specified fault conditions, including combinations of faults. The principle underlying the NETS SQSS is that the NETS should have sufficient spare capability or "redundancy" such that defined fault conditions do not result in widespread supply interruptions. The level of security of supply has been determined to ensure that the risk of supply interruptions is managed to a level that maintains a minimum standard of transmission system performance. The faults NGET needs to design the system to be compliant with are called "Secured Events"

4.2.9 The NETS SQSS defines the performance required of the NETS in terms of Quality and Security of Supply for secured events that at all times:

- Electricity system frequency should be maintained within statutory limits;
- No part of the NETS should be overloaded beyond its capability;
- Voltage performance should be within acceptable statutory limits; and
- The system should remain electrically stable.

4.3 Existing transmission network

4.3.1 The transmission network in Wales and England was primarily constructed in the 1960s. It was designed to connect the inland large coal fired power stations, Hydro Power and Nuclear Power Stations in the across Wales and England, with changes occurring in the later parts of the century connecting gas fired power stations in the South and North Wales in particular. Little or no transmission infrastructure was constructed in some areas, such as Mid Wales, so there is currently limited ability to support new connections.

4.3.2 The connection of low carbon generation to reach government targets, requires connection of new generation across Scotland, Wales and England. This particular project seeks to support the connection of renewable energy in Scotland and ensuring that it can be transferred to where it is needed in England and Wales across multiple critical boundaries described below.

4.3.3 The existing transmission system in Wales, Midlands and North of England is shown in Figure 4.1.

Figure 4.1 - The National Electricity System in Scotland, Wales, the Midlands and the North of England

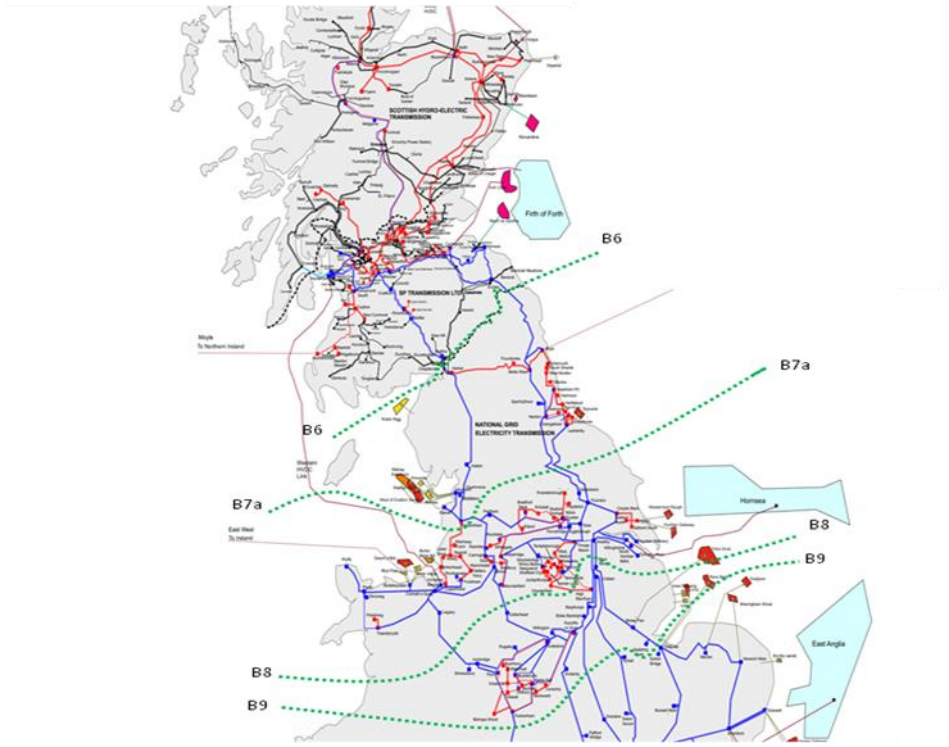
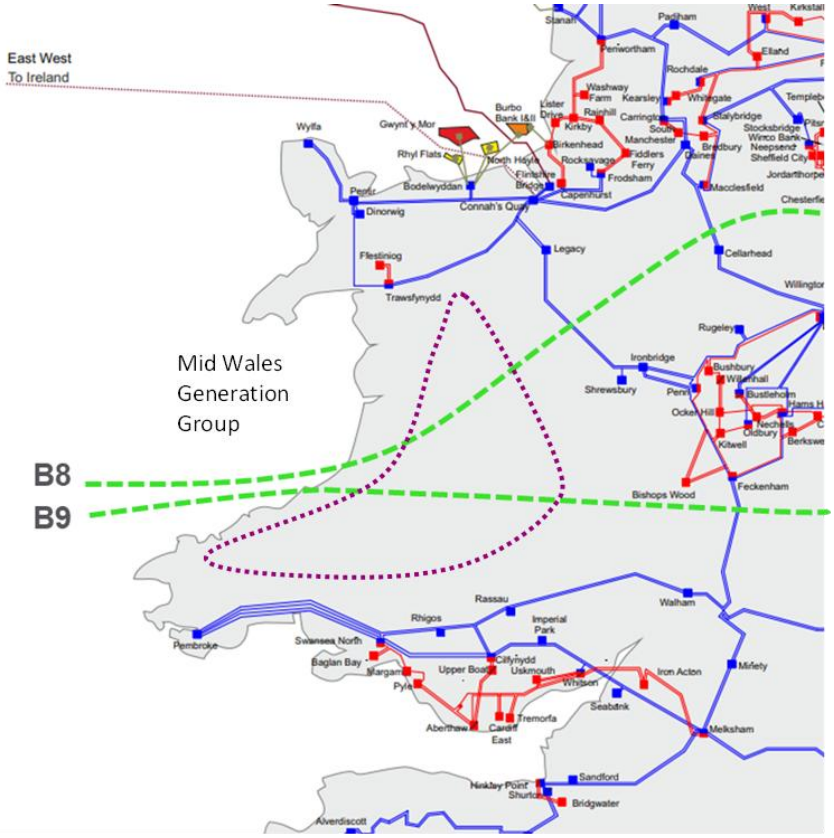


Figure 4.2 - Mid Wales generation group



4.4 Generation groups

4.4.1 Figure 4.2 identifies the Mid Wales generation group areas under consideration, which currently has no transmission infrastructure, any options considering connections to this group are reliant on other transmission works being required in the area for connection of generation.

4.4.2 The Mid Wales generation group does not have any transmission connected generation contracts currently however the areas indicated by Welsh Government Energy Policy would be capable of accommodating 4 to 6 GW of onshore low carbon generation.

4.5 Boundaries

4.5.1 The transmission system shown in Figure 4.1 shows system boundaries B6 and B7a.

4.5.2 A boundary splits the system into two parts, crossing critical circuit paths that carry power between areas and where power flow limitations may be encountered. Boundaries help identify regions where reinforcement is most needed by enabling analysis of power transfers between separated areas. They can be local boundaries, which are small areas of the Transmission System with a high concentration of generation, or wider boundaries, which are large areas containing significant amounts of both generation and demand. Boundary definitions have evolved over many years of planning and operating the transmission system.

4.5.3 Future boundary requirements are assessed using the FES to identify expected future power flows across the boundaries. Power system analysis is conducted by the ESO and NGET to determine the boundary capability, which is the maximum power flow that can be transferred across a boundary while maintaining compliance with technical standards. Limiting factors on transmission capacity include thermal circuit rating, voltage constraints, and dynamic stability.

4.6 Boundaries B6 and B7a

4.6.1 Boundaries B6 and B7a are wider system boundaries containing areas with significant amounts of both generation and demand. Studies have been undertaken to assess the impact of changes in demand and generation on power flows across the boundary and to determine if these impacts require reinforcement to the transmission system.

4.6.2 The boundaries B6 and B7a as described above have been evaluated using the Economy Planned Transfer assessment, which takes prescribed generation contributions from above and below the boundary, alongside demand in each area to determine the expected flow across the boundary. In this case the Economy Planned Transfer condition represents the most onerous boundary condition which must be secured by NGET to the requirements set out in the NETS SQSS.

4.6.3 Each of the circuits which cross the B6 and B7a boundaries has a capacity during the winter ACS period. The summation of the capacities for all of these circuits provides the pre-fault capacity. The post fault capacity is defined by the remaining capacity across a boundary following the worst fault "Secured Event" as described above.

4.6.4 Each boundary then will see flows across it based upon the circuit parameters and system conditions, when the natural flow of energy on every circuit will be maximised. This is known as the circuit boundary capability, which is based upon the capability seen following the worst fault "secured event". The following capacities and capabilities are applicable to the boundaries before reinforcement in 2035.

Table 4.1 - Transmission Boundary Capacity and Capability 2035

System Boundary Export or Generation Group required transfer		2035 Post Fault Capability	2035 Post Fault Capacity	Capability Deficit	Capacity Deficit	Secured Event Fault
B6 – 2035 (system boundary)	28,405 MW	16,800 MW	24,665 MW	-11,605 MW	-3,740 MW	New CMN3 Circuit
B7a – 2035 (system boundary)	25,203 MW	19,700 MW	23,805 MW	-5,503 MW	-1,398 MW	Norton – Osbaldwick Double Circuit

4.6.5 Table 4.2 below shows how the existing generation groups and boundaries perform in 2035 for the expected planned transfer flows.

Table 4.2 - Existing boundary performance by 2035

System Boundary	Pre-Fault Capacity 2035	Post Fault Capacity 2035	Post Fault Capability 2035
B6	31,595 MW	24,665 MW	16,800 MW
B7a	30,457 MW	23,805 MW	19,700 MW

4.6.6 The boundary assessments completed on the Economy Planned Transfer, as defined in the NETS SQS, already account for generation contribution. To ensure that an appropriate measure of need using current assessments of capacity at the date of this report, NGET has taken the Holistic Transition, Electric Engagement, Hydrogen Evolution, CP30 – Further Flex and Renewables and CP30 – New Dispatch boundary requirement scenarios from the ETYS 2024 based upon FES 2024 backgrounds, as of February 2025. An average of all five scenarios has been applied, which aligns with NESO's use of three (plus two CP30, (Clean Power 2030)) background scenarios up to 2035, to identify expected future boundary flows.

4.6.7 As described in the “Communicating our thermal needs” section set out in the NESO ETYS 24 documentation, the FES boundary graphs for each area display two sets of shaded areas. The 50th Percentile of power flows lies in the 25% and 75% range of the graph. The 90th percentile of power flows lies in the 5% to 95% range of the ETYS graphs. It states that where the capability of the boundary is between these two regions, 75% and 95%, over 20 years, then there may be a need for reinforcement.

4.6.8 NGET uses the average of the 95% percentile number across the five scenarios for boundary analysis. This ensures that for all five scenarios, the need case capacity and capability requirement would lie between the 75% and 95% ranges of annual power flows for all five scenarios and demonstrating the need for reinforcement regardless of which scenario occurs. Against this assessment in all five FES 24 and CP2030 scenarios should there is clearly a shortfall against boundary capability and capacity for the B8 and B9 boundaries that by 2035 will require reinforcement.

4.6.9 The largest capacity AC route NGET currently accommodate on NGET's network is two circuit transmission circuits of 3,465 MW each, on a single set of towers (6,930 MW double circuit capacity).

4.6.10 The largest HVDC capacity systems NGET currently accommodate with HVDC cables is 2,000 MW.

4.6.11 Therefore, proposals seek to provide a minimum of 2000 MW of capacity across B6, B7a as a minimum. They also seek to minimise the impact upon any generation group such that no further adverse impact is incurred against proposed generation likely backgrounds.

4.6.12 The ESO independently provide their evaluation of boundaries for the ETYS 2024. For the B6 and B7a boundaries the exports in Table 4.2 align with these assessments. The requirements for 95% of the Leading the Way Scenario as the scenario that meet the government target of 50 GW of offshore wind by 2030.

4.6.13 From 2035, further increases in boundary requirements are expected and this is reflected in NGET's existing contractual commitments. To address these needs additional reinforcements to these boundaries are expected in Central England and Wales which will supplement these boundaries in the future. This will facilitate connections beyond 2030 when further increases in generation are expected in all regions, which will be subject to their own detailed needs case and options assessment. These future requirements would be informed by further SOR and needs case assessments. These emerging requirements do not affect the need case set out within this SOR.

4.7 Needs Case Conclusions

4.7.1 Currently the need for the project set out above indicates by 2035:

- A need to provide Capacity across the B6 and B7a boundaries with proposed 2 GW HVDC connections further reducing the deficit.
- Any options considering connections to Mid Wales would require further transmission works to connect proposed generation and HVDC options within this area.
- HVDC connections are considered post fault neutral in most circumstances as flow can be dropped to 0 MW for a local connection area fault at the NGET end.

5. Options identification and selection process

5.1 Introduction

5.1.1 When a need to reinforce the NETS is established, NGET bring together a multidisciplinary project team to evaluate a wide range of options. This team produces a list of potential strategic options which can be further refined through evaluation processes, and which are described within this report.

5.1.2 The Project Team keeps the options under review, for example, as changes to the drivers emerge as a consequence of interactions with other projects. Throughout this review, potential strategic options can be modified or deselected, and new options can be included.

5.2 Identifying the technically feasible options

5.2.1 Once the need case has been established, there is a requirement to consider the many ways in which the need could be met. Before undertaking any detailed optioneering work, a technical compliance filter was applied to make sure that all of the potential strategic options considered would work on the network, with any that would not meet technical standards or would not work in practice rejected. There are potentially many ways in which the identified need could be met, so further network modelling is carried out to understand the issues better. This initial identification is based on the network planning information which was available from NESO at the time of appraisal.

5.3 Review of recommended technology option

5.3.1 The HND recommendation, published by NESO, includes a HVDC connection from a wind farm in southwest Scotland to a T-point in the South Ayrshire area, which then further connects to a substation in Wales, to enable electricity transmission towards the south of the UK, where electricity consumption is higher. Following this recommendation for the connection of a new 2 GW High Voltage Direct Current (HVDC) link from South Ayrshire to Wales, NGET considered currently available alternative technology options which could be used to address the identified need for additional transmission system capacity.

5.3.2 The largest capacity AC technology option that can be used on NGET's transmission system consists of two 3,465 MW transmission circuits that are supported on a single set of towers (6,930 MW double circuit capacity). The largest HVDC capacity systems that can currently be accommodated on NGET's transmission system are 2,000 MW HVDC cables.

5.3.3 Power flows on AC transmission system circuits cannot be controlled to the same extent as can be achieved using HVDC connections. This lower level of controllability can result in higher power flows particularly during transmission system fault conditions. Taking account of the potential for higher power flows that could be expected, therefore, to provide the potential equivalent capacity, an AC option would need to consist of a

high capacity (6,930 MW) double circuit route to meet any high loading during fault conditions.

5.3.4 Delivery of an onshore solution with a long route length is expected to carry a higher programme and delivery risk compared to a primarily HVDC offshore solution.

5.3.5 An AC based onshore option would be expected to result in a greater level of environmental and socio-economic impact compared to the primarily subsea HVDC options and provides limited benefit over those options. Therefore, it is considered a less preferable option which does not meet the requirements to progress beyond the technical and benefit filter stage.

5.3.6 Further details of the initial evaluation of this onshore alternative option are provided in Appendix G.

5.4 Potential strategic options

5.4.1 NGET began with the identification of technically feasible options which meet the Need Case as is set out in Chapter 4 of this SOR. These options cover a wide geographical area and are presented in this document.

5.4.2 A “benefits filter” to the technically feasible options, which allows NGET to focus on those that best meet its obligations to the environment and consumers. It also ensures that any option presented, has a comparable net benefit over an alternative. The criteria for any potential strategic option to be considered further are any the following:

- An environmental benefit;
- A technical system benefit;
- A capital and lifetime cost benefit, which includes the consideration of initial capital costs and long-term maintenance and operating costs; or
- A socio-economic benefit.

5.4.3 When the net benefits of options are closely aligned, each option is documented and included for appraisal. This ensures that all possible solutions are appraised, regardless of having similar capability.

5.4.4 Following the application of the benefits filter, eleven options were identified as having comparable net benefits and potential technical compliance, warranting further evaluation.

5.4.5 Table 5.1 lists the potential strategic options and is followed by a summary of the benefit filter application for potential options for the Project.

Table 5.1 - Potential strategic options

Potential Strategic Option (Substation Connection Option)	Outcome
1 - Connection to Pentir	Taken forward for detailed appraisal
2 - Connection to Wylfa South	Taken forward for detailed appraisal
3 - Connection to Bodelwyddan	Taken forward for detailed appraisal
4 - Connection to Aberystwyth	Discounted due to lack of existing 400 kV infrastructure in Mid-Wales
5 - Connection to Llanarth	Discounted due to lack of existing 400 kV infrastructure in Mid-Wales
6 - Connection Lampeter	Discounted due to lack of existing 400 kV infrastructure in Mid-Wales
7 - Connection to South Wales Connection Node C	Taken forward for detailed appraisal
8 - Connection to Pembroke	Taken forward for detailed appraisal
9 - Connection to Swansea North	Taken forward for detailed appraisal
10 - Connection to Carmarthen Bay (Llandyfaelog)	Taken forward for detailed appraisal
11 - Connection to Baglan Bay	Taken forward for detailed appraisal
12 - Connection to Aberthaw	Discounted based on failing the technical benefits filter
13 - Connection to South Wales West Connection Node B	Taken forward for detailed appraisal
14 - Connection to Connah’s Quay	Taken forward for detailed appraisal
15 - Connection to Bryncir	Taken forward for detailed appraisal
16 - Connection to Heysham	Discounted on the basis of failing to fully meet the need case drivers

Application of Benefit Filter

5.4.6 There is no existing 400 kV substation/infrastructure in the mid-Wales region. Any connection point at a mid-Wales substation (Aberystwyth, Lampeter, Llanarth) would require at least one double circuit to connect to the network in order to accommodate the 2 GW link of the Project, hence, the three mid-Wales substations have been discounted from the longlist in Table 5.1. These are potential options 4, 5 and 6 to Aberystwyth, Llanarth and Lampeter.

5.4.7 Landing in Aberthaw does not provide any notable benefits when compared to the other potential options. It is a 275 kV substation on the same 275 kV network as Baglan Bay substation, and hence this substation and the local network would need the same reinforcement works when compared to connecting into Baglan Bay substation. However, Aberthaw is further to the east when compared to Baglan Bay and hence would lead to a longer cable route length. This would increase the project capex and increase environmental considerations, when compared with potential option 12 to Baglan Bay. Therefore, this option was discounted.

5.4.8 Landing in Heysham does not fully meet the needs case drivers, as it only provides benefit to the B6 boundary and would require another link towards North Wales to provide a benefit to B7a, hence this option has also been discounted at this stage.

5.4.9 The appraisal of all potential strategic options led to eleven strategic options being selected to take forward for detailed appraisal, the details of which are contained within the proceeding sections. These are indicated within the Table 5.1 outcome column and Table 5.2 in the following section.

5.5 Proposed Strategic Options

5.5.1 Eleven strategic options that potentially achieve the Needs Case and present a socio-economic benefit, an environmental benefit, a technical system benefit or a cost benefit were proposed for detailed appraisal and are outlined in Table 5.2 below. Each proposed strategic option has been checked for compliance with SQSS standard.

5.5.2 Undertaking this appraisal ensures stakeholders can see how NGET have made their judgement and balanced the relevant factors in accordance with the relevant legal duties.

Table 5.2 - Proposed strategic options for appraisal

Proposed strategic option title	Option description[32]
Strategic Option AC6-1 – Pentir	288 km new offshore subsea transmission connection
Strategic Option AC6-2 – Wylfa South	252 km new offshore subsea transmission connection
Strategic Option AC6-3 – Bodelwyddan	306 km new offshore subsea transmission connection
Strategic Option AC6-4 – Pembroke	504 km new offshore subsea transmission connection
Strategic Option AC6-5 – South Wales West Connection Node C	552 km new offshore subsea transmission connection
Strategic Option AC6-6 – Carmarthen Bay (Llandyfaelog)	576 km new offshore subsea transmission connection
Strategic Option AC6-7 – Swansea North	612 km new offshore subsea transmission connection
Strategic Option AC6-8 – Baglan Bay	612 km new offshore subsea transmission connection
Strategic Option AC6-9 – South Wales West Connection Node B	630 km new offshore subsea transmission connection
Strategic Option AC6-10 – Connah's Quay	330 km new offshore subsea transmission connection
Strategic Option AC6-11 – Bryncir	303 km new offshore subsea transmission connection

5.6 NGET's approach to appraising the proposed strategic options

5.6.1 At this stage of the optioneering process, the approach is based on the identification of 'differentiators.' This is where, one option clearly provides a benefit over another, for example, in the form of a lesser environmental impact. At this stage, it is often not possible to identify differences against all appraisal factors due to the limited design detail and broad geographical area being considered.

[32] The methodology for calculating the option length is set out in the appraisal assumptions below.

5.6.2 This SOR will be subject to continuous back-check and review throughout the development stages. This means the evaluation that has been undertaken and is presented in this document will be revisited as the project progresses and further information becomes available or as circumstances evolve.

5.6.3 The appraisal process considers the following areas:

- Environmental appraisal topics which consider whether there are environmental constraints or issues of sufficient importance to influence decision making at a strategic level, having particular regard for internationally or nationally important receptors.
- Socio-economic topics which consider whether there are socio-economic constraints or issues of sufficient importance to influence decision making at a strategic level, having particular regard for internationally or nationally important receptors.
- Consideration of technical benefits includes, whether the option is providing the required capacity to meet the need case; whether the option has particular system benefits over alternatives; whether the option introduces any system complexity that would cause system operability issues.
- Consideration of capital and lifetime costs includes a range of factors:
  - Capital cost of the substation and wider works
  - Capital cost of the circuit costs for each technology appraised
  - Circuit lifetime costs, including circuit capital cost, cost of loses over 40 years and cost of operation over 40 years.

Appraisal assumptions

5.6.4 When considering each strategic option, NGET estimate circuit cost information for the following technology options for all offshore based options:

a) 400 kV AC Offshore cable

b) 525 kV HVDC Offshore cable and converter stations

5.6.5 A full evaluation and costs used in the appraisals can be found in Appendix D.

5.6.6 In this appraisal, all options are considered using information appropriate to this stage of their development on the assumption that they are deliverable in a reasonable timescale. Timescales and deliverability would only be considered further in the appraisal process should they become differentiating factors in the selection of the option that best meets NGET's environmental and legal obligations. If these issues of delivery timescales and risk do become differentiating factors in selection of an option, the issue would be set out clearly in the options conclusion. If these factors are not differentiating, they will not be considered further for this appraisal.

5.6.7 At this initial appraisal stage, NGET prepare indicative estimates of the capital costs. These indicative estimates are based on the high-level scope of works defined for each strategic option in respect of each technology option that is considered to be feasible. As these estimates are prepared before detailed design work has been carried out, NGET make equivalent assumptions for each option. Final project costs for any solution taken forward following detailed design, consenting and mitigation will be in excess of any high-level appraisal cost. However, all options would incur these increases

proportional to initial estimate in the development of a detailed solution. This methodology ensures that all options for appraisal are compared on a like-for-like basis.

5.6.8 Strategic options are identified at a high level as solutions for the transmission of electricity between defined geographic points. For onshore strategic projects, estimated potential circuit lengths are derived by summing straight-line distances between successive nodes identified for the whole route, with a 20% allowance applied to accommodate potential route deviations that may arise should the option progress to more detailed routing and siting. Where a clear constraint exists, such as an estuary, watercourse, or other significant geographical feature, an alternative route length will be derived and explained within the option. For offshore elements, straight-line distances are taken to an offshore midpoint, with a 20% allowance applied to provide for variation in route length.

5.6.9 These initial option lengths do not define route corridors, and environmental appraisal is provided over a wide study area between points of connection. Any routes for circuit technologies to take would be subject to detailed routeing and siting for any strategic option taken forward as a preferred option(s).

5.6.10 Landfall locations along the Wirral coastline, following a similar corridor to Western Link 1 (WL1), were considered alongside potential landfall options in North Wales and South Wales. However, the Wirral coastline presents significant constraints when assessed against the landfall siting criteria. These constraints include extensive intertidal areas exceeding 1.5 km in width along much of the coastline, a high concentration of marine designations, and limited feasible onward routing opportunities due to dense urbanisation, the presence of settlements, recreational areas, and heritage assets terrestrially. As a result, available corridors are highly constrained in comparison to alternative landfall locations in North and South Wales, and the consideration of landfall options along the Wirral coastline was not taken forward.

5.6.11 The options in the following sections of this report have been taken forward in this document as they meet the Needs Case and have been selected using the methodology set out above.

Summary points

5.6.12 Eleven strategic options that potentially achieve the Need Case and present an environmental benefit; a technical system benefit; a socio-economic benefit; or a capital and lifetime cost benefit, which includes the consideration of initial capital costs and long-term maintenance and operating costs; were proposed for detailed appraisal.

5.6.13 The details and results of this detailed appraisal follow in Chapter 6 onwards.

6. The results of NGET's appraisal of strategic options

6.1 Introduction

6.1.1 This chapter presents a summary of the findings of the appraisal process undertaken for each of the eleven strategic options identified for the Project. This section will discuss each of the options, looking at each option from a technical, environmental, socio-economic, and cost perspective. This section concludes with a tabulated summary of the appraisal to provide a visual indication of the benefits and disadvantages of each option comparatively.

6.1.2 In this appraisal, all options are considered using information appropriate to this stage of their development on the assumption that they are deliverable in a reasonable timescale.

6.1.3 Strategic options are identified at a very high level as being electrical solutions between geographic points. Therefore, the potential circuit lengths are derived by taking a straight-line distance between the points and adding 20% to accommodate potential route deviations that might be required if the route proceeds forward to more detailed routeing and siting. This reflects standard methodology at this stage of the process.

6.1.4 At this development stage potential landfalls across North Wales and South Wales for the new HVDC circuits were assessed to confirm that feasible connection opportunities exist. A number of potential areas for landfall were identified. Each potential strategic option detailed in this report has a defined potential landfall (the point at which the offshore cables reach the shore) and connection point (the point at which the Project connects to the wider transmission network).

6.1.5 NGET notes that there are common features and considerations across multiple strategic options. However, the appraisal of these shared elements has been included within the sub-section for each individual strategic option.

6.1.6 The Project will require works within the licence areas of both SPEN (the Transmission Owner across southern Scotland) and NGET (the Transmission Owner across England and Wales).

6.1.7 Within this SOR, the lengths of the study areas, and associated circuit costs, account for the total distance from the starting point in Scotland to the end point in Wales. The technical appraisal, including NGET's view on required substation works, does not account for works required at substations owned and operated by SPEN, or new substations that may be required within SPEN's licence area. The environmental and socio-economic appraisal has considered cross-border marine issues from the landfall in SPEN's licence area in Scotland through to the landfall in NGET's licence area in Wales. However, the environmental and socio-economic appraisal does not consider terrestrial elements within SPEN's licence area in Scotland, which will be appropriately considered by SPEN in their ongoing design evolution and subsequent environmental appraisal works.

6.1.8 Regarding the cost appraisals for each of the strategic options, the cost tables included within each appraisal present figures and numbers for the following cost terms, with

definitions provided in the bullet points below. The same applies for all other strategic options presented within section 6.2 of this report.

- Capital Cost of New Circuits is a term utilised to demonstrate the initial capital expenditure associated with the implementation of a new circuit.
- Net Present Value (NPV) of Cost of Losses is a term utilised to demonstrate the present-day monetary value of cost of losses while factoring in initial capital investment required for the project.
- NPV of Operation and Maintenance Costs is a term utilised to demonstrate the present-day monetary value of operation and maintenance costs while factoring in initial capital investment required for the project.
- Lifetime Cost of New Circuits is a term utilised to demonstrate the total capital expenditure associated with the implementation of a new circuit and is calculated by summing the above three cost terms.

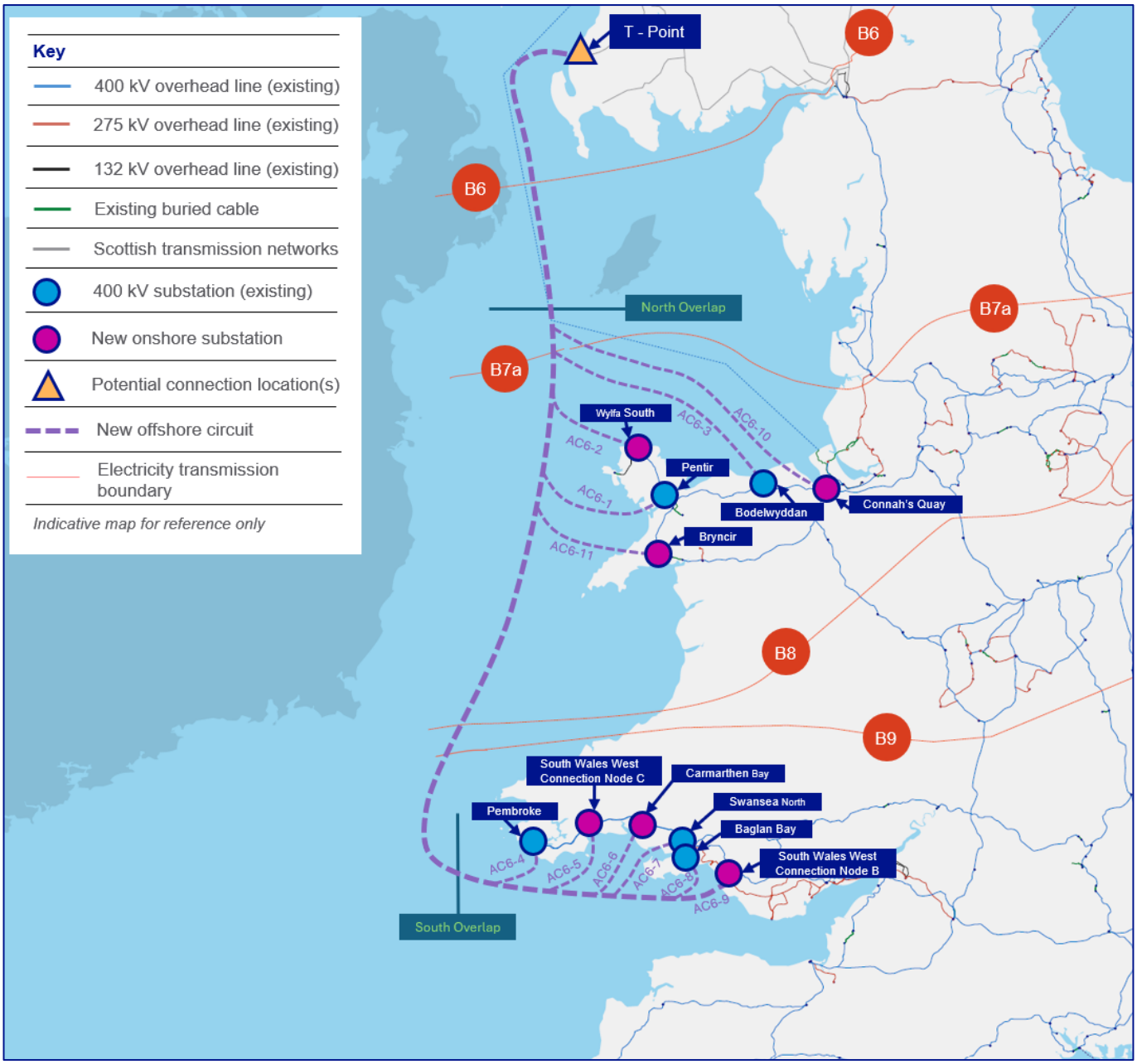
6.1.9 It should be noted that all the figures within this chapter 6 are indicative and do not represent feasible routes for potential assessment or installation; they should instead be considered for illustrative purposes only.

6.2 Appraisal of the strategic options

6.2.1 Figure 6.1 below illustrates all eleven strategic options that have undergone detailed appraisal, as discussed within chapter 6 of this Strategic Options Report (SOR). The common study area for all the strategic options extends from the starting point at T-Point in Scotland to the southern tip of the Isle of Man, referred to as the North Overlap. Beyond this common point, the study areas for the strategic options diverge as they head towards the northern Welsh coastline. Following an initial environmental assessment, the area to the east of the Isle of Man was excluded from the detailed appraisal due to the extensive existing and proposed marine infrastructure located southeast of the Isle of Man (within both the Isle of Man's and English waters), which would likely obstruct any potential cable route corridors in this region.

6.2.2 The area between T-Point and the southern part of Wales, designated as the South Overlap, serves as the common study area for all strategic options with connection points in South Wales. Each strategic option's study area encompasses these common areas, with North Wales-landing options considering the North Overlap section, while South Wales-landing options account for both the North and South Overlaps. Additionally, each strategic option incorporates the individual areas as presented in the map, Figure 6.1 below.

Figure 6.1 - Map view of all strategic options



6.2.3 All strategic options are appraised under the assumption that the entire length of the HVDC lines for all options, AC6-1 to AC6-11, will be installed subsea and underground after the landfall up to the respective substations. The routes of the strategic options shown in the figures in this SOR, especially in this chapter 6, are all indicative maps and solely for reference only and are not to be considered as routing.

6.2.4 It is important to note that the Options Appraisal Summary Tables (OAST's), which informed the routes identified in Figure 6.1, assessed each route against specific criteria related to various environmental, social, and technical constraints. This assessment aimed to identify the most appropriate routes between the proposed connection points. Consequently, where there is a high concentration of constraints near a connection point, the routes have been designed to avoid interactions as much as reasonably possible. For instance, the avoidance of routing to the east of the Isle of Man is due to a

high concentration of marine infrastructure to the north of the Bodelwyddan route, which is not traversable. As a result, the proposed route to the Bodelwyddan connection point is confined to a narrow study area.

6.2.5 The environmental and socio-economic appraisal considered whether there is a potential to identify a suitable location for an onshore converter station within 5 km of each substation of interest. As there is the intention to avoid various receptors of varying perceived susceptibility to change, there is an acknowledgement that there may be receptors outside of the study areas considered for high-level routeing and siting which could be affected should construction activity and permanent infrastructure be installed in their vicinity. In particular, this is acknowledged when considering the receptor of Eryri (Snowdonia) National park, which is located outside the study area but could be susceptible to activities associated with the Project.

6.2.6 A detailed environmental analysis of the SPAs and SACs is yet to be undertaken. Therefore, within the assessment below, whether there "could" be effects is a worst case and is subject to that detailed analysis being undertaken. This allows for this appraisal to be carried out on an equal basis across the eleven strategic options. Further, scheme mitigation is not yet determined and neither is the extent of that mitigation that can be considered as "embedded" for the purposes of the assessment. Following that detailed analysis there will be backcheck to ensure the actual assessed effects are taken account in the route optioneering process.

Identification of Potential Landfall Locations

6.2.7 Indicative landfall identification utilised the characterisation of sensitive receptors across both the marine and terrestrial environments to identify areas which have the potential to be considered for a viable landfall location.

6.2.8 In identifying potential landfall sites, consideration has also been given to:

- the physical space available to accommodate the temporary works and permanent footprint of one or both projects at the landfall site;
- the characteristics of the coastal area, which were reviewed to identify areas which were appropriate for cable burial (either through trenched or trenchless solutions). These characteristics were cliff heights of less than 30m, and an intertidal range of less than 1.5 km, due to the technical installation constraints which would otherwise arise;
- the potential for offshore routeing for 15 km to ensure that there are feasible corridors from the landfall site; and
- the potential for onshore routeing to the identified substation and converter station buffer area (5 km buffer) around each connection point ensures that there are feasible corridors from the landfall site.

Strategic Option AC6-1 – Pentir

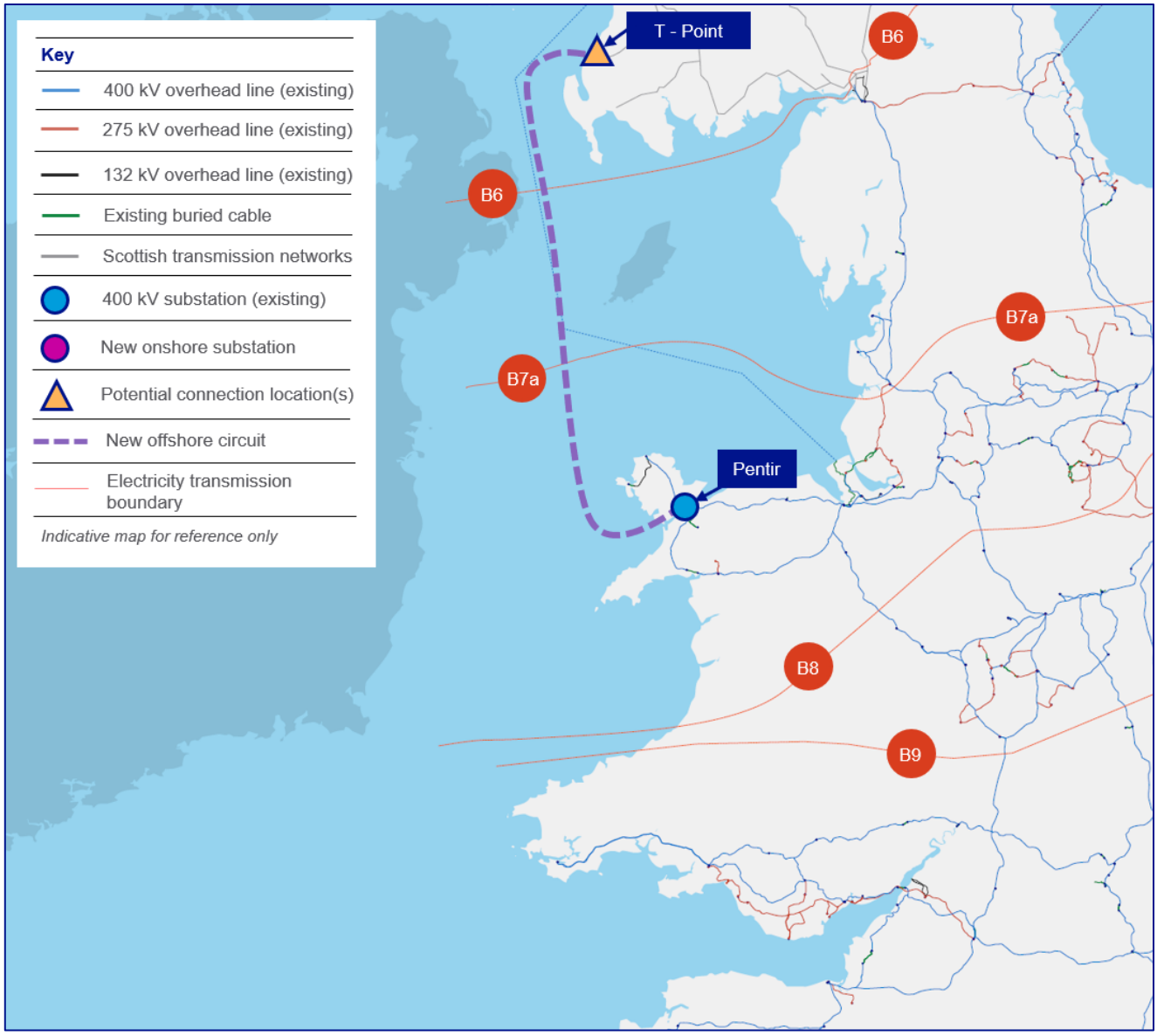
Description of the strategic option AC6-1

6.2.9 Strategic Option AC6-1 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) to the existing Pentir 400 kV substation in north Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the northern Welsh coastline.

6.2.10 For the purposes of the appraisal of Strategic Option AC6-1, consideration has been given to the additional costs or impacts of accommodating the Project connection at the existing Pentir 400 kV substation.

6.2.11 Figure 6.2 below presents an indicative map for Strategic Option AC6-1 (for illustrative purposes only and does not denote viable development route)

Figure 6.2 - Indicative study area of Strategic Option AC6-1



6.2.12 The circuit distance for this connection is 288 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Pentir substation.

6.2.13 This strategic option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Pentir. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project connection, which falls within NGET's licence area. Approximately 12 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.14 There are a number of international and national designated marine ecology sites present throughout the study area comprising Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs), Marine Conservation Zones (MCZs), Marine Protected Areas (MPAs) and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- All SPAs, SSSIs, MCZs and Annex I habitats can be avoided
- There are two SACs – The North Anglesey Marine SAC and The North Channel SAC – that are unlikely to be avoidable
- There is one MPA – The Clyde Sea Sill MPA – that cannot be avoided

6.2.15 Strategic Option AC6-1 passes through two likely unavoidable SACs; one off the coast of Northern Ireland and one off the coast of Anglesey in North Wales. There is also one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations. Regarding the SPAs, although they can be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.16 Where features cannot be avoided, there is potential for habitat loss or damage as a result of construction activities (e.g. cable burial, cable protection). Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats, where appropriate.

6.2.17 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.18 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. Construction Environmental Management Plan, CEMP) to reduce potential effects to the marine environment.

6.2.19 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. However, it will remain likely, and therefore it is anticipated, that there will be consenting implications related to these designated sites, such as potential seasonal restrictions.

6.2.20 It should be noted that there are currently nine cables which cross The North Channel SAC, eight cables which cross the North Anglesey Marine SAC, and six that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, all three sites are likely to require crossing.

Marine Historic Environment

6.2.21 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.22 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.23 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.24 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.25 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.26 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present.

6.2.27 The landfall area around Pentir has a beach width less than 500 m and a coastal height which is mostly less than 30 m so it may be suitable for landfall.

6.2.28 An unavoidable designation within Strategic Option AC6-1’s study area is the Clyde Sea Sill MPA. This MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed' and cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.29 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.30 This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort’s Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.31 Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required.

6.2.32 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.33 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.34 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely, however, that there will be consenting implications related to this designated site.

6.2.35 It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal - Terrestrial

Terrestrial Ecology

6.2.36 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising Special Protection Areas (SPAs), Special Area of Conservation (SACs), Ramsar sites, Sites of Special Scientific Interest (SSSIs), Natural Nature Reserves (NNRs), Country Parks, Local Nature Reserves (LNRs) and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- There are no SPAs or Ramsar sites within the study area of this strategic option.
- There is one SAC – the Afon Gwyrfai a Llyn Cwellyn SAC – which cannot be avoided.
- There is one SSSI – the Afon Gwyrfai a Llyn Cwellyn SSSI – which cannot be avoided.
- All other ecological receptors could be avoided.

6.2.37 There is potential for impacts, resulting from construction activities of the cable system to designated feature Afon Gwyrfai a Llyn Cwellyn (SAC and SSSI) that cannot be avoided. The SAC and SSSI will require crossing which would likely result in habitat loss, loss of vegetation, as well as visual and biodiversity impact.

6.2.38 There are other designated sites including SACs, NNR and SSSIs which will most likely be in close proximity to the cable. This may result in temporary adverse effects upon the designations, in addition to the potential for direct and indirect impacts to protected species.

6.2.39 Mitigation in relation to SACs and SSSIs may include surveys to confirm habitats present, micro routeing and/or trenchless installation methods. While routeing underground cables through or near these designated sites could be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. It is not anticipated that there would be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, NNR and SSSI etc).

6.2.40 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory bodies to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.41 Permanent impacts from the converter station during the operational phase could be mitigated through standard landscaping and visual screening measures. Appropriate mitigation will be identified in subsequent stages as appropriate assessment work is carried out.

6.2.42 It is not anticipated that there would be any long term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.43 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a small number of statutory designated ecological designations (i.e. SSSIs to the north and southeast of the substation connection station approximately 3 km away), however, within the 5 km radius, there are large amounts of areas clear of these designations. Thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.44 Within this strategic option, no Air Quality Management Areas (AQMAs) have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.45 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 1, 2, 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites. From these, some Grade 2 and 3 of Agricultural land cannot be avoided, however, geopark, peatland and Regionally Important Geodiversity Sites could be avoided.

6.2.46 There may be a need to route through high value agricultural land if other areas are heavily constrained. There is potential for adverse effects on agricultural land and soils, which may present scrutiny from technical consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration and loss of agricultural productivity.

6.2.47 It is generally advisable to avoid routeing through Grade 1, 2 and 3a agricultural land, where possible. If routeing through these areas is unavoidable then standard protection measures could be applied during the construction phase to minimise impacts on soils.

6.2.48 Construction methods such as low-ground-pressure machinery can be utilised to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may also be required to verify desk-based data. With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.49 Whilst some areas of Grade 2 and 3 agricultural land cannot be avoided, due to the temporary nature of construction works and the implementation of construction mitigation measures to sustainably manage and protect soils, it is unlikely there would be adverse long-term impacts to deem this strategic option unfeasible.

6.2.50 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Several land parcels around the substation are classified as Grade 4 or lower, making them more suitable locations for the converter station. However, mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.51 Landscape and Visual Amenity constraints have been identified across this strategic option's study area, including National Parks, Coastal Paths, Areas of Outstanding Natural Beauty (AONB), National Trails, Biosphere Reserves, Heritage Coasts and LandMAP aspects. Historic, Geological and habitat landscapes have also been considered. LandMAP aspects are five national datasets (across Wales) consisting of Geological Landscape, Landscape Habitats, Visual and Sensory, Historic Landscape, Cultural Landscape Services.

6.2.52 More specifically, there are two Coastal Paths which cannot be avoided - the Wales Coast Path and the Isle of Anglesey Coastal Path. All National Parks and AONBs could be avoided. There are four LandMAP aspects rated as High, and one rated as Outstanding within this strategic option largely along the coastline.

6.2.53 There is a potential that the Coastal Paths mentioned above will likely require crossing and would result in potential temporary visual impacts to their users.

6.2.54 There would likely be consenting implications as a result of closing, stopping or diverting Public Right of Way (PRoW). This could lead to timeline delays.

6.2.55 Although National Parks and AONBs could be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.56 Mitigation measures would likely include cabling via trenchless installation methods (such as Horizontal Directional Drilling (HDD)) and careful routeing of trenched installation methods, as well as likely implementing erosion control measures.

6.2.57 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), National Parks, AONBs and Coastal Paths where possible.

6.2.58 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.59 Regarding suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase could be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.60 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-1 study area.

6.2.61 From the above, all Listed Buildings, Scheduled Monuments (SMs), Conservation Areas and Registered Parks and Gardens could be avoided, however, there is one RLOSI that cannot be avoided.

6.2.62 There is potential for temporary impacts to occur to the setting of the heritage assets, however, most assets could be directly avoided with careful routeing of the cable. One RLOSI requires crossing when routeing to the substation as it covers the radius surrounding Pentir substation. There are also multiple Scheduled Monuments and Listed Buildings within close proximity to the potential routeing line. However, all impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration and visual impacts. There are limited assets that are within the study area of this strategic option.

6.2.63 Mitigation would require careful routeing to avoid impacts to designated heritage assets; standard protection measures could be applied during the construction phase. Screening and vibration monitoring mitigation measures may be implemented during the construction phase to reduce impact to Scheduled Monuments and Listed Buildings in close proximity.

6.2.64 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long-term visual impact is low risk due to avoiding the use of Overhead Lines (OHLs).

6.2.65 There are unlikely to be adverse effects on the designated assets within the strategic option study area when careful routeing and site selection is undertaken.

6.2.66 Regarding suitability for the additional converter station, the proposed converter station will require careful consideration of the area surrounding the substation to avoid impacts to the RLOSI, Listed Buildings and Scheduled Monuments. This is necessary to minimise the potential setting impacts on the designated assets. However, all other assets are not situated within the 5 km radius.

Hydrology

6.2.67 Strategic Option AC6-1’s study area includes three main rivers that cannot be avoided.

6.2.68 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.69 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures could be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an Flood Risk Assessment (FRA), and management). The appropriate consents could be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.70 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.71 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.72 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and Flood Risk Assessment (FRA), the long-term adverse effects on hydrology are unlikely to be significant.

6.2.73 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, considering that main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses, 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.74 Throughout Strategic Option AC6-1, the following receptors have been considered: Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are no currently consented wind/wave/or tidal site agreements within this strategic option. There are, however, two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 18 cables which cannot be avoided.
- There is one active disposal site which could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.75 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements. Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.76 The disposal site off the coast of Scotland could be avoided via routeing and siting.

6.2.77 There is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications.

6.2.78 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation.

6.2.79 Notice to mariners, engagement with Fisheries Liaison Officer(s) (FLOs), and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option's study area.

6.2.80 Under any strategic option selected, there will be a requirement to cross three pipelines and at least 18 cables. AC6-1 has amongst the fewest crossing that will be required. The disposal site could be avoided via routeing and siting mitigation.

6.2.81 There are shipping routes and fishing grounds within this strategic option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.82 There are two notable settlements, Bangor and Caernarfon, within the study area of this strategic option, both of which could be avoided through careful routeing.

6.2.83 Routeing in close proximity around urban areas could have temporary adverse effects on residential and commercial receptors, i.e. road closures, noise and vibration and other disruptions. Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.84 Routeing directly through or under the two aforementioned settlements is not possible.

6.2.85 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.86 Implementation on Construction Traffic Management Plan (CTMP) may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include Noise and Vibration (N&V) control measures and potential screening.

6.2.87 With appropriate mitigation measures in place, it is unlikely that there would be residual effects to these receptors.

6.2.88 There are unlikely to be adverse effects on the features identified within the study area. Settlements are present within this strategic option, however, due to the temporary nature of the construction works and with careful routeing, impacts on these areas could be avoided.

Tourism and Recreation

6.2.89 There are no areas of National Trust Land within this study area. However, there are four National Cycle Network routes, of which, National Cycle Network Route 8 cannot be avoided.

6.2.90 Crossing this route would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping or diverting the Cycle Network. This could lead to timeline delays.

6.2.91 If it is not possible to avoid a National Cycle Network route, standard protection measures could be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and burial of

the cabling (via either trenched or trenchless installation methods) and an appropriate CEMP, the impacts would not be permanent. It has been noted in the past that similar land owned by Sustrans, has been deemed as Crown Authority land, where no Compulsory Acquisition powers are afforded and there is the potential for excessive costs. This is much harder to determine at this stage of the project and will rely on land ownerships to be more progressed.

6.2.92 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.93 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the assets or users within the study area (due to the temporary nature of the cabling works) when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.94 Across the study area of Strategic Option AC6-1, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- Two OHLs may require crossing.

6.2.95 Regarding the two OHLs that may require crossing, due to the underground nature of the works, no adverse effects will occur, however, height restrictions on construction vehicles and standard protection measures will be employed during construction practices and coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.96 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.97 Regarding suitability for the additional converter station, the study area for the proposed converter station falls within the area where the Historic Landfill Sites, Ports, OHLs and Heliports area is located, therefore, careful placement is required. However, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.98 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-1 would satisfy the National Electricity Transmission System (NETS) Security and Quality of Supply Standards (SQSS), whilst providing uplift in transmission capacity across boundaries B6 and B7a.

6.2.99 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the existing Pentir 400 kV substation in North Wales.

- A new 525 kV DC converter station at Pentir would be required and the existing Pentir 400 kV substation would require a two-bay extension with associated substation works.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.100 As mentioned in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable

b) 525 kV HVDC subsea cable and converter stations

6.2.101 Strategic Option AC6-1 requires the following transmission works to satisfy the requirements of the Security and Quality of Supply Standard (SQSS):

- Substation Works
  - Pentir would require bay extensions and associated works to accommodate the connection of AC6.
- New Circuit Requirements
  - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
  - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Pentir substation.

6.2.102 Table 6.1 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.1 – Capital Costs for Strategic Option AC6-1

Item	Capital Cost	
Substation and Wider Works	£82.0m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (288 km)	£12,279.2m	£2,500.4m
Total Capital Cost	**£12,361.2m**	**£2,582.4m**

6.2.103 Table 6.2 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.2 – Lifetime cost by subsea technology Option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£12,279.2m	£2,500.4m
NPV of Cost of Losses over 40 years	£280.7m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£66.0m	£74.3m
Lifetime Cost of New Circuits	**£12,626m**	**£2,732m**

6.2.104 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has a reasonable NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.105 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-1 is a 288 km connection, configured as an HVDC subsea circuit, between T-Point and the existing 400 kV Pentir Substation. In light of this analysis, the starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-2 – Wylfa South

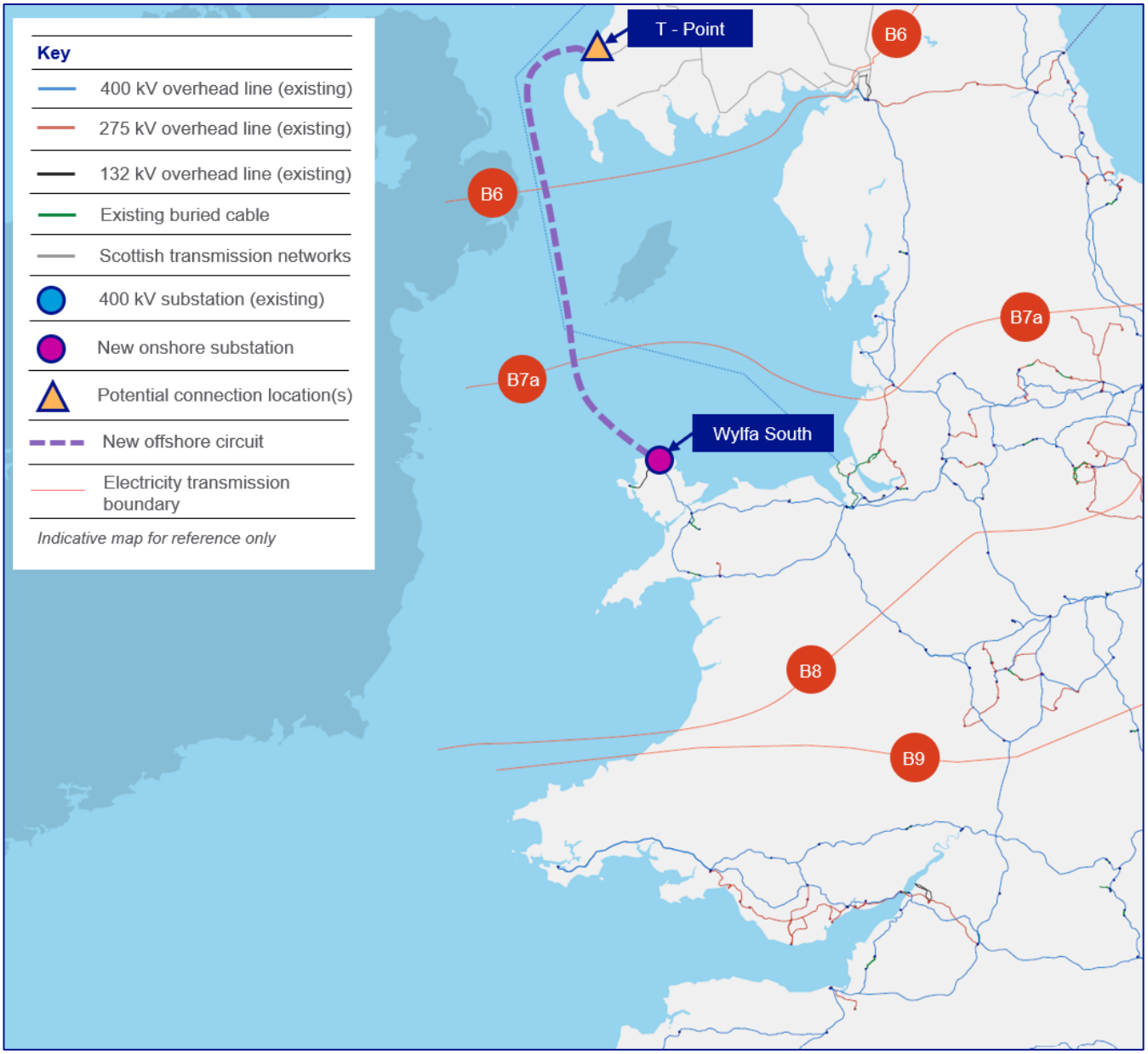
Description of the strategic option AC6-2

6.2.106 Strategic Option AC6-2 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) to the proposed Wylfa South 400 kV substation. The majority of the new circuit would be routed within the Irish Sea, making landfall on the northern Welsh coastline.

6.2.107 For the purposes of the appraisal of Strategic Option AC6-2, consideration has been given to the additional costs or impacts of accommodating the Project connection at the proposed Wylfa South 400 kV substation.

6.2.108 Figure 6.3 below presents an indicative map for Strategic Option AC6-2 (for illustrative purposes only and does not denote viable development route).

Figure 6.3 – Indicative study area of Strategic Option AC6-2



6.2.109 The circuit distance for this connection is 252 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Wylfa South substation.

6.2.110 This strategic option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Wylfa South. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 11 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.111 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- There is one SPA – Anglesey Terns SPA – this cannot be avoided
- There is one SAC – North Anglesey Marine SAC – this cannot be avoided
- There is one MPA – The Clyde Sea Sill MPA – this cannot be avoided.
- All SSSIs and MCZs could be avoided
- There is one SAC – The North Channel SAC – that is unlikely to be avoided
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.112 Strategic Option AC6-2 passes through one unavoidable SPA and one unavoidable SAC, one likely unavoidable SAC off the coast of Northern Ireland and one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations. Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.113 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.114 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects on the marine environment.

6.2.115 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction

methods. It will remain likely and, therefore, it is anticipated that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.116 It should be noted that there are currently two cables which cross the Anglesey Terns SPA, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

Marine Historic Environment

6.2.117 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.118 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.119 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.120 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.121 At this stage, it cannot be confirmed that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.122 Sediment type and depth throughout this strategic option is variable. Throughout the corridor there are areas of exposed bedrock.

6.2.123 The beach width around the potential Wylfa South landfall area is less than 500 m and the coastal height is mostly less than 30 m. Therefore, this area may be suitable for landfall.

6.2.124 The Clyde Sea Sill MPA is partially designated for its ‘circalittoral and offshore sand and coarse sediment communities’ and ‘marine geomorphology of the Scottish shelf seabed’, and it cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.125 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort’s Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.126 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.127 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial.

6.2.128 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.129 Additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.130 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely, however, that there will be consenting implications related to this designated site.

6.2.131 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.132 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- There is one SAC which cannot be avoided – Abermenai to Aberffraw Dunes SAC.
- There is one SSSI which cannot be avoided – Llyn Alaw SSSI
- There are no SPAs, NNRs, Dedicated Forests or Ramsar sites within this strategic option.
- All other receptors could be avoided.

6.2.133 There is potential for impacts to designated features (SAC, SSSIs, LNRs, Registered Common Land, RSPB Reserve and Ancient Woodland Inventory) associated with construction activities of the cable. The designated features associated with this strategic option are avoidable. If crossing of the designated features is unavoidable it would likely result in habitat loss, loss of vegetation, and a visual and biodiversity impact. The designated sites which will most likely be in close proximity to the cable may experience temporary adverse effects.

6.2.134 Mitigation in relation to SAC, SSSIs, LNRs, Registered Common Land, Royal Society for the Protection of Birds (RSPB) Reserve and Ancient Woodland Inventory may include surveys to confirm habitat and micro routeing and/or trenchless installation methods. While routeing underground cables through or near these designated sites could be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SAC, SSSIs, LNRs, Registered Common Land, RSPB Reserve and Ancient Woodland Inventory).

6.2.135 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a small number of statutory designated ecological designations (i.e. SSSIs to the west, southwest and northeast of the substation

connection station) however within the 5 km radius there are large amounts of areas clear of these designations thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.136 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.137 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 1, 2, 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites. From these, Grades 1 and 2 agricultural lands may not be avoided, and Grade 3 agricultural land cannot be avoided.

6.2.138 GeoMôn UNESCO Global Geopark is a Geopark covering the entire island of Anglesey within the study area of AC6-2, hence, it will require crossing. However, peatland and Regionally Important Geodiversity Sites could be avoided. There may be a need to route through high value agricultural land if other areas are heavily constrained. There is potential for adverse effects on agricultural land and soils.

6.2.139 Construction on this land may lead to soil compaction, which reduces soil permeability, aeration and loss of agricultural productivity. Adverse impacts may occur to the Geopark in respect to disturbance to natural beauty, geological features and impacts may lead to sanctions and even loss of UNESCO designation.

6.2.140 It is generally advisable to avoid routeing through Grade 1, 2 and 3a agricultural land where possible. If routeing through these areas is unavoidable then standard protection measures could be applied during the construction phase to minimise impacts on soils.

6.2.141 Construction methods such as low-ground-pressure machinery can be utilised to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may also be required to verify desk-based data.

6.2.142 When routeing through the GeoPark, standard protection measures could be applied during the construction phase to minimise permanent impacts. Early engagement with the respective specialist consultee would be required to discuss mitigation measures.

6.2.143 With the implementation of appropriate mitigation measures, it is unlikely that there would be residual effects to these receptors.

6.2.144 Whilst there are areas of Grade 1 and 2 agricultural lands within this strategic option, these areas could be avoided through detailed routeing and siting. Whilst areas of Grade 3 agricultural land may not be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.145 Even though the Geopark has to be crossed, there is potential for construction within this area with the consenting implications. Due to the temporary nature of the works, there are not anticipated long term adverse effects.

6.2.146 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Very few land parcels around the substation are

classified as Grade 4 or lower, with the majority of land in a 5 km radius being Grade 3b. Areas of Grade 4 or below are more suitable locations for the converter station, however, mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.147 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

6.2.148 For strategic option AC6-2, there is one Coastal Path which cannot be avoided – the Isle of Anglesey Coastal Path (Llwybr Arfordirol Ynis Môn). There are three LandMAP aspects rated as High, and one rated as Outstanding within this strategic option largely along the coastline.

6.2.149 There is one AONB that cannot be avoided within the study area of this strategic option – Anglesey (Ynys Môn) AONB. Mitigation measures may be required whilst traversing the AONB and would likely include cabling via trenchless installation methods such as HDD as well as likely implementing erosion control measures. It is not considered feasible to underground via trenchless solutions through the entirety of the AONB.

6.2.150 Views from the AONB and users of the Coastal Path are likely to be affected albeit for a temporary period during the construction phase, due to vehicles and other construction equipment. There would likely be consenting implications as a result of closing, stopping up or diverting ProW, which could lead to timeline delays.

6.2.151 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and careful routeing of trenched installation methods, as well as likely implementing erosion control measures.

6.2.152 These measures may also include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), AONBs and Coastal Paths where possible.

6.2.153 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.154 Regarding the suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.155 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-2 study area. All of these can be avoided.

6.2.156 There is potential for temporary impacts to occur to the setting of the heritage assets, however, all assets could be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration and visual impacts.

6.2.157 There are unlikely to be adverse effects on the designated assets within the study area when careful routeing and site selection is applied.

6.2.158 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of location surrounding the substation to avoid the RLOSI area to northeast of the substation connection point and Listed Buildings. This is necessary to minimise the impact to setting on the designated assets. The 5 km radius surrounding the substation is densely populated with assets within this strategic option. Careful setting and siting would be required.

Hydrology

6.2.159 For strategic option AC6-2, the following receptors have been considered; Main Rivers, Water Courses, Surface Water and Flood risk from: Rivers, the Sea, Surface Water and Small Watercourses, Areas Benefitting from Flood Defences. Of these, there are three main rivers that cannot be avoided.

6.2.160 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.161 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures could be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.162 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.163 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.164 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.165 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, considering that four main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses, i.e. implementing a minimum construction buffer from watercourses, 30m or more.

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.166 Throughout Strategic Option AC6-2, the following have been considered to potentially have an effect; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which could be avoided.
- There are three currently consented wave energy site agreements within this strategic option. There are no currently consented wind or tidal sites. There are however two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 18 cables which cannot be avoided.
- There is one active disposal site, this could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.167 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.168 The three wave energy sites can be avoided via routeing and siting.

6.2.169 The disposal site off the coast of Scotland can be avoided via routeing and siting.

6.2.170 There is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications.

6.2.171 Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.172 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation.

6.2.173 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.174 Under any strategic option selected, there will be a requirement to cross three pipelines and at least 18 cables. The Wylfa South Strategic Option has amongst the fewest crossings that will be required. The three wave sites and disposal site could be avoided via routeing and siting mitigation.

6.2.175 This option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area.

6.2.176 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.177 There is one notable settlement, Amlwch, in the northern section of this strategic option which could be avoided. From landfall there are sporadic individual settlements located throughout the study area, all of which could be avoided.

6.2.178 The Amlwch settlement, and all the individual settlements, could be avoided through detailed routeing. Routeing in close proximity, around, urban areas could have temporary adverse effects on residential and commercial receptors, i.e. road closures, noise and vibration and other disruptions.

6.2.179 Effects could include disruption to local communities and traffic congestion, through the potential increased construction traffic and dust which could result from construction vehicles.

6.2.180 Routeing directly through or under these settlements is not possible.

6.2.181 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.182 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.183 With appropriate mitigation measures in place, it is anticipated that it would be unlikely that there would be residual effects to these receptors.

6.2.184 There are unlikely to be adverse effects on the features identified within the study area. The limited settlements that are present within this strategic option are unlikely to have adverse effects due to the temporary nature of the construction works and with careful routeing, these areas could be avoided.

Tourism and Recreation

6.2.185 Both National Trust Land and the National Cycle Network could be affected by this Strategic Option.

- National Trust land could be avoided. Where it cannot be avoided, it would require special parliamentary procedures to be fulfilled, in order to utilise compulsory powers, which could in turn cause delays in the programme.
- National Cycle Network (NCN) routes 5 and 8 may not be avoidable, depending on landfall location. Where the NCN cannot be avoided, it has been noted in the past that similar land owned by Sustrans, has been deemed as Crown Authority land, where no Compulsory Acquisition powers are afforded and there is the potential for excessive costs. This is much harder to determine at this stage of the project and will rely on land ownerships to be more progressed.

6.2.186 Routeing through these assets could cause adverse effects for users and have a temporary economic impact on tourism. There would likely be consenting implications as a result of temporarily closing, stopping up or diverting the Cycle Network. This could lead to timeline delays.

6.2.187 It is advised to avoid routeing and making landfall at the southwest locations of Anglesey. If not possible to avoid the National Cycle Network route, standard protection measures could be applied during the construction phase to mitigate impacts on users and the asset itself. It is anticipated that, due to the temporary nature of the construction works and the potential for the implementation of underground cabling installation methods, the impacts are unlikely to be permanent.

6.2.188 Crossing a National Cycle Network route may be unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of the cabling works) when detailed routeing, stakeholder engagement and implementation of appropriate mitigation measures are applied.

Land Use and Other Infrastructure

6.2.189 Across Strategic Option AC6-2, the following receptors have been identified; Historic Landfall Sites, Airports, Military Areas, Ports and Harbours, National Grid Assets (OHLs, Cable and substations)

- All, Historic Landfill Sites, Airports, Military Areas and Ports and Harbours can be avoided.
- One OHL will require crossing.

6.2.190 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is applied.

6.2.191 Regarding suitability for the additional converter station, the 5 km study area for the proposed converter station falls within the area where the Ports, OHLs, Landfall sites and Military areas are located thus, careful placement is required. However, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.192 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-2 would satisfy the NETS SQSS, whilst providing additional transmission capacity across boundaries B6 and B7a in North Wales.

6.2.193 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the proposed Wylfa South 400 kV substation in North Wales. This substation is trigged by a different connection project, however, should that project not proceed, the substation would be required as part of the Project scope of works.
- A new 525 kV DC converter station at Wylfa South would be required and the proposed Wylfa South substation would need to accommodate the bays required for AC6-2.
- This link would connect to the proposed Wylfa South 400 kV substation. This construction is considered to be outside of the Project scope for the purposes of this SOR, as it is currently being triggered by a solar connection project. This strategic option requires a double turn in of existing Pentir – Wylfa circuits.

- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.194 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable

b) 525 kV HVDC subsea cable and converter stations

6.2.195 Strategic Option AC6-2 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Two bays at the proposed Wylfa South 400 kV substation to accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Wylfa South substation.

6.2.196 Table 6.3 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.3 – Capital Costs for Strategic Option AC6-2

Item	Capital Cost	
Substation and Wider Works	£20.5 m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (252 km)	£10,731.0m	£2,304.9m
Total Capital Cost	**£10,751.5m**	**£2,325.4m**

6.2.197 Table 6.4 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.4 - Lifetime cost by Subsea Technology Option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£10,731.0m	£2,304.9m
NPV of Cost of Losses over 40 years	£249.1m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£56.9m	£74.1m
Lifetime Cost of New Circuits	**£11,037m**	**£2,536m**

6.2.198 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has a reasonable NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.199 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-2 is a 252 km connection, configured as an HVDC subsea circuit, between T-Point and the proposed 400 kV Wylfa South substation. As a result, the presumption on further development of this option, should it be selected, would be based on an HVDC subsea connection.

Strategic Option AC6-3 – Bodelwyddan

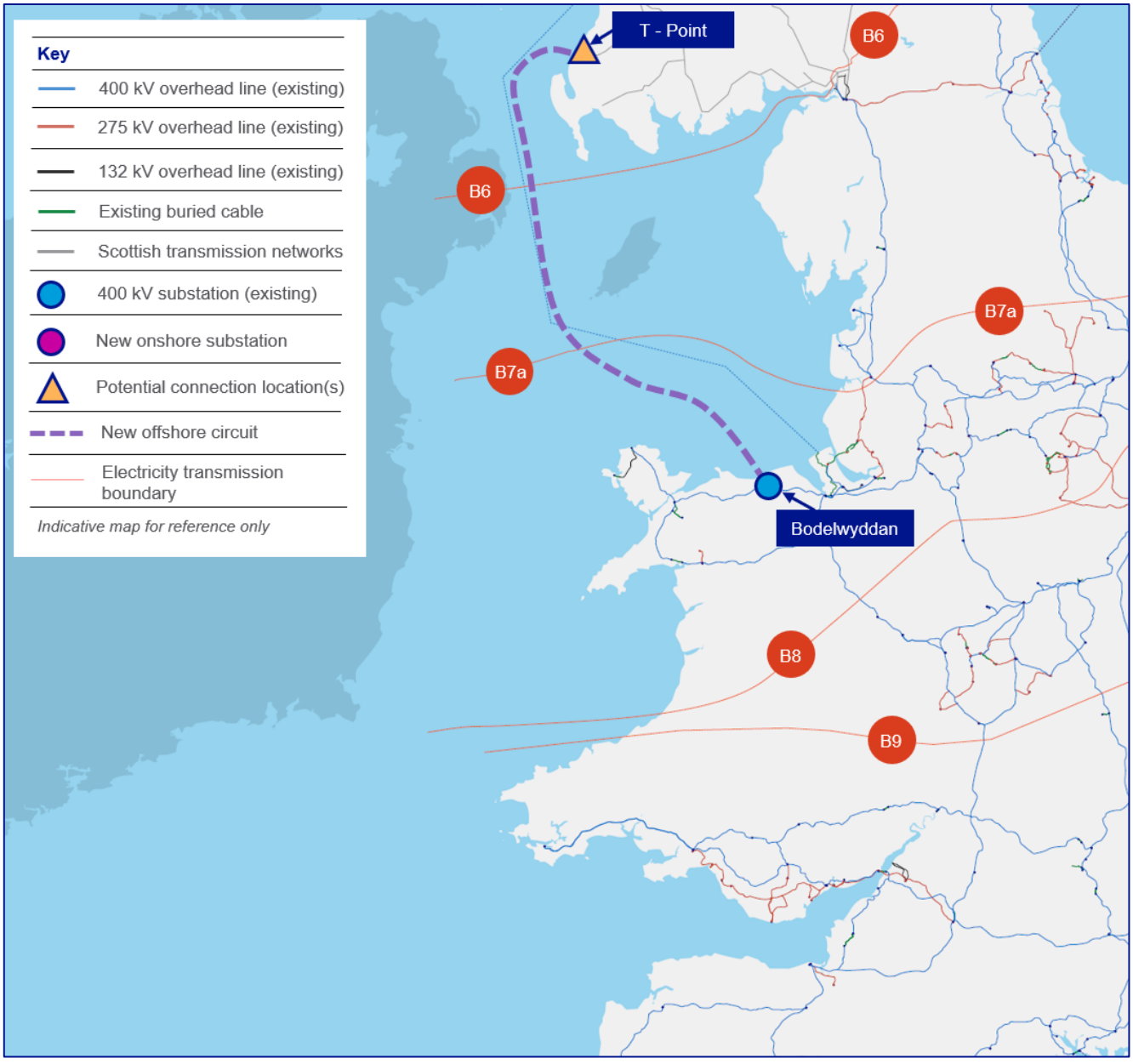
Description of the strategic option AC6-3

6.2.200 Strategic Option AC6-3 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) to the existing Bodelwyddan 400 kV substation in north Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the northern Welsh coastline.

6.2.201 For the purposes of the appraisal of Strategic Option AC6-3, consideration has been given to the additional costs or impacts of extending the existing Bodelwyddan 400 kV substation to connect AC6-3.

6.2.202 Figure 6.4 below presents an indicative map for Strategic Option AC6-3 (for illustrative purposes only and does not denote viable development route).

Figure 6.4 - Indicative study area of Strategic Option AC6-3



6.2.203 The circuit distance for this connection is 306 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Bodelwyddan substation.

6.2.204 This strategic option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Bodelwyddan. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 8 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.205 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- There is one SPA which cannot be avoided – Liverpool Bay SPA.
- There are two SACs which are unlikely to be avoided - North Channel SAC and North Anglesey Marine SAC.
- All SSSI sites along the coastline could be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.206 Where features cannot be avoided there is potential for habitat loss or damage due to construction activities (e.g. cable burial, cable protection).

6.2.207 This strategic option passes through one unavoidable SPA at the point of potential landfall and two likely unavoidable SACs, one between Wales and Isle of Man and the other off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.208 Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.209 Detailed cable routeing may be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats, where appropriate.

6.2.210 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.211 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects to the marine environment.

6.2.212 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through design and construction methods. However, it will remain likely, and therefore it is anticipated that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.213 It should be noted that there are currently 33 cables which cross the Liverpool Bay SPA, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible.

Marine Historic Environment

6.2.214 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.215 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features.

6.2.216 It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.217 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.218 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.219 At this stage, it cannot be confirmed that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.220 Sediment type and depth throughout this strategic option is variable. Throughout the corridor there are areas of exposed bedrock.

6.2.221 The beach width around the potential Bodelwyddan landfall area is less than 500 m, with the exception of near the mouth of the River Clwyd which could be avoided. Areas with a beach width less than 500 m are suitable for landfall. The coastal height is mostly less than 30 m so may be suitable for landfall.

6.2.222 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. It cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.223 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.224 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.225 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments.

6.2.226 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.227 Additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.228 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.229 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.230 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- SSSI and SPA within this strategic option may require crossing when making landfall.
- Ramsar site, SAC, LNR and Ancient Woodlands can be avoided with careful routeing.
- All other receptors can be avoided.

6.2.231 There is potential for impacts to designated features of one or more designated sites (Ancient Woodlands, SPA, SAC, Ramsar, LNR, and SSSIs) that cannot be avoided during construction activities of the cable. However, these features are present at the eastern most point of the strategic option thus, if the cable was to make landfall to the northwest of Abergele then these designations could be avoided.

6.2.232 Although Ancient Woodlands, SPA, SAC, Ramsar, LNR, and SSSIs could be avoided, there is still potential for direct and indirect impacts on these receptors.

6.2.233 Mitigation in relation to the designated sites may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods, sediment and erosion control measures. If routeing and landfall was to occur to the northwest of Abergele then there are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SPA, SAC, Ramsar, LNR etc). Ancient Woodlands and SSSIs would have temporary impacts, and careful routeing would be required.

6.2.234 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.235 There are not anticipated to be any long-term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.236 Regarding suitability for the additional converter station, the study area for the proposed converter station contains statutory designated ecological designations (i.e. a SSSI, SAC and Ancient Woodlands), however, even though the study area has these receptors, within the 5 km radius, there are large areas clear of these designations, thus, through careful siting of the converter station, it is possible to mitigate potential adverse effects, which would result in an insignificant effect arising from its construction or operation.

Air Quality

6.2.237 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.238 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 1, 2, 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites.

6.2.239 Some Agricultural Grades 1 and 2 may not be avoided and Grade 3 Agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites could be avoided.

6.2.240 There may be a need to route through high value agricultural land if other areas are heavily constrained. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration, resulting in a loss of agricultural productivity.

6.2.241 Where possible, it is advisable to avoid routeing through Grade 1, 2 and 3a agricultural land. Routeing should aim to avoid high value agricultural land where possible, by routeing away from St Asaph, Prestalyn and Abergele. If routeing through high value

agricultural land is unavoidable, then standard protection measures should be applied during the construction phase to minimise impacts on soils.

6.2.242 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.243 Whilst there are areas of Grade 1 and 2 agricultural lands within this strategic option, these areas can be avoided through detailed routeing. Whilst areas of Grade 3 agricultural land may not be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.244 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Very few land parcels around the substation are classified as Grade 4 or lower, the majority of land in a 5 km radius is 3b or above. Areas of Grade 4 or below and 'non-agricultural' land are more suitable locations for the converter station however; mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.245 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

6.2.246 More specifically, there is one Coastal Path which cannot be avoided – the Wales Coast Path. The National Trail and AONB could be avoided. There are four LandMAP aspects rated as High and one rated as Outstanding within this strategic option.

6.2.247 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path.

6.2.248 There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.249 Although National Trail and AONB can be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.250 There is one proposed North East Wales National Park, which will cover a sizeable area between Prestatyn, Connah's Quay and Welshpool. It broadly aligns with the existing AONB, although over a much larger area. If AC6-3 makes landfall near the Dee at Talacre, it would require traversal of the new proposed National Park. Mitigation in relation to this may require making landfall to the southwest of Abergele within the Liverpool Bay SPA, which would in turn require crossing a Registered Park.

6.2.251 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and careful routeing of trenched installation methods as well as likely implementing erosion control measures.

6.2.252 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), AONBs, National Trails and Coastal Paths where possible.

6.2.253 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.254 Regarding suitability for the additional converter station, permanent impacts from the converter station during the operational phase can be mitigated through standard landscaping and visual screening measures. Although the proposed new National Park site in north-east Wales is present within the 5 km radius of the converter station, there are several parcels of land that are free from this constraint.

Historic Environment

6.2.255 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-3 study area.

6.2.256 All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens, Conservation Areas and RLOSIs could be avoided.

6.2.257 There is potential for temporary impacts to occur to the setting of the heritage assets, however, most assets could be directly avoided with careful routeing of the cable.

6.2.258 This strategic option is densely populated with Historic Environment assets, this flags that a lot of routeing is anticipated to be necessary to divert around several assets. When making landfall northwest of Abergele, a registered park and garden is located immediately as landfall is made as well as SMs in close proximity. Both of these receptors could be avoided through careful routeing and siting. All impacts are anticipated to be associated with construction activities of cable installation, which would be temporary in nature i.e. noise, vibration and visual impacts.

6.2.259 Potential mitigation could include careful routeing to avoid impacts to designated heritage assets, standard protection measures could be applied during the construction phase. Screening and vibration monitoring mitigation measures may be implemented during the construction phase to reduce impact to all assets in close proximity.

6.2.260 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long term visual impact is low risk due to avoiding use of OHLs.

6.2.261 There are unlikely to be adverse effects on the designated assets within the strategic option study area when careful routeing and site selection is undertaken.

6.2.262 Regarding suitability for the additional converter station, siting the proposed converter station will require careful consideration of the area surrounding the substation to avoid impacts to the RLOSI, Listed Buildings and SMs. This is necessary to minimise the potential impacts to setting on the designated assets. The 5 km radius surrounding the substation is densely populated with assets within this strategic option, hence, careful setting and siting would be required.

Hydrology

6.2.263 Strategic Option AC6-3’s study area includes one main river that cannot be avoided.

6.2.264 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.265 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures could be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). Appropriate consents would be required to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.266 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.267 With these mitigation measures put in place, it is unlikely that there would be any significant residual effects to these receptors.

6.2.268 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.269 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, with three main rivers being located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses, 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.270 Throughout Strategic Option AC6-3, the following receptors have been considered; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are six pipelines which may require crossing depending on where landfall is made. Three of these pipelines cannot be avoided.
- There is one wind site in this strategic option. There are also two potential wind sites which are in the concept/early planning stage. All these sites may be avoided.
- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.
- There are 25 cables which may require crossing depending on where landfall is made. 18 of these cables cannot be avoided.
- There is one active disposal site, this could be avoided.

- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.

6.2.271 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.272 The disposal site off the coast of Scotland could be avoided via routeing and siting.

6.2.273 The one active wind site could be avoided via routeing and siting.

6.2.274 There is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications.

6.2.275 Early engagement with cable and pipeline owners/responsible parties could help mitigate any potential timeline delays of legal implications.

6.2.276 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation.

6.2.277 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.278 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 18 cables. Under worst case scenarios, this may involve crossing six pipelines and 25 cables. The one wind site and disposal site can be avoided via routeing and siting mitigation.

6.2.279 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within its study area.

6.2.280 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.281 There are five major settlements within this strategic option, St. Asaph, Abergele, Kinmel Bay, Rhyl and Prestatyn. With smaller settlements dispersed around the strategic option, this study area has a relatively high frequency of settlements.

6.2.282 These could be avoided through detailed routeing. Routeing around urban areas would have adverse effects on residential and commercial receptors. Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.283 Routeing through these settlements is not possible.

6.2.284 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.285 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.286 With the implementation of appropriate mitigation measures, where necessary, it is unlikely that there would be residual effects to these receptors.

6.2.287 Regarding suitability for the additional converter station, routeing and siting of a converter station within 5 km of the existing substation may cause long term visual effect on surrounding settlements, specifically St Asaph. Locating the converter station south of the substation may reduce this impact for the larger settlement areas, due to the understanding that the topography in that location is undulating, which could provide some screening of above ground infrastructure. Mitigation measures will need implementing once further assessments are undertaken.

Tourism and Recreation

6.2.288 National Trust land could be avoided.

6.2.289 There are two National Cycle Network routes, of which, National Cycle Network route 5 cannot be avoided.

6.2.290 Crossing this route would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping up or diverting the Cycle Network. This could lead to timeline delays.

6.2.291 If it is not possible to avoid a National Cycle Network route, standard protection measures should be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods, such as HDD, the impacts would not be permanent.

6.2.292 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation measures in place, it is unlikely residual effects will be experienced.

6.2.293 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of the cabling works) when carrying out detailed routeing and siting, stakeholder engagement and implementation of appropriate mitigation measures.

Land Use and Other Infrastructure

6.2.294 Across Strategic Option AC6-3, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- One OHL and one cable may require crossing.

6.2.295 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.296 Regarding suitability for the additional converter station, the study area for the proposed converter station includes Historic Landfill Sites, OHL, cables, Heliport, Ports and Military area therefore, careful placement is required. Large areas are available within the 5 km buffer to locate a converter station that would not impact these receptors and,

construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.297 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-3 would satisfy the NETS SQSS, whilst providing an uplift in transmission capacity across boundaries B6 and B7a in North Wales.

6.2.298 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the existing Bodelwyddan 400 kV substation in North Wales.
- A new 525 kV DC converter station at Bodelwyddan would be required and the existing Bodelwyddan substation would require a two-bay extension.
- The existing site at Bodelwyddan is highly constrained, which may lead to challenges with the substation extension.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.299 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable

b) 525 kV HVDC subsea cable and converter stations

6.2.300 Strategic Option AC6-3 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Bay extensions to the existing Bodelwyddan 400 kV Substation to accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Bodelwyddan substation.

6.2.301 Table 6.5 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.5 - Capital Costs for Strategic Option AC6-3

Item	Capital Cost	
Substation and Wider Works	£ 20.5m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (306 km)	£13,040.1m	£2,583.7m
Total Capital Cost	**£13,060.6m**	**£2,604.2m**

6.2.302 Table 6.6 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.6 - Lifetime Cost by Subsea Technology Option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£13,040.1m	£2,583.7m
NPV of Cost of Losses over 40 years	£301.1m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£69.6m	£74.3m
Lifetime Cost of New Circuits	**£13,411m**	**£2,815m**

6.2.303 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has a reasonable NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.304 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-3 is a 306 km connection, configured as an HVDC subsea circuit, between T-Point and the existing 400 kV Bodelwyddan Substation. In light of this analysis, the starting presumption for further development of this option, should it be selected, would be for a HVDC subsea connection.

Strategic Option AC6-4 – Pembroke

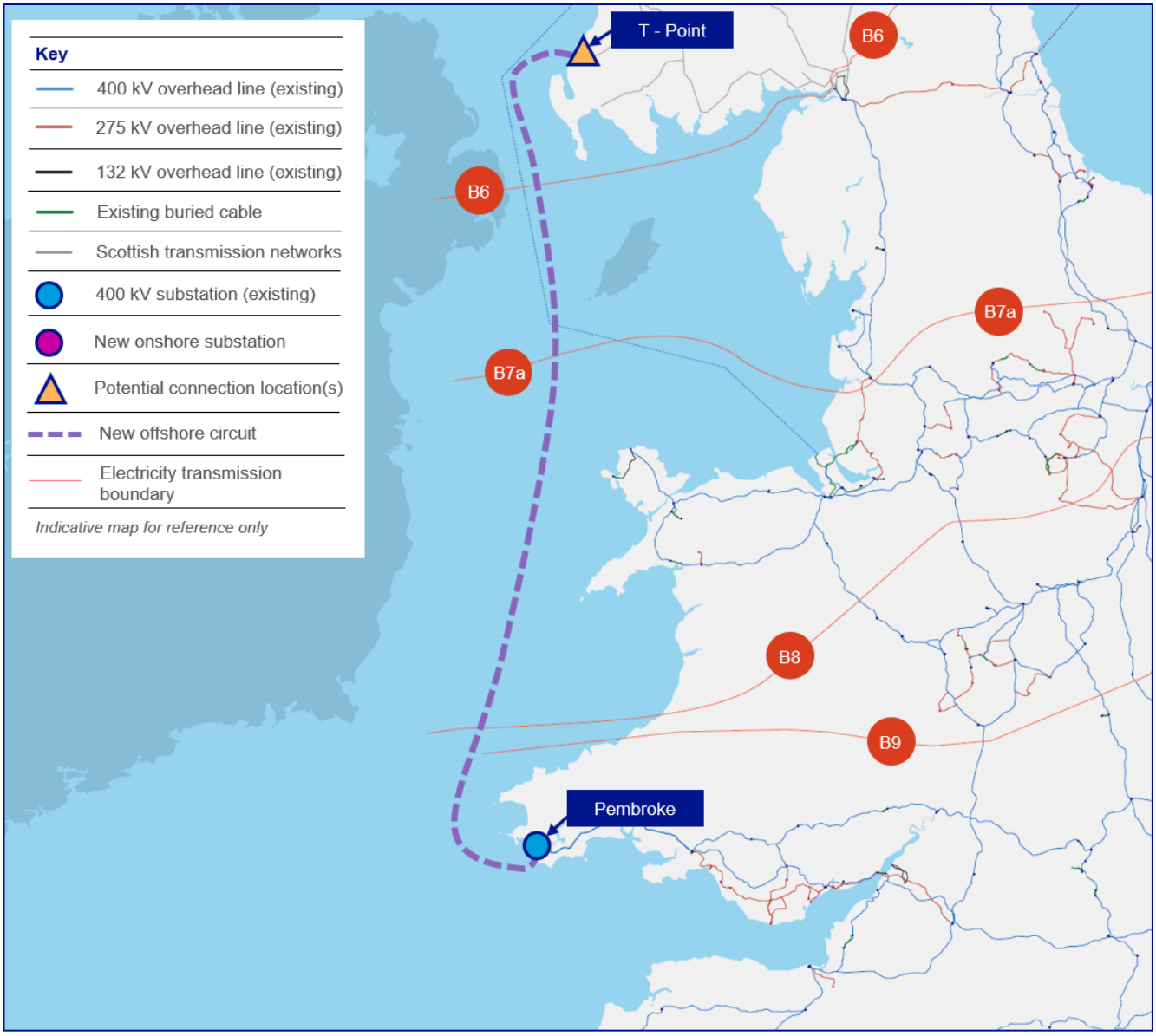
Description of the strategic option AC6-4

6.2.305 Strategic Option AC6-4 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to the existing Pembroke 400 kV substation in south Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.306 For the purposes of the appraisal of Strategic Option AC6-4, consideration has been given to the additional costs or impacts of extending the existing Pembroke 400 kV substation to connect AC6-4.

6.2.307 Figure 6.5 below presents an indicative map for Strategic Option AC6-4 (for illustrative purposes only and does not denote viable development route).

Figure 6.5 - Indicative study area of Strategic Option AC6-4



6.2.308 The circuit distance for this connection is 504 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the southern Welsh coastline; and
- a straight-line distance from the landfall to the Pembroke substation.

6.2.309 This option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Pembroke. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 9 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.310 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZs, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- There is one SPA which cannot be avoided - Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are four SACs which cannot be avoided - Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and the North Anglesey Marine SAC.
- There is one SAC that is unlikely to be avoided - North Channel SAC.
- SSSI sites occupy this coastline and cannot be avoided.
- All MCZs can be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- A high proportion of Annex I habitats (reefs) is reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.311 A potential long-term effect of this work required would be habitat loss or damage due to construction activities (e.g. cable burial, cable protection) where features cannot be avoided.

6.2.312 Strategic Option AC6-4 passes through one unavoidable SPA and four unavoidable SACs within Welsh waters, and one likely unavoidable SAC, off the coast of Ireland. There is one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.313 Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.314 Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats, where appropriate.

6.2.315 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.316 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects on the marine environment.

6.2.317 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated that though that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.318 It should be noted that there are currently seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, 17 that cross the Bristol Channel Approaches, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.319 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.320 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.321 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.322 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.323 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.324 Throughout this strategic option, sediment type and depth throughout this are variable, with areas of exposed bedrock being presented.

6.2.325 The beach width around the potential Pembroke landfall area is less than 500 m and the coastal height is generally less than 30 m (with some areas greater than 30 m which could be avoided), so it may be suitable for landfall.

6.2.326 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. It cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.327 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.328 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.329 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments.

6.2.330 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.331 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.332 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.333 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.334 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, Local Nature Reserves and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- There is one SAC which cannot be avoided - Limestone Coast of South West Wales
- There is one SPA which cannot be avoided - Castlemartin Coast SPA
- There are two SSSIs which cannot be avoided - Castlemartin SSSI and Stackpole SSSI
- There is one NNR that cannot be avoided - Stackpole NNR

- There are no Ramsar sites, RSPB Reserves, Country Parks or Registered Common Land within this strategic option.
- All other receptors could be avoided.

6.2.335 The SAC, SPA, SSSIs and NNR cannot be avoided due to running the whole length of the coastline within the study area. Visual, noise and vibration disturbance from within or from the designated sites are likely to be affected albeit for a temporary period during the construction phase, due to vehicles and other construction equipment. Crossing these designations would result in potential habitat loss and disturbance to species, drilling could lead to long-term changes in the landscape and natural structure of limestone cliffs could exacerbate erosion. Coastal Grasslands often home specialised plant species and communities that thrive in the thin, calcareous soils. Cabling activities could lead to soil compaction, habitat loss, and fragmentation.

6.2.336 If these designations require crossing, there would likely be consenting implications as a result including an expectation to conduct additional survey work and habitat risk assessments. Although other SSSIs and Ancient woodland could be avoided, there is still potential for direct and indirect impacts these receptors.

6.2.337 Mitigation in relation to the designated sites may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods, sediment and erosion control measures. While routeing underground cables through or near these designated sites can be mitigated through careful planning, the use of advanced technologies and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. Ramsar sites, Country Parks, RSPB Reserves etc).

6.2.338 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.339 There are not anticipated to be any long-term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.340 A high number of associated projects are seeking landfall within the Pembroke area. Due to the aforementioned onshore constraints, making landfall in this area would involve crossing an SSSI and National Park.

6.2.341 Regarding suitability for the additional converter station, the study area for the proposed converter station contains statutory designated ecological designations (i.e. SSSIs and Ancient Woodlands). However, even though the study area is dense in receptors, within the 5 km radius, there are areas clear of these designations, thus, through the implementation of careful siting of the converter station, as appropriate, there is potential for there to be no significant impacts as a result of its construction or operation.

Air Quality

6.2.342 There is one AQMA present within this strategic option, situated in the centre of Pembroke, which falls just within the study area but could be avoided.

6.2.343 Where appropriate, the implementation of a CTMP, as well as other relevant mitigation strategies, during the construction phase, would be anticipated to result in no long term adverse outcomes associated with the AQMA within this strategic option.

6.2.344 Regarding suitability for the additional converter station, the AQMA falls within the 5 km study area for the proposed converter station thus, careful siting will be required to place the converter station to avoid long term impacts to the Pembroke AQMA. Avoid siting converter station in close proximity to Pembroke thus, no impacts are anticipated as a result of its construction or operation.

Geology and Soils

6.2.345 Throughout the study area of Strategic Option AC6-4, underlying geology has identified that Grade 1 Agricultural land may not be avoidable. The majority of land is Grade 2 and Grade 3 Agricultural land, which cannot be avoided. Peatland and Regionally Important Geodiversity Sites could be avoided.

6.2.346 Grade 2 and Grade 3 agricultural land will likely need to be routed through given its extent. Grade 1 land can be avoided with careful routeing. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration and loss of agricultural productivity.

6.2.347 Routeing should aim to avoid Grade 2 agricultural land where possible however large areas from landfall to the substation are Grade 2 and 3 are unavoidable. Where routeing through this is unavoidable, standard protection measures could be applied during the construction phase to minimise impacts on soils.

6.2.348 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.349 Whilst there are areas of Grade 1 agricultural land within this strategic option, these areas can be avoided through detailed routeing.

6.2.350 Whilst large areas of Grade 2 and some Grade 3 agricultural land may not be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.351 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Very few land parcels around the substation are classified as Grade 4 or lower, the majority of land in a 5 km radius is 3b or above. Areas of Grade 4 or below and ‘non-agricultural’ land are more suitable locations for the converter station however; mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.352 Landscape and Visual Amenity constraints have been identified across this strategic option’s study area.

6.2.353 For Strategic Option AC6-4, there is one Coastal Path which cannot be avoided - Pembrokeshire Coastal Path (this is a section of the larger Wales Coast Path). There is one National Trail that cannot be avoided - the Pembrokeshire Coast path.

6.2.354 There is one National Park that cannot be avoided within the study area of this strategic option – the Pembrokeshire Coast National Park.

6.2.355 Mitigation measures may be required whilst traversing the National Park and would likely include cabling via trenchless installation methods such as HDD as well as likely implementing erosion control measures. It is not considered feasible to underground via trenchless solutions through the entirety of the National Park.

6.2.356 There are three LandMAP aspects rated as High and one rated as Outstanding within this strategic option, largely along the coastline.

6.2.357 There is a potential that the Coastal Path and National Trail listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path. There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.358 Although National Parks and AONBs could be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.359 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and careful routeing of trenched installation methods as well as likely implementing erosion control measures.

6.2.360 Careful routeing and siting is likely to be required to avoid visual impacts, where possible. Additional mitigation could include the implementation of trenchless cable installation methods (such as HDD); however, it is not considered feasible to underground via trenchless solutions through the entirety of the National Park.

6.2.361 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.362 Regarding suitability for the additional converter station, careful siting of the proposed converter station would be required to minimise permanent impacts to the specified Coastal Paths, National Trails and National Parks. Permanent impacts from the converter station during the operational phase could be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.363 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-4 study area.

- All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens, Conservation Areas could be avoided.
- There is one RLOSI that cannot be avoided.

6.2.364 There is potential for temporary impacts to occur to the setting of the heritage assets, however most assets can be directly avoided with careful routeing of the cable. One RLOSI requires crossing when routeing to the substation as it covers the radius surrounding Pembroke substation, there are also two SMs and Conservation Areas

within close proximity to the potential routeing line. However, all impacts are temporary, associated with construction activities of the cable i.e. noise, vibration and visual impacts. There are limited assets that would be affected within this strategic option.

6.2.365 Mitigation would require careful routeing to avoid impacts to designated heritage assets and standard protection measures should be applied during the construction phase. Screening and vibration monitoring mitigation measures may be implemented during the construction phase to reduce impact to SMs in close proximity.

6.2.366 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long-term visual impact is low risk due to avoiding use of OHLs.

6.2.367 There are unlikely to be adverse effects on the designated assets within the strategic option study area when careful routeing and site selection is undertaken.

6.2.368 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of location surrounding the substation to avoid the RLOSI, Conservation areas, Listed Buildings, Registered Parks and Garden and SMs. This is necessary to minimise the impact to setting on the designated assets. However, all other heritage assets are situated within the 5 km radius.

Hydrology

6.2.369 Within this strategic option's study area, all main rivers could be avoided.

6.2.370 There is potential for impacts on hydrology and flood risk within this strategic option. However, most of the features identified can be directly avoided with careful routeing and mitigated by using standard protection measures during construction.

6.2.371 Mitigation would require careful routeing to avoid impacts on rivers and floodplains. Standard protection measures should be applied during the construction phase. The appropriate consents should be applied for to undertake works in close proximity to rivers, within the floodplain and near flood defences.

6.2.372 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors. There are unlikely to be adverse effects on the features identified within the study area when careful routeing and site selection is applied.

6.2.373 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, considering that two main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses, 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.374 Throughout Strategic Option AC6-4, the following have been considered to potentially have an effect.

- There are no subsea or surface oil and gas wells.

- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 19 cables which cannot be avoided.
- There are five active disposal sites, these could all be avoided.
- There is one offshore military firing range, this could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.375 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements. Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.376 The active disposal sites could be avoided via routeing and siting.

6.2.377 The two potential wind sites should be monitored for future development, but at this stage do not require mitigation.

6.2.378 There is potential for interaction between construction vessels and other marine vessel users, this may lead to consenting and legal implications.

6.2.379 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.380 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 19 cables.

6.2.381 This option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area.

6.2.382 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.383 There are three major settlements, Milford Haven, Pembroke and Pembroke Dock in the north of the corridor, all of which are likely to be avoided. From landfall, further individual settlements will require careful routeing.

6.2.384 Routeing through urban areas would have adverse effects on residential and commercial receptors. Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.385 Routeing through these settlements is not possible, and this strategic option should be avoided if this needs to occur.

6.2.386 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.387 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.388 With mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.389 There are unlikely to be adverse effects on the features identified within the study area. The limited settlements that are present within this strategic option are unlikely to have adverse effects due to the temporary nature of the construction works and with careful routeing, impacts on these areas could be avoided.

Tourism and Recreation

6.2.390 There is one area of National Trust Land within this study area that may require crossing, near Stackpole coast. Additionally, there is one National Cycle Network route, which could be avoided.

6.2.391 Crossing this route would result in potential temporary visual impacts to users of the land and temporary closures. Routeing through these assets would cause adverse effects for users and have a temporary economic impact on tourism.

6.2.392 If routeing through National Trust land is required, then standard protection measures should be applied during the construction phase to mitigate impacts on assets.

6.2.393 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.394 Overall, the National Trust land is likely unavoidable. When detailed routeing, stakeholder engagement and mitigation measures are applied, adverse effects can be minimised.

6.2.395 Regarding suitability for the additional converter station, siting of the converter station location within the 5 km buffer of the substation can avoid all these receptors due to not falling within this area.

Land Use and Other Infrastructure

6.2.396 Across the study area of Strategic Option AC6-4, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- Two OHLs may require crossing.

6.2.397 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.398 Regarding suitability for the additional converter station, the study area for the proposed converter station falls within the area where Historic Landfill Sites, Ports OHLs and Military area is located, therefore careful placement is required. However, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.399 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-4 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.400 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the existing Pembroke 400 kV substation in South Wales.
- A new 525 kV DC converter station at Pembroke would be required and the existing Pembroke substation would require a two-bay extension.
- The existing Pembroke 400 kV substation is an indoor Air-Insulated Substation (AIS) and it would be challenging to extend the site further to accommodate the Project's HVDC connection.
- As for all south Wales connections, AC6-4 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.401 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.402 Strategic Option AC6-4 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Bay extensions to the existing Pembroke 400 kV Substation to accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Pembroke substation.

6.2.403 Table 6.7 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.7 - Capital Costs for Strategic Option AC6-4

Item	Capital Cost	
Substation and Wider Works	£20.5m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (504 km)	£21,544.1m	£3,644.2m
Total Capital Cost	**£21,564.6m**	**£3,664.7m**

6.2.404 Table 6.8 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.8 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£21,544.1m	£3,644.2m
NPV of Cost of Losses over 40 years	£507.4m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£116.5m	£75.1m
Lifetime Cost of New Circuits	**£22,168m**	**£3,876m**

6.2.405 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.406 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-4 is a 504 km connection, configured as an HVDC subsea circuit, between T-Point and the existing 400 kV Pembroke Substation. In light of this analysis, the starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

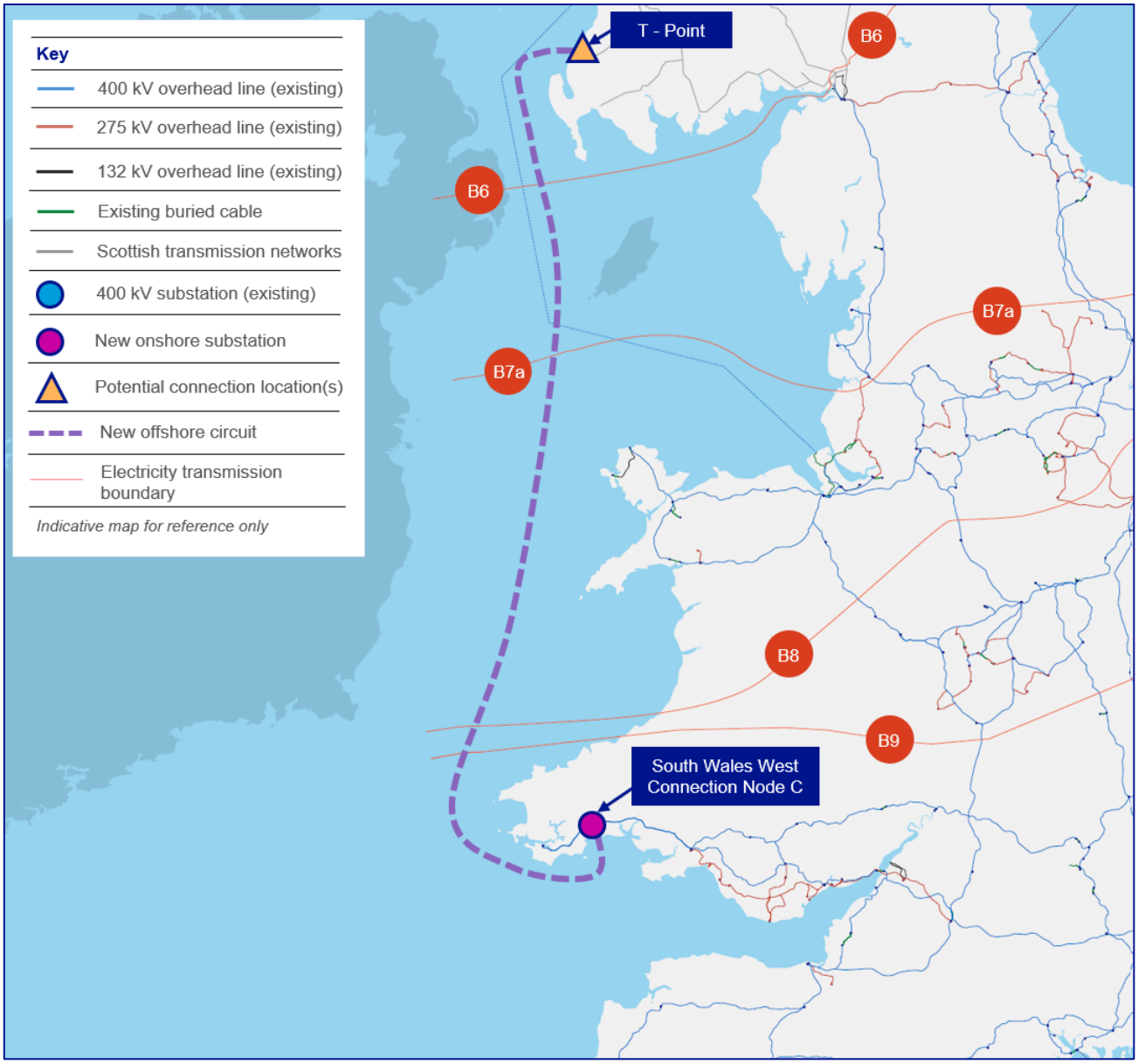
Strategic Option AC6-5 – South Wales West Connection Node C

Description of the strategic option AC6-5

6.2.407 Strategic Option AC6-5 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to a new South Wales West Connection Node C 400 kV substation in the Llanteg area in south Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.408 Figure 6.6 below presents an indicative map for Strategic Option AC6-5 (for illustrative purposes only and does not denote viable development rout).

Figure 6.6 - Indicative study area of Strategic Option AC6-5



6.2.409 The circuit distance for this connection is 552 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the southern Welsh coastline;
- and a straight-line distance from the landfall to the substation in the Llanteg area

6.2.410 This option is formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Llanteg. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 3 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.411 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- There are two SPAs which cannot be avoided - Carmarthen Bay SPA and Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are five SACs which cannot be avoided - Carmarthen Bay and Estuaries SAC, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC.
- There is one SAC that is unlikely to be avoided - The North Channel SAC.
- SSSI sites occupy this coastline and cannot be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.412 This strategic option passes through two unavoidable SPA and five unavoidable SACs within Welsh waters, and one likely unavoidable SACs, off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. This may result in direct loss of habitat and potential direct impacts to protected species associated with these designations. Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.413 Where features cannot be avoided there is potential for habitat loss or damage due to construction activities (e.g. cable burial, cable protection).

6.2.414 Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats.

6.2.415 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.416 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects on the marine environment.

6.2.417 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated that though that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.418 It should be noted that there are currently: Seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, 17 that cross the Bristol Channel Approaches, one cable that crosses the Carmarthen Bay and Estuaries SAC, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

6.2.419 There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.420 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.421 During construction, there is the potential for accidental direct physical effects due to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works could take place.

6.2.422 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.423 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.424 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.425 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present.

6.2.426 The beach width around the potential Llanteg landfall area is less than 500 m, so may be suitable for landfall. The coastal height is generally less than 30 m, so may be suitable for landfall. There are areas greater than 30 m which could be avoided.

6.2.427 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed' and it cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.428 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.429 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.430 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments.

6.2.431 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.432 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.433 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.434 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial ecology

6.2.435 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites SSSIs, NNRs, Country Parks, Local Nature Reserves and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- There is one SSSI which cannot be avoided - Amroth and Colby Woodlands SSSI.
- There are no onshore SPAs, onshore IBAs, SACs, NNRs, Country Parks, Registered Common Land, RSPB Reserves or Ramsar sites within this strategic option.
- All other receptors could be avoided.

6.2.436 The SSSI cannot be avoided due to running the whole length of the coastline. During the construction phase, vehicles and other equipment are likely to cause temporary visual and noise disturbances within or near the SSSI. Crossing these designations would result in potential habitat loss and disturbance to species, soil erosion, sedimentation, and potential contamination of nearby watercourses.

6.2.437 If these designations require crossing, there would likely be consenting implications and there would likely be an expectation to conduct additional survey work and habitat risk assessments.

6.2.438 Mitigation in relation to Ancient Woodlands and SSSIs may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods. While routeing underground cables through or near ancient woodlands and SSSIs can be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, SACs, NNR and Ramsar sites etc).

6.2.439 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.440 It is not anticipated that there would be any adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Ancient Woodlands may be avoided via routeing and siting, however, if this is not possible, further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.441 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a limited amount of statutory designated ecological designations (i.e. a few SSSIs and Ancient Woodlands). Within the 5 km radius there are large amounts of areas clear of these designations thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.442 Within this strategic option, no Air Quality Management Area's (AQMAs) have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.443 Throughout the study area of this strategic option, underlying geology has identified that Grade 3 Agricultural land could not be avoided. Regionally Important Geodiversity Sites could be avoided, along with Geoparks, peatlands and Grade 1 and 2 Agricultural Land.

6.2.444 Grade 3 agricultural land is unavoidable given its extent throughout the strategic option. There is potential for adverse effects on agricultural land and soils, which may present scrutiny from technical consultees during the planning stage.

6.2.445 Construction on this land may lead to soil compaction, which reduces soil permeability and aeration resulting in a loss of agricultural productivity.

6.2.446 Where routeing through grade 3 agricultural land is unavoidable, standard protection measures should be implemented during the construction phase to minimise impacts on soils.

6.2.447 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely there would be significant residual effects to these receptors.

6.2.448 Whilst areas of Grade 3 agricultural land could not be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grade 1 and 2.

6.2.449 Regarding suitability for the converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Very few land parcels around the substation are classified as Grade 4 or lower, the majority of land in a 5 km radius is 3a or 3b. Areas of Grade 4 or below and 'non-agricultural' land are more suitable locations for the converter station however, within this strategic option the converter station will most likely be located in Grade 3 land and mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.450 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

- There is one Coastal Path which cannot be avoided - Wales Coast Path.
- The Pembrokeshire Coast National Park could be avoided.
- There are four LandMAP aspects rated as High and one rated as Outstanding within this strategic option largely along the coastline as you make landfall.

6.2.451 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts its users.

6.2.452 There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.453 Although the National Park could be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.454 Mitigation measures would likely include cabling via trenchless installation methods such as HDD and routeing as well as likely implementing erosion control measures.

6.2.455 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground) National Park and Coastal Paths where possible.

6.2.456 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.457 Careful siting of the proposed converter station would be required to minimise permanent impacts to the specified Coastal Paths. Permanent impacts from the converter station during the operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.458 Within the study area of AC6-5, there are international and national designated or important historic environment and cultural heritage sites present throughout the study area.

6.2.459 All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens and RLOSI could be avoided.

6.2.460 There is potential for temporary impacts to occur to the setting of the heritage assets, however most assets can be directly avoided with careful routeing of the cable. One RLOSI may require crossing during landfall due to covering that section of the coastline, however there are options to make landfall further west along the coastline to avoid crossing. Two scheduled monuments are in close proximity to routeing while making landfall and may have temporary impacts during construction. All impacts are associated with construction activities of the cable, these are temporary impacts i.e. noise, vibration and visual impacts. There are limited designated assets with the study area of this strategic option.

6.2.461 Mitigation could require careful routeing to avoid impacts to designated heritage assets, standard protection measures should be applied during the construction phase. Screening and vibration monitoring mitigation measures may be implemented during the construction phase to reduce the impact on Scheduled Monuments in close proximity.

6.2.462 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long-term visual impact is low risk due to avoiding use of OHLs.

6.2.463 There are unlikely to be adverse effects on the designated assets within the study area when careful routeing and site selection is undertaken.

6.2.464 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of the location surrounding the substation, to minimise the impact on the designated assets.

Hydrology

6.2.465 Strategic Option AC6-5’s study area includes one main river that cannot be avoided.

6.2.466 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.467 Appropriate mitigation could require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely a FRA and management). The appropriate consents could be applied for to undertake works in

close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.468 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.469 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.470 There is not anticipated to be any long-term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.471 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, considering two main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses, 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.472 Throughout Strategic Option AC6-5, the following have been considered; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 19 cables which cannot be avoided.
- There are five active disposal sites, these could all be avoided.
- There is one offshore military firing range, this could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There is very little fishing activity within Carmarthen Bay. There are several areas of fishing activity further north within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.473 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.474 The active disposal sites could be avoided via routeing and siting.

6.2.475 There is potential for interaction between construction vessels and other marine vessel users, this may lead to consenting and legal implications. Notice to mariners,

engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.476 Early engagement with cable and pipeline owners/responsible parties could help mitigate any potential timeline delays of legal implications.

6.2.477 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation

6.2.478 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 19 cables.

6.2.479 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area.

6.2.480 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.481 There are no major settlements present within the study area of this strategic option. There are individual properties that will likely require careful routeing around.

6.2.482 These individual properties could be avoided through detailed routeing. Routeing around urban areas would have adverse effects on residential and commercial receptors.

6.2.483 Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.484 Routeing through these settlements is not possible.

6.2.485 Standard protection measures should be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties should be carefully routed around and avoided.

6.2.486 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.487 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.488 The limited individual settlements that are present within this strategic option are unlikely to have adverse effects due to the temporary nature of the construction works and with careful routeing impacts on these areas could be avoided.

Tourism and Recreation

6.2.489 There is an area of National Trust land that could be avoided within this strategic option's study area. There is one National Cycle Network route, National Cycle Network route 4, which cannot be avoided.

6.2.490 Crossing this route would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping or diverting Cycle Network. This could lead to timeline delays.

6.2.491 If it is not possible to avoid a National Cycle Network route, standard protection measures could be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods, such as HDD, the impacts would not be permanent.

6.2.492 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.493 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of the cabling works) when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.494 Across the study area of Strategic Option AC6-5, the following receptors have been identified.

- There are no Historic Landfill Sites, Airports, Military Areas and Ports and Harbours within this strategic option.
- Two OHLs may require crossing.

6.2.495 Construction and routeing of an underground cable near an OHL is unlikely to cause adverse effects due to temporary and limited interference with infrastructure.

6.2.496 Height restrictions on construction vehicles and standard protection measures will be employed during construction practices, coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.497 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is applied.

6.2.498 Regarding suitability for the additional converter station, the study area for the proposed converter station falls outside of the area where the Airport, Landfill, Military areas and Ports are located, however, two OHLs are included. Construction is unlikely to be a constraint for routeing and siting of the converter station although, careful routeing around these OHLs will be required within this strategic option.

Summary of the technical appraisal

6.2.499 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-5 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.500 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the proposed South Wales West Connection Node C (SWCN C) 400 kV substation in the Llanteg area in South Wales. This substation is trigged by different connection projects, however, should these projects not proceed, the substation would be required as part of the AC6 scope of works and has been included in this appraisal to account for this eventuality.
- A new 525 kV DC converter station in the Llanteg area would be required.
- As for all south Wales connections, AC6-5 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option will also require a double turn in of the existing 400 kV Pembroke-Swansea North circuits and bay extenstions at the proposed South Wales West Connection Node C 400 kV substation.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.501 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.502 Strategic Option AC6-5 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Currently, there is no existing substation infrastructure in the Llanteg area. The substation that AC6-5 would be connecting into is, as of now, being triggered by different projects in the area; Should these projects not proceed, the ten-bay substation would be required as part of the AC6 scope of works and has, hence, been included in the cost appraisal to account for this eventuality.
    - In the case where the SWCN C substation is triggered by planned projects in the Llanteg area, AC6-9 would only require to utilise two bays at the site.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the SWCN C substation.

6.2.503 Table 6.9 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.9 - Capital Costs for Strategic Option AC6-5

Item	Capital Cost	
Substation and Wider Works	£179.4m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (552 km)	£23,591.0m	£3,881.3m
Total Capital Cost	**£23,770.4m**	**£4,060.7m**

6.2.504 Table 6.10 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.10 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£23,591.0m	£3,881.3m
NPV of Cost of Losses over 40 years	£558.8m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£127.1m	£75.3m
Lifetime Cost of New Circuits	**£24,277m**	**£4,114m**

6.2.505 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.506 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-5 is a 552 km connection, configured as an HVDC subsea circuit, between T-Point and a new 400 kV South Wales West Connection Node C substation. In light of this analysis, the starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-6 – Carmarthen Bay

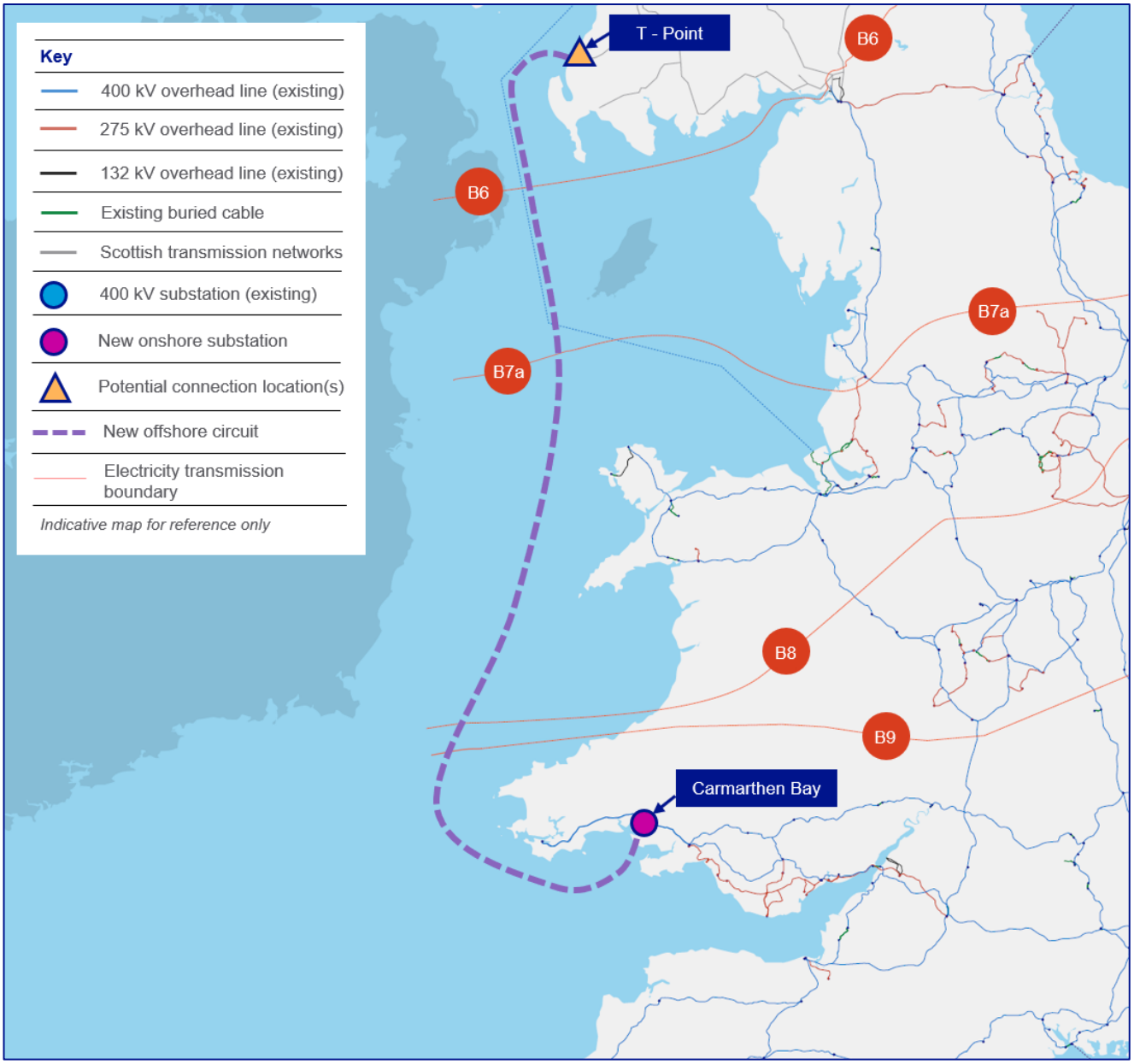
Description of the strategic option AC6-6

6.2.507 Strategic Option AC6-6 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to the proposed Llandyfaelog 400 kV substation (Carmarthen Bay) in south Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.508 For the purposes of the appraisal of Strategic Option AC6-6, consideration has been given to the additional costs or impacts of accommodating the Project connection at the proposed Llandyfaelog 400 kV substation to connect AC6-6.

6.2.509 Figure 6.7 below presents an indicative map for Strategic Option AC6-6 (for illustrative purposes only and does not denote viable development route).

Figure 6.7 - Indicative study area of Strategic Option AC6-6



6.2.510 The circuit distance for this connection is 576 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Llandyfaelog substation.

6.2.511 This option is formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Llandyfaelog. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project connection, which falls within NGET's licence area. Approximately 5 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.512 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, the appraisal shows that:

- There are two SPAs which cannot be avoided - Carmarthen Bay SPA and Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are six SACs which cannot be avoided - Carmarthen Bay and Estuaries SAC, Bristol Channel Approaches SAC, Carmarthen Bay Dunes SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC.
- There is one SAC that is unlikely to be avoided - The North Channel SAC.
- SSSI sites occupy this coastline and cannot be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.513 This strategic option passes through two unavoidable SPAs and six unavoidable SACs within Welsh waters, and one likely unavoidable SACs, off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. This may result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.514 Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.515 Where features cannot be avoided, there is potential for habitat loss or damage as a result of construction activities (e.g. cable burial, cable protection).

6.2.516 Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats.

6.2.517 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.518 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce effects to the marine environment.

6.2.519 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated, that there will be consenting implications related to these designated sites, such as potential seasonal restrictions.

6.2.520 It should be noted that there are currently: seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, 17 that cross the Bristol Channel Approaches, one cable that crosses the Carmarthen Bay and Estuaries SAC, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

6.2.521 There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.522 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.523 During construction, there is the potential for accidental direct physical effects due to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works could take place.

6.2.524 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.525 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.526 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.527 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present.

6.2.528 The landfall area has a beach width greater than 500 m (1.5 km at the narrowest point), so it may not be suitable for landfall. The coastal height is mostly less than 30 m so may be suitable for landfall.

6.2.529 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. It cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.530 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.531 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.532 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments. Technical and engineering input would be required to determine if the intertidal area would allow for construction.

6.2.533 Best practice methods for cable burial can be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.534 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.535 There is potential that this strategic option may not be sufficient for construction due to the wide intertidal zone (1.5 km). Further technical and engineering inputs would be required to determine this.

6.2.536 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.537 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within this area is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial ecology

6.2.538 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, the appraisal shows that:

- There is one SSSI which cannot be avoided - Pembrey Coast SSSI
- There are no NNRs, Registered Common Land, RSPB Reserves within this strategic option.
- All other receptors can be avoided.

6.2.539 There is potential for impacts to one or more designated site (Dedicated Forest, Country Park and SSSI) from construction activities of the cable that cannot be avoided. The SSSI will require crossing which would likely result in habitat loss, loss of vegetation, visual and biodiversity impact. The onshore SAC, SPA and Ramsar will most likely be in close proximity to the cable which may result in temporary adverse effects. Due to the country park and dedicated forest running along the coastline between Burry Port and Kidwelly, it is most likely one of these designations will require crossing while making landfall and result in loss of vegetation and habitat.

6.2.540 Mitigation in relation to Country Parks, Dedicated Forests and SSSIs may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods, there is potential to use trenchless solutions for the narrowest section of Country Park for 1.5 km inland. While impacts from routeing underground cables through or near these designated sites can be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, SACs, NNR and Ramsar sites etc).

6.2.541 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.542 It is not anticipated that there would be any long-term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.543 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a limited amount of statutory designated ecological designations (i.e. one SSSI to the east of the converter station), however, within the 5 km radius there are large amounts of areas clear of these designations thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.544 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.545 Throughout the study area of this strategic option, underlying geology has identified that Grade 3 Agricultural land cannot be avoided. Regionally Important Geodiversity Sites can be avoided, along with Geoparks, peatlands and Grade 1 and 2 Agricultural Land.

6.2.546 Grade 3 agricultural land is unavoidable given its extent throughout the strategic option. There is potential for adverse effects on agricultural land and soils, which could lead to additional consenting considerations.

6.2.547 Construction on this land may lead to soil compaction, which reduces soil permeability and aeration resulting in a loss of agricultural productivity. Where routeing through

grade 3 agricultural land is unavoidable, standard protection measures should be implemented during the construction phase to minimise impacts on soils.

6.2.548 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely there would be significant residual effects to these receptors.

6.2.549 Whilst areas of Grade 3 agricultural land cannot be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.550 Regarding the suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Very few land parcels around the substation are classified as Grade 4 or lower, the majority of land in a 5 km radius is 3a or 3b. Areas of Grade 4 or below and 'non-agricultural' land are more suitable locations for the converter station however, within this strategic option the converter station will most likely be located in Grade 3 land and mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.551 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

- There is one Coastal Path which cannot be avoided - Wales Coast Path.
- The Pembrokeshire Coast National Park could be avoided.
- There are four LandMAP aspects rated as High and one rated as Outstanding within this strategic option largely along the coastline as landfall is made.

6.2.552 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path. There could be consenting implications as a result of closing, stopping or diverting PRoW which could lead to timeline delays.

6.2.553 Although the National Park could be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.554 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and careful routeing, as well as likely implementing erosion control measures.

6.2.555 Mitigation measures in relation to these landscape and visual features would likely include the routeing of the underground cable to avoid key views, long-distance open views (particularly from high ground), National Parks, and Coastal Paths where possible.

6.2.556 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.557 There is potential for temporary adverse visual effects due to construction and future maintenance of underground cables; this can be reduced through careful routeing.

There is not anticipated to be any adverse outcomes associated with the presence of sensitive receptors within this strategic option.

6.2.558 Careful siting of the proposed converter station would be required to minimise permanent impacts to the specified Coastal Paths. Permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.559 Within the study area of strategic option AC6-6, there are international and national designated or important historic environment and cultural heritage sites present throughout the study area, comprising Listed Buildings (Grade I and II), SMs, Registered Parks and Gardens, Conservation Areas and RLOSI. From these;

- All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens, Conservation Areas could be avoided.
- There is one RLOSI that cannot be avoided.

6.2.560 There is potential for temporary impacts to occur to the setting of the heritage assets, however most assets could be directly avoided with careful routeing of the cable. One RLOSI requires crossing during landfall due to covering the coastline between Kidwelly and Burry Port, however all impacts which are associated with construction activities of the cable are temporary impacts i.e. noise, vibration and visual impacts.

6.2.561 Mitigation would require careful routeing to avoid impacts to designated heritage assets, standard protection measures should be applied during the construction phase.

6.2.562 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long-term visual impact is low risk due to avoiding use of OHLs.

6.2.563 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration within the 5 km area surrounding the substation to avoid the Conservation Area, Parks and Gardens and Listed Buildings and to minimise the impact on the designated assets. However, all other historic assets are situated within the 5 km radius.

Hydrology

6.2.564 Strategic Option AC6-6 study area includes four main rivers that could not be avoided.

6.2.565 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.566 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.567 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.568 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.569 There is not anticipated to be any long-term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.570 Regarding suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise impacts on hydrology, considering that one main river is located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses, 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.571 Throughout Strategic Option AC6-6, the following receptors have been considered; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 19 cables which cannot be avoided.
- There are five active disposal sites, these could all be avoided.
- There is one offshore military firing range, this could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There is very little fishing activity within Carmarthen Bay. There are several areas of fishing activity further north within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.572 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements. Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.573 The active disposal sites could be avoided via routeing and siting.

6.2.574 There is potential for interaction between construction vessels and other marine vessel users, this may lead to consenting and legal implications.

6.2.575 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation.

6.2.576 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.577 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 19 cables.

6.2.578 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area.

6.2.579 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.580 There are two major settlements present within this strategic option including Kidwelly in the centre and Burry Port further south on the coast. Smaller settlements are located throughout the study area up to the substation.

6.2.581 Burry Port and Kidwelly could be avoided through detailed routeing. Routeing around urban areas would have adverse effects on residential and commercial receptors. Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.582 Routeing through these settlements is not possible.

6.2.583 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties should be carefully routed around and avoided.

6.2.584 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.585 With appropriate mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.586 There are unlikely to be adverse effects on the features identified within the study area. Settlements are present within this strategic option, however, due to the temporary nature of the construction works and with careful routeing, impacts on these areas could be avoided.

Tourism and Recreation

6.2.587 There are no areas of National Trust Land within this study area. However, there is one National Cycle Network route, National Cycle Network route 4, which cannot be avoided.

6.2.588 Crossing this route would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping or diverting the Cycle Network. This could lead to timeline delays.

6.2.589 If it is not possible to avoid a National Cycle Network route, standard protection measures could be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods (such as HDD), the impacts would not be permanent.

6.2.590 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.591 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of the cabling works) when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.592 Across the study area of Strategic Option AC6-6, the following receptors have been identified.

- All, Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- Two OHLs may require crossing.

6.2.593 There is potential for temporary impacts to occur on the land use assets however all assets could be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable, these are temporary impacts i.e. noise, vibration, operational disruption and visual impacts.

6.2.594 Cables cannot route through or be in close proximity to Airports and Ports. Mitigation would require careful routeing to avoid impacts to land use assets and standard protection measures should be applied during the construction phase. Early engagement with Airport and Port authorities may be required if construction works are within the area. Height restrictions on construction vehicles and standard protection measures will be employed during construction practices, coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.595 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.596 Regarding suitability for the additional converter, the study area for the proposed converter station falls outside of the area where the Historic Landfill Sites and Ports are located, however, the OHLs fall within this area. In addition, the Pembrey Airport would be in proximity to the landfall location and may pose a potential issue for the converter station location. Despite this, construction is unlikely to be a constraint for routeing and siting of the converter station, although, careful routeing around the OHL will be required within this strategic option.

Summary of the technical appraisal

6.2.597 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-6 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.598 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the proposed Llandyfaelog 400 kV substation in South Wales. This substation is trigged by a different connection project, however, should that project not proceed, the substation would be required as part of the Project scope of works and has been included in this appraisal to account for this eventuality.
- A new 525 kV DC converter station at Llandyfaelog would be required and the proposed Llandyfaelog substation would need to accommodate the two bays required to accommodate this strategic option.
- As for all south Wales connections, AC6-6 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.599 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.600 Strategic Option AC6-6 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Currently, there is no existing substation infrastructure in the Carmarthen Bay area. The substation (Llandyfaelog) that AC6-6 would be connecting into is, as of now, being triggered by a different project in the area; Should that projects not proceed, the ten-bay substation would be required as part of the Project scope of works and has, hence, been included in the cost appraisal to account for this eventuality.
    - In the case where the Llandyfaelog substation is triggered by planned projects in the Carmarthen Bay area, AC6-6 would only require to utilise two bays at the site.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Llandyfaelog substation.

6.2.601 Table 6.11 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.11 - Capital Costs for Strategic Option AC6-6

Item	Capital Cost	
Substation and Wider Works	£179.4m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (576 km)	£24,614.1m	£4,015.9m
Total Capital Cost	**£24,793.5m**	**£4,195.3m**

6.2.602 Table 6.12 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.12 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£24,614.1m	£4,015.9m
NPV of Cost of Losses over 40 years	£579.9m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£132.8m	£75.3m
Lifetime Cost of New Circuits	**£25,327m**	**£4,248m**

6.2.603 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.604 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-6 is a 576 km connection, configured as an HVDC subsea circuit, between T-Point and a new 400 kV Llandyfaelog Substation. In light of this analysis, the starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-7 – Swansea North

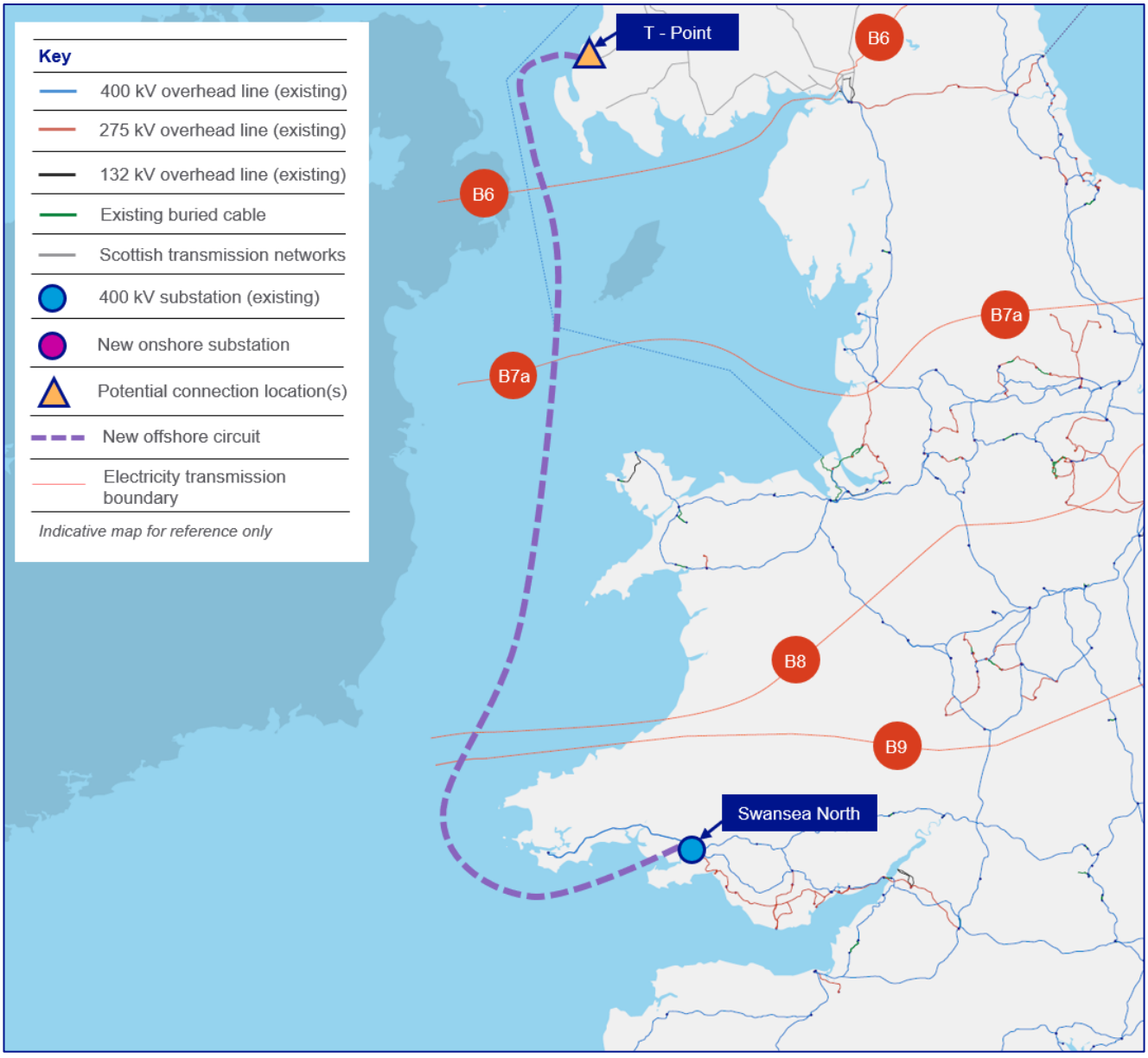
Description of the strategic option AC6-7

6.2.605 Strategic Option AC6-7 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to an existing Swansea North 400 kV substation in south Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.606 For the purposes of the appraisal of Strategic Option AC6-7, consideration has been given to the additional costs or impacts of extending the existing Swansea North 400 kV substation to connect AC6-7.

6.2.607 Figure 6.8 below presents an indicative map for Strategic Option AC6-7 (for illustrative purposes only and does not denote viable development route).

Figure 6.8 - Indicative study area of Strategic Option AC6-7



6.2.608 The circuit distance for this connection is 612 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the southern Welsh coastline;
- and a straight-line distance from the landfall to the Swansea North substation.

6.2.609 This option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Swansea North. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project connection, which falls within NGET's licence area. Approximately 30 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.610 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPA, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, our appraisal shows that:

- There are two SPAs which cannot be avoided - Carmarthen Bay SPA and Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are six SACs which cannot be avoided - Carmarthen Bay and Estuaries SAC, Bristol Channel Approaches SAC, Carmarthen Bay Dunes SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC.
- There is one SAC that is unlikely to be avoided - The North Channel SAC.
- SSSI sites occupy this coastline and cannot be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.611 This strategic option passes through two unavoidable SPAs and six unavoidable SACs within Welsh waters, and one likely unavoidable SAC, off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. This may result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.612 Detailed cable routeing could be used to avoid designations where possible. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats and impacts to protected species due to migratory and foraging ranges.

6.2.613 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required.

Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.614 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce effects to the marine environment.

6.2.615 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore is anticipated that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.616 It should be noted that there are currently: seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, 17 that cross the Bristol Channel Approaches, one cable that crosses the Carmarthen Bay and Estuaries SAC, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

6.2.617 There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.618 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.619 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works could take place.

6.2.620 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.621 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

Marine Geology

6.2.622 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present. The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.623 The landfall area around the potential Swansea North landfall area has a beach width greater than 500 m (1.5 km at the narrowest point). It may not be suitable for landfall. The coastal height is mostly less than 30 m so it may be suitable for landfall.

6.2.624 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.625 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.626 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments. Technical and engineering input would be required to determine if the intertidal area would allow for construction.

6.2.627 Best practice methods for cable burial can be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.628 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.629 There is potential that this strategic option may not be suitable for construction due to the wide intertidal zone (1.5 km) present within the area. Further technical and engineering inputs would be required to determine this.

6.2.630 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods, however, It will remain likely that there will be consenting implications related to this designated site.

6.2.631 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within the area is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.632 There are a number of international and national designated terrestrial ecology sites present throughout the study area. The following has been identified;

- There is one SSSI which cannot be avoided - Pembrey Coast SSSI;
- There are SACs, SPAs, Registered Common Land, RSPB Reserves within this strategic option, all of which can be avoided but may be in close proximity;
- All other receptors could be avoided.

6.2.633 There is potential for impacts to designated features of one or more designated sites (Dedicated forest, Country Park and SSSI) that cannot be avoided, associated with construction activities of the cable. The SSSI will require crossing which would likely result in habitat loss, loss of vegetation, and visual and biodiversity impact. The onshore SAC, SPA and Ramsar will most likely be in close proximity to the cable which may result in temporary adverse effects. Due to the country park and dedicated forest running along the coastline between Burry Port and Kidwelly, it is most likely one of these designations will require crossing while making landfall, resulting in loss of vegetation and habitat.

6.2.634 Although dedicated forest, Country Park and other SSSIs can be avoided, there is still potential for direct and indirect impacts to these receptors.

6.2.635 Mitigation in relation to Country Parks, Dedicated Forests and SSSIs may include surveys to confirm habitat and root presence and location, as well as micro routeing and/or trenchless installation methods. There is also potential to use trenchless solutions for the narrowest section of Country Park for 1.5 km inland. While routeing underground cables through or near these designated sites can be mitigated through careful planning, the use of advanced technologies and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, SACs, NNR and Ramsar sites etc).

6.2.636 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.637 There are not anticipated to be any long-term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.638 The study area for the proposed converter station only contains a limited amount of statutory designated ecological designations (i.e. one SSSI to the east of the substation). However, within the 5 km radius, there are large amounts of areas clear of these designations, thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.639 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.640 Throughout the study are of this strategic option, Grade 3 Agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites can be avoided, along with Grade 2 Agricultural Grade land.

6.2.641 Grade 3 Agricultural land is unavoidable given its extent throughout the strategic option. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage.

6.2.642 Where routeing through Grade 3 agricultural land is unavoidable, standard protection measures should be implemented during the construction phase to minimise impacts on soils.

6.2.643 Construction methods such as low-ground-pressure machinery can be utilised to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely there would be significant residual effects to these receptors.

6.2.644 Whilst areas of Grade 3 agricultural land cannot be avoided within this strategic option, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.645 The assessment is based on routeing designed to avoid Grade 1 and 2 land. However, if an alternative route is chosen in the future, Grade 2 land within the study area could be impacted.

6.2.646 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grade 1 and 2 land. Large areas around the substation are classified as Grade 4 or lower. Areas of Grade 4 or below are more suitable locations for the converter station, however, within this strategic option the converter station may require being located in Grade 3 land and mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.647 Landscape and Visual Amenity constraints have been identified across this strategic option's study area, including National Parks, Coastal Paths, AONB, National Trails, Biosphere Reserves, Heritage Coasts and LandMAP aspects. Historic, Geological and habitat landscapes have also been considered. LandMAP aspects are five national datasets (across Wales) consisting of Geological Landscape, Landscape Habitats, Visual and Sensory, Historic Landscape, Cultural Landscape Services.

- There is one Coastal Path which cannot be avoided - Wales Coast Path.
- There are four LandMAP aspects rated as High and one rated as Outstanding within this strategic option.

6.2.648 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path. There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.649 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and routeing, as well as likely implementing erosion control measures.

6.2.650 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground) and Coastal Paths where possible.

6.2.651 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.652 There may be potential temporary adverse visual effects due to construction and future repair/servicing of underground cable, this can be reduced through careful routeing. There is not anticipated to be any adverse outcomes associated with the presence of sensitive receptors within this strategic option.

6.2.653 Regarding suitability for the additional converter station, careful siting of the proposed converter station would be required to minimise permanent impacts to the specified Coastal Paths. Permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.654 Within the study area of AC6-7, there are international and national designated or important historic environment and cultural heritage sites present, comprising Listed Buildings (Grade I and II), Scheduled Monuments, Registered Parks and Gardens, Conservation Areas and Registered Landscapes of Outstanding and of Special Interest (RLOSI). Of these;

- All Listed Buildings (Grade I and II*), Scheduled Monuments (SMs), Registered Parks and Gardens, Conservation Areas could be avoided.
- There is one RLOSI that cannot be avoided.

6.2.655 There is potential for temporary impacts to occur to the setting of the heritage assets, however most assets can be directly avoided with careful routeing of the cable. One RLOSI requires crossing during landfall due to covering the coastline between Kidwelly and Burry Port, however, all impacts are associated with construction activities of the cable These are temporary impacts (i.e. noise, vibration and visual impacts).

6.2.656 Mitigation would require careful routeing to avoid impacts to designated heritage assets. Standard protection measures should be applied during the construction phase.

6.2.657 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works. In addition, long term visual impact is low risk due to avoiding the use of OHLs.

6.2.658 There are unlikely to be adverse effects on the designated assets within the study area when careful routeing and site selection is applied.

6.2.659 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of the location surrounding the substation to avoid the Conservation Area, Parks and Gardens and Listed Buildings, which is necessary to minimise the impact to setting on the designated assets. However, all other assets are not situated within the 5 km radius.

Hydrology

6.2.660 For Strategic Option AC6-7, there are four main rivers within this strategic option, two main rivers that cannot be avoided and two that may be avoided with careful routeing. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.661 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies within the floodplain and near flood defences.

6.2.662 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place, when working close to Main Rivers and surface water bodies, would ensure effects to the water environment are minimised.

6.2.663 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.664 Regarding the suitability for the additional converter station, the proposed converter station location must carefully consider the surrounding area to minimise the impacts on hydrology, five main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from the watercourse of 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.665 Throughout Strategic Option AC6-7, the following receptors have been identified.

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 19 cables which cannot be avoided.
- There are five active disposal sites, which could all be avoided.
- There is one offshore military firing range that could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There is very little fishing activity within Carmarthen Bay. There are several areas of fishing activity further north within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.666 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.667 Early engagement with cable and pipeline owners/responsible parties could help mitigate any potential timeline delays of legal implications.

6.2.668 The active disposal sites could be avoided via routeing and siting.

6.2.669 The two potential wind sites could be monitored for future development, but, at this stage, do not require mitigation.

6.2.670 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 19 cables.

6.2.671 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area.

6.2.672 There are shipping routes and fishing grounds within the study area of the strategic option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.673 There are three major settlements present within this strategic option including Kidwelly in the centre and Burry Port further south on the coast, with North Swansea also located within 5 km buffer around the substation. Smaller settlements are located throughout the study area up to the substation.

6.2.674 Burry Port and North Swansea (in close proximity to the substation) can be avoided through detailed routeing. Routeing around urban areas would have adverse effects on residential and commercial receptors. Effects include disruption to local communities and traffic congestion through increased construction traffic and dust from construction vehicles.

6.2.675 Routeing through these settlements is not possible.

6.2.676 Standard protection measures should be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.677 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.678 There are unlikely to be adverse effects on the features identified within the study area. Settlements are present within this strategic option, however, due to the temporary nature of the construction works and with careful routeing, impacts on these areas could be avoided.

Tourism and Recreation

6.2.679 There are no areas of National Trust Land within this study area, however there are three National Cycle Network routes, of which National Cycle Network route 4 and 47 cannot be avoided. Crossing these two routes would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions.

6.2.680 There would likely be consenting implications as a result of temporarily closing, stopping or diverting Cycle Network, which could lead to timeline delays. If it is not possible to avoid a National Cycle Network route, standard protection measures should be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods, such as HDD, the impacts would not be permanent.

6.2.681 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.682 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to temporary nature of cabling works) when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.683 Across the study area of Strategic Option AC6-7, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- One or more OHLs may require crossing.

6.2.684 There is potential for temporary impacts to occur on the land use assets, however, all assets can be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration, operational disruption and visual impacts.

6.2.685 Cables cannot route through or be in close proximity to Airports and Ports. Mitigation would require careful routeing to avoid impacts to land use assets and standard protection measures should be applied during the construction phase. Early engagement with Airport and Port authorities may be required if construction works are within the area. Height restrictions on construction vehicles and standard protection measures will be employed during construction practices and coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.686 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is applied.

6.2.687 Regarding suitability for the additional converter station, the study area for the proposed converter station falls outside of the area where the Ports are located, however, multiple Historic Landfill Sites and OHLs are present within this area. In addition, the Pembrey Airport would be in proximity to the landfall location and may pose a potential issue for the converter station location. Construction is unlikely to be a constraint for routeing and siting of the converter station although careful routeing around these landfill sites and OHLs will be required within this strategic option.

Summary of the technical appraisal

6.2.688 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-7 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.689 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the existing Swansea North 400 kV substation in South Wales.
- A new 525 kV DC converter station at Swansea North would be required and the existing Swansea North substation which requires bay extensions as it is currently at full capacity. There are currently two 400 kV double circuits leaving the substation.
- As for all south Wales connections, AC6-7 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.690 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.691 Strategic Option AC6-7 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Utilisation of two bays, if available at the time of commissioning, or bay extensions at the existing Swansea North 400 kV substation to accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Swansea North substation.

6.2.692 Table 6.13 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.13 - Capital Costs for Strategic Option AC6-7

Item	Capital Cost	
Substation and Wider Works	£20.5m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (612 km)	£26,163.0m	£4,288.2m
Total Capital Cost	**£26,183.5m**	**£4,308.7m**

6.2.693 Table 6.14 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.14 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£26,163.0m	£4,288.2m
NPV of Cost of Losses over 40 years	£620.8m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£141.1m	£75.5m
Lifetime Cost of New Circuits	**£26,925m**	**£4,521m**

6.2.694 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.695 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-7 is a 612 km connection, configured as an HVDC subsea circuit, between T-Point and the existing 400 kV Swansea North Substation. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-8 – Baglan Bay

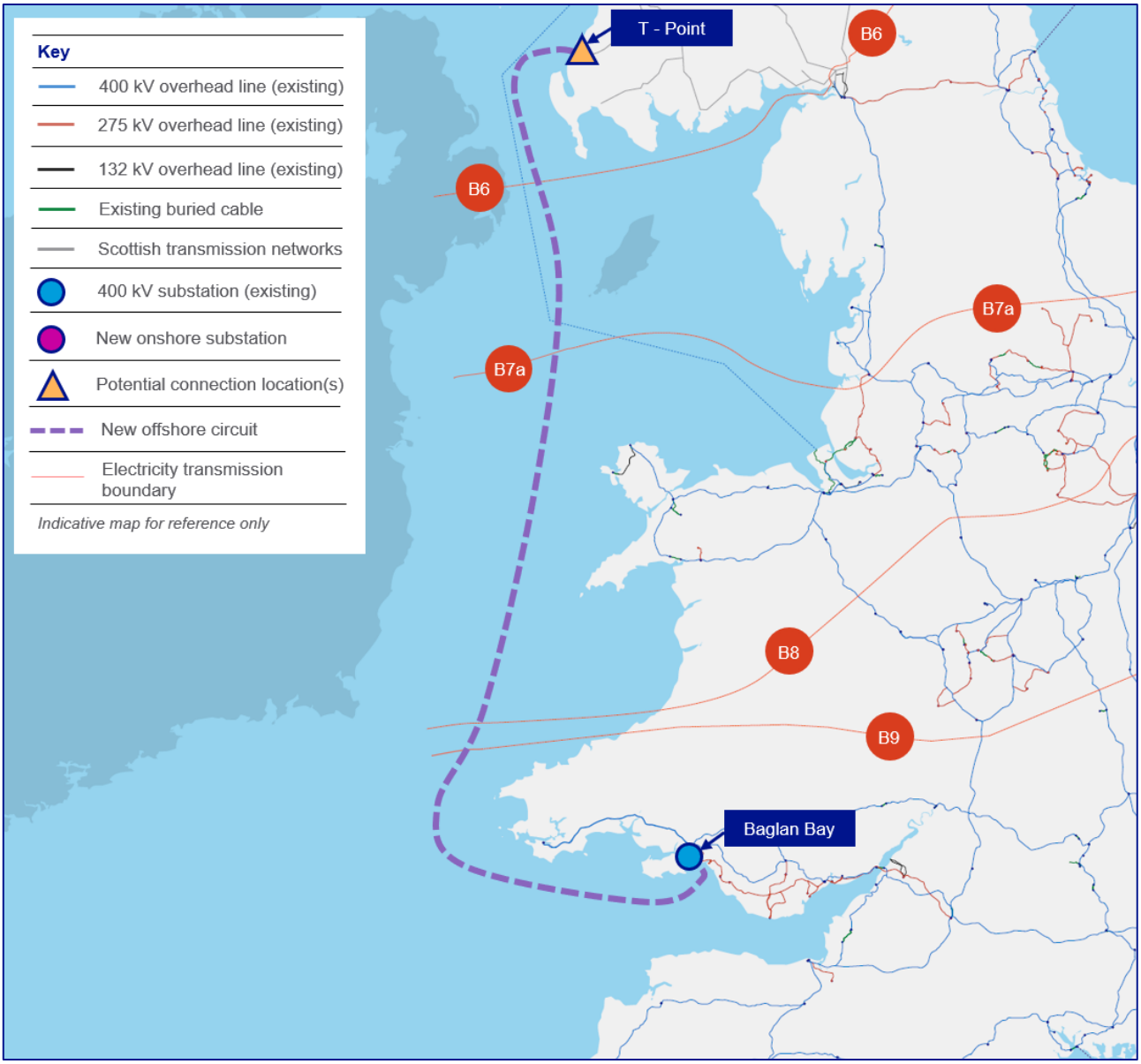
Description of the strategic option AC6-8

6.2.696 Strategic Option AC6-8 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to the existing Baglan Bay 275 kV substation in south Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.697 For the purposes of the appraisal of Strategic Option AC6-8, consideration has been given to the additional costs or impacts of extending the existing Baglan Bay 275 kV substation to connect AC6-8.

6.2.698 Figure 6.9 below presents an indicative map for Strategic Option AC6-8 (for illustrative purposes only and does not denote viable development route).

Figure 6.9 - Indicative study area of Strategic Option AC6-8



6.2.699 The circuit distance for this connection is 612 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the southern Welsh coastline;
- and a straight-line distance from the landfall to the Baglan Bay substation.

6.2.700 This strategic option is formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Baglan Bay. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 1 km of onshore underground HVDC cable would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.701 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, our appraisal shows that:

- There is one SPAs which cannot be avoided - Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are four SACs which cannot be avoided - Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is one SAC that is unlikely to be avoided - The North Channel SAC.
- SSSI sites occupy this coastline and are unlikely to be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.702 This strategic option passes through one unavoidable SPA and four unavoidable SACs within Welsh waters, and one likely unavoidable SACs, off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.703 Where features cannot be avoided, there is potential for habitat loss or damage as a result of construction activities (e.g. cable burial, cable protection).

6.2.704 Detailed cable routeing may be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats.

6.2.705 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s),

SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.706 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce potential effects to the marine environment.

6.2.707 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. It will remain likely, and therefore it is anticipated that there will be consenting implications related to these designated sites.

6.2.708 It should be noted that there are currently: seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, seventeen that cross the Bristol Channel Approaches, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consent within these areas is possible.

6.2.709 There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.710 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.711 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features.

6.2.712 It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks within which no temporary or permanent works could take place.

6.2.713 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.714 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.715 It cannot not be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.716 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present.

6.2.717 The beach width around the potential Baglan Bay landfall area is generally less than 500 m with the exception of the mouth of the River Neath which exceeds 1 km. This area may be avoided, however, there are potential terrestrial constraints which may restrict this. The beach width means this area may be suitable for landfall. On the

contrary, the area around the River Neath mouth has a wider intertidal zone so it may not be suitable for construction, but it could be avoided.

6.2.718 The coastal height is generally less than 30 m so it may be suitable for landfall.

6.2.719 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. It cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed from cable installation activities. Construction activities may result in direct geological impacts.

6.2.720 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.721 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments. Technical and engineering input would be required to determine if the intertidal area would allow for construction.

6.2.722 Best practice methods for cable burial can be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.723 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.724 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.725 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within the area is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.726 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, our appraisal shows that:

- There are no SPAs, Country Parks, Registered Common Land and RSPB Reserves within this strategic option.
- All other receptors could be avoided.

6.2.727 There is potential for impacts to designated features of one designated sites (SSSI) that will be in close proximity to making landfall, associated with construction activities of the cable. The relevant designated features that could be impacted include habitat loss, loss of vegetation, visual and biodiversity impact and disturbance to species.

6.2.728 Mitigation in relation to SSSI may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods. While routeing underground cables through or near ancient woodlands can be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, SACs, Ramsar, NNR and LNRs etc).

6.2.729 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.730 There are not anticipated to be any adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. SSSIs may be avoided via routeing and siting, however, if this is not optional, further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.731 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a limited amount of statutory designated ecological designations (i.e. SSSIs, LNRs, NNRs and Ancient Woodlands), however, within the 5 km radius there are large amounts of areas clear of these designations thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.732 Within this strategic option, the Neath Port Talbot AQMA is present in the southeast of the study area. It is generally advisable to avoid construction traffic through Port Talbot.

6.2.733 With a CTMP and other mitigation measures in place for the construction phase, it is not anticipated that there will be any long-term adverse outcomes associated with the Port Talbot AQMA within this strategic option.

6.2.734 The AQMA falls within the 5 km study area for the proposed converter station thus, careful siting will be required when placing the converter station to avoid long term impacts to the Port Talbot AQMA. By avoiding siting the converter station in close proximity to the AQMA, no impacts are anticipated as a result of its construction or operation.

Geology and Soils

6.2.735 Throughout Strategic Option AC6-8, Grade 3 Agricultural land cannot be avoided. Large areas of Peatland could be avoided.

6.2.736 Grade 3 agricultural land is unavoidable given its extent throughout the strategic option. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration and loss of agricultural productivity.

6.2.737 Where routeing through Grade 3 agricultural land is unavoidable, standard protection measures should be implemented during the construction phase to minimise impacts on soils.

6.2.738 Construction methods such as low-ground-pressure machinery can be utilised to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may also be required to verify desk-based data. With these mitigation measures put in place, it is unlikely there would be significant residual effects to these receptors.

6.2.739 Regarding suitability for the additional converter station, the proposed converter station within this strategic option will most likely be located within Grade 3 agricultural land due to the current location of Baglan Bay substation. Large areas around the substation are classified as Urban areas, thus not suitable for converter station location.

Landscape and Visual Amenity

6.2.740 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

- There is one Coastal Path which cannot be avoided - Wales Coast Path.
- There is one LandMAP aspect rated as High within this strategic option.

6.2.741 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path. There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.742 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground) and Coastal Paths, where possible. There is also likely the need to implement erosion control measures

6.2.743 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.744 Regarding suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.745 Within the study area of Strategic Option AC6-8, there are international and national designated or important historic environment and cultural heritage sites present throughout the study area.

- All Listed Buildings (Grade I and II*), Scheduled Monuments (SMs), Registered Parks and Gardens, Conservation Areas can be avoided.

6.2.746 There is potential for temporary impacts to occur to the setting of the heritage assets, however, all assets can be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration and visual impacts.

6.2.747 There are unlikely to be adverse effects on the designated assets within the study area when careful routeing and site selection is applied.

6.2.748 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of location surrounding the substation; this is necessary to minimise the impact to setting on the designated assets.

Hydrology

6.2.749 All main rivers within the strategic option's study area could be avoided. There is potential for impacts on hydrology and flood risk within this strategic option, however, most of the features identified can be directly avoided with careful routeing and mitigated by using standard protection measures during construction.

6.2.750 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.751 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.752 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.753 There is not anticipated to be any long-term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.754 Regarding suitability for the additional converter station, the proposed converter station location must careful consider impacts on hydrology as two main rivers are located within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses (i.e. implementing a minimum construction buffer from watercourses of 30m or more).

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.755 Throughout Strategic Option AC6-8, the following receptors have been identified;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 22 cables which cannot be avoided.
- There are five active disposal site; these could all be avoided.

- There is one offshore military firing range which could be avoided.
- There are several key shipping corridors which cross this study area between England and Ireland and Scotland and Ireland. These include common Ferry routes.
- There is very little fishing activity within Carmarthen Bay. There are several areas of fishing activity further north within this strategic option, most notably between Ireland and the Isle of Man.

6.2.756 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements. Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.757 The active disposal sites could be avoided via routeing and siting.

6.2.758 There is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option's study area.

6.2.759 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation. Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 22 cables.

6.2.760 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area. There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.761 There are eight major settlements present within this strategic option: Skewen is located in the northwest of this strategic option's study area, along with Coed Darcy and Jersey Marine to the west. The major settlements of Briton Ferry, Baglan, Baglan Moors, Aberavon and Port Talbot are spread across the southeast of this area. The existing substation is located in close proximity to the individual properties; however, routeing will not have to pass these residential areas.

6.2.762 Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.763 Routeing through these settlements is not possible.

6.2.764 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties should be carefully routed around and avoided.

6.2.765 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.766 With appropriate mitigation measures in place, it is unlikely that there would be residual effects to these receptors.

6.2.767 There are unlikely to be adverse effects on the features identified within the study area. Settlements are present within this strategic option, however, due to the temporary nature of the construction works and with careful routeing, these areas could be avoided.

Tourism and Recreation

6.2.768 There are no areas of National Trust Land within this study area. However, there are three National Cycle Network routes, all of which could be avoided.

6.2.769 There are no adverse effects due to the routeing not crossing or impacting these assets.

Land Use and Other Infrastructure

6.2.770 Across the study area of Strategic Option AC6-8, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.

6.2.771 All OHLs and cables could be avoided. There is potential for temporary impacts to occur on the land use assets, however, all assets can be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration, operational disruption and visual impacts.

6.2.772 Cables cannot route through or be in close proximity to Ports. Mitigation would require careful routeing to avoid impacts to land use assets, standard protection measures should be applied during the construction phase. Early engagement with Port authorities may be required if construction works are within the area. Height restrictions on construction vehicles and standard protection measures will be employed during construction practices, coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.773 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is applied.

6.2.774 Regarding suitability for the additional converter station, the study area for the proposed converter station falls within the area where the Historic Landfill Sites, OHLs, Ports are located thus, careful placement is required however, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option. Summary of the technical appraisal

Summary of the technical appraisal

6.2.775 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-8 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.776 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at the existing Baglan Bay 275 kV substation.
- A new 525 kV DC converter station at Baglan Bay would be required and the existing Baglan Bay substation would require a two-bay extension.
- This strategic option would also require rebuild at Margam and Pyle 275 kV substations.
- As for all south Wales connections, AC6-8 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

6.2.777 There is extensive enabling works required for this option, a summary of which is as follows:

- Upgrade of 132 kV circuits up to 275 kV
- Cable section replacement in Baglan Bay – Swansea & Baglan Bay – Margam circuits
- Reconductoring of two 275 kV circuits from Baglan Bay substation
- Bay extension at Swansea North 400 kV substation to accommodate a new 400/275 kV transformer.
- Super-Grid Transformer (SGT) replacement at Swansea North

Summary of the cost appraisal

6.2.778 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.779 Strategic Option AC6-8 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Bay extensions at the existing Baglan Bay 275 kV Substation to accommodate the AC6 connection.
    - Rebuild at Margam and Pyle 275 kV substation and uprating to 400 kV
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the Baglan Bay substation.

6.2.780 Table 6.15 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.15 - Capital Costs for Strategic Option AC6-8

Item	Capital Cost	
Substation and Wider Works	£20.5m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (612 km)	£26,163.0m	£4,195.3m
Total Capital Cost	**£26,183.5m**	**£4,215.8m**

6.2.781 Table 6.16 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.16 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£26,163.0m	£4,195.3m
NPV of Cost of Losses over 40 years	£620.8m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£141.1m	£75.5m
Lifetime Cost of New Circuits	**£26,925m**	**£4,428m**

6.2.782 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.783 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-8 is a 612 km connection, configured as an HVDC subsea circuit, between T-Point and the existing 275 kV Baglan Bay Substation. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-9 – South Wales West Connection Node B

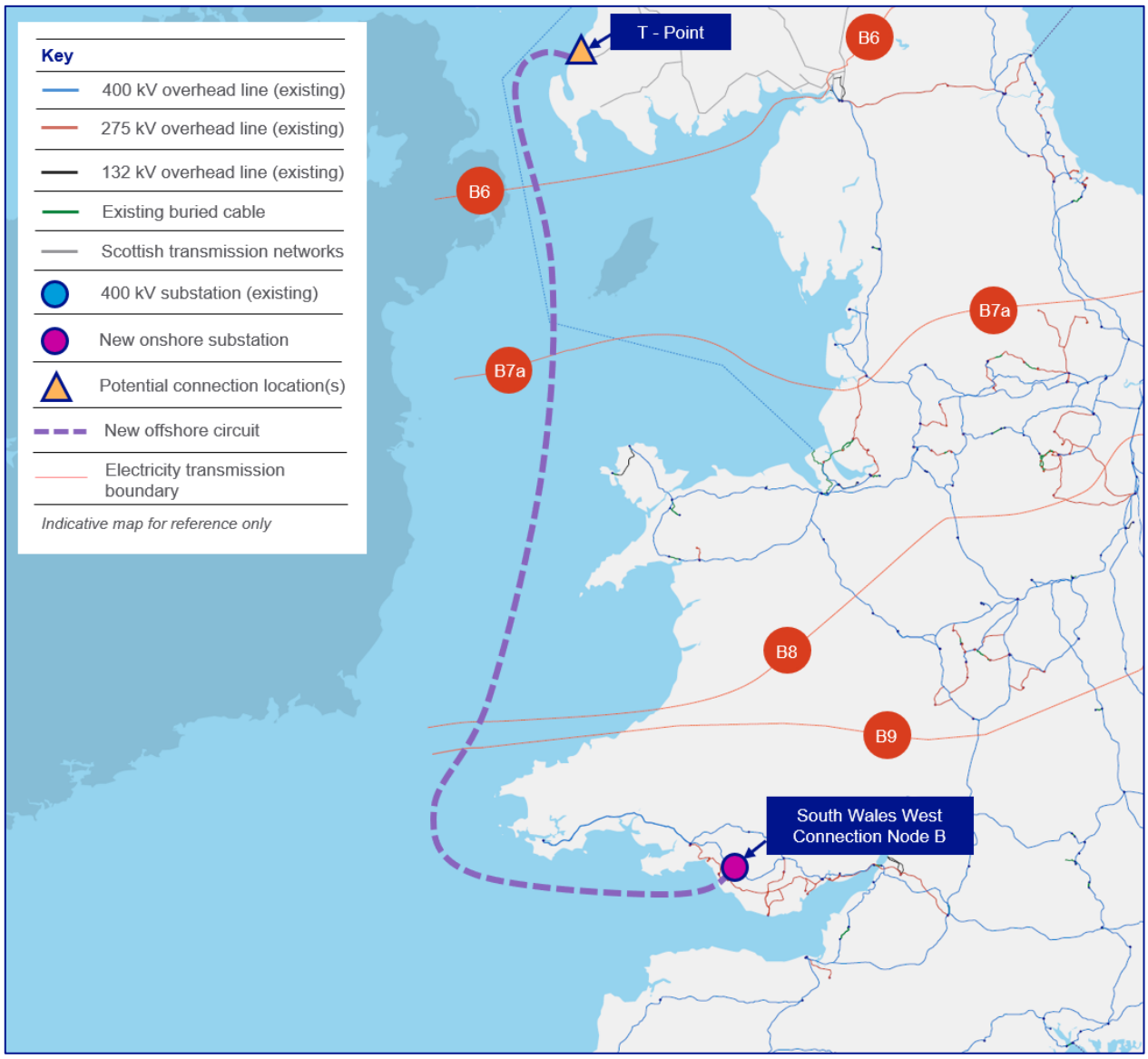
Description of the strategic option AC6-9

6.2.784 Strategic Option AC6-9 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) connecting to the proposed South Wales West Connection Node B 400 kV substation in the Bridgend area in South Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the southern Welsh coastline.

6.2.785 For the purposes of the appraisal of Strategic Option AC6-9, consideration has been given to the additional costs or impacts of connecting into the proposed South Wales Connection Node B 400 kV substation.

6.2.786 Figure 6.10 below presents an indicative map for Strategic Option AC6-9 (for illustrative purposes only and does not denote viable development route).

Figure 6.10 - Indicative study area of Strategic Option AC6-9



6.2.787 The circuit distance for this connection is 630 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the southern Welsh coastline;
- and a straight-line distance from the landfall to the South Wales West Connection Node B substation.

6.2.788 This strategic option is formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Bridgend. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 11 km of onshore underground HVDC cable would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.789 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, our appraisal shows that:

- There is one SPA which cannot be avoided – the Skomer, Skokholm, and the Seas Off Pembroke SPA.
- There are four SACs which cannot be avoided - Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC.
- There is one SAC that is unlikely to be avoided - The North Channel SAC.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but some of these may be avoided.

6.2.790 Where features cannot be avoided there is potential for habitat loss or damage as a result of construction activities (e.g. cable burial, cable protection).

6.2.791 This strategic option passes through one unavoidable SPA and four unavoidable SACs within Welsh waters, and one likely unavoidable SAC, off the coast of Northern Ireland. There is one unavoidable MPA in Scotland. This may result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.792 Although other designated sites in this strategic option could be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges. Detailed cable routeing may be used to avoid designations and micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats.

6.2.793 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.794 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce effects to the marine environment.

6.2.795 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to these designated sites.

6.2.796 In addition to these designated areas, there are areas of Annex I reef habitat throughout this Strategic option, including large areas located within Bristol channel, around the Pembrokeshire Peninsula and to the north-west of Anglesey. The reef habitat around the Pembrokeshire Peninsula is a primary reason for designation of the Pembrokeshire Marine SAC.

6.2.797 It should be noted that there are currently: seven cables which cross the Skomer, Skokholm, and the Seas Off Pembroke SPA, seventeen that cross the Bristol Channel Approaches, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA, indicating that consenting within these areas is possible.

6.2.798 There is currently one cable that crosses the Pembrokeshire Marine SAC: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk.

Marine Historic Environment

6.2.799 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.800 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works could take place.

6.2.801 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.802 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.803 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.804 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present. This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.805 The beach width around the potential Bridgend landfall area is generally less than 500 m with the exception of the area around the Traeth yr Afon mouth that has a wider intertidal zone, so it may not be suitable for construction, but it could be avoided. The coastal height is generally less than 30 m, so it may be suitable for landfall, however, there are areas greater than 30 m which could be avoided.

6.2.806 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed' and cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.807 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.808 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments. Technical and engineering input would be required to determine if the intertidal area would allow for construction.

6.2.809 Best practice methods for cable burial can be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.810 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.811 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely, though, that there will be consenting implications related to this designated site.

6.2.812 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.813 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, our appraisal shows that:

- There are no SPAs or Ramsar sites, RSPB Reserves within this strategic option.

- There are four SSSIs along the coastline of this strategic option; all can be avoided.
- There is one LPA, IBA and SAC within this strategic option; all can be avoided.
- All other receptors could be avoided.

6.2.814 There is potential for impacts to designated features of one or more designated sites (Ancient Woodlands) that cannot be avoided, associated with construction activities of the cable. The relevant designated features that could be impacted include habitat loss, loss of vegetation, as well as visual and biodiversity impact.

6.2.815 Although NNRs, LNRs, Country Park and other SSSIs could be avoided, there is still potential for direct and indirect impacts on these receptors.

6.2.816 Mitigation in relation to Ancient Woodlands may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods. While routeing underground cables through or near ancient woodlands can be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. There are not anticipated to be any residual effects on other protected sensitive ecology receptors (i.e. NNRs, LNRs Country Park and other SSSIs etc).

6.2.817 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.818 Regarding suitability for the additional converter station, the study area for the proposed converter station only contains a limited amount of statutory designated ecological designations (i.e. a few SSSIs and Ancient Woodlands), however, within the 5 km radius, there are large amounts of areas clear of these designations, thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.819 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.820 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 1, 2, 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites. From these, Grade 3 Agricultural land cannot be avoided, but Grades 1 and 2 Agricultural Land could be avoided. Peatland and Regionally Important Geodiversity Sites could be avoided.

6.2.821 Grade 3 agricultural land would likely need to be routed through given its extent along the coast of this strategic option. There is potential for adverse effects on agricultural land and soils, which may present scrutiny from technical consultees during the planning stage. However, the land is not considered to be of the highest quality compared to Grades 1 and 2.

6.2.822 It is generally advisable to avoid routeing south of Bridgend and the surrounding areas of Pyle. Routeing should aim to avoid Grade 3 agricultural land where possible by

cabling nearby Porthcawl. Standard protection measures should be implemented during the construction phase to minimise impacts on soils.

6.2.823 Construction methods such as low-ground-pressure machinery can be utilised to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may also be required to verify desk-based data. With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.824 Whilst there are areas of Grade 1 and 2 agricultural land within this strategic option, these areas could be avoided through detailed routeing. However, if an alternative route is chosen in the future, Grade 2 land within the study area could be impacted.

6.2.825 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural lands, particularly Grade 1 and 2 land. Large areas around the substation are classified as Grade 4 or lower. Areas of Grade 4 or below and 'non-agricultural' land are more suitable locations for the converter station however, within this strategic option the converter station may require being located in Grade 3 land and mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.826 Landscape and Visual Amenity constraints have been identified across this strategic option's study area.

- There is one Coastal Path which cannot be avoided - Wales Coast Path.
- The Heritage Coast could be avoided.
- There are three LandMAP aspects rated as Outstanding and one rated as High within this strategic option.

6.2.827 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to users of Coastal Path.

6.2.828 There would likely be consenting implications as a result of closing, stopping or diverting PRoW which could lead to timeline delays.

6.2.829 Although the Heritage Coast can be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.830 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and routeing, as well as likely implementing erosion control measures. Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), Heritage Coast and Coastal Paths where possible.

6.2.831 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.832 Potential temporary adverse visual effects due to construction and future maintenance of underground cable, this can be reduced through careful routeing. There is not

anticipated to be any adverse outcomes associated with the presence of sensitive receptors within this strategic option.

6.2.833 Regarding suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures.

Historic Environment

6.2.834 There are international and national designated or important historic environment and cultural heritage sites present throughout the study area of AC6-9.

- All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens, Conservation Areas and RLOSIs could be avoided.

6.2.835 There is potential for temporary impacts to occur to the setting of the heritage assets, however, all assets can be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable, these are temporary impacts i.e. noise, vibration and visual impacts.

6.2.836 Mitigation would require careful routeing to avoid impacts to designated heritage assets; standard protection measures should be applied during the construction phase.

6.2.837 With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors due to the temporary and transient nature of the construction works and the long-term visual impact is low risk due to avoiding the use of OHLs.

6.2.838 Regarding suitability for the additional converter station, the proposed converter station will require careful consideration of the area surrounding the substation to minimise the setting impacts on the designated assets.

Hydrology

6.2.839 For Strategic Option AC6-9, there is one main river that cannot be avoided.

6.2.840 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.841 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.842 There is not anticipated to be any long-term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.843 Regarding suitability for the additional converter station, the proposed converter station location must careful consider impacts on hydrology as two main rivers are located

within a 5 km radius of the substation. Mitigation measures may be necessary to reduce any adverse effects on these watercourses, i.e. implementing a minimum construction buffer from watercourses of 30m or more.

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.844 Throughout Strategic Option AC6-9, the following receptors have been considered; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 22 cables which cannot be avoided.
- There are five active disposal site; these can all be avoided.
- There is one offshore military firing range, which could be avoided.
- There are several key shipping corridors which cross this study area between England and Ireland and Scotland and Ireland. These include common Ferry routes.
- There is very little fishing activity within Carmarthen Bay. There are several areas of fishing activity further north within this strategic option, most notably between Ireland and the Isle of Man.

6.2.845 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements. Early engagement with cable and pipeline owners/responsible parties would help mitigate any potential timeline delays of legal implications.

6.2.846 The active disposal sites could be avoided via routeing and siting.

6.2.847 The two potential wind sites should be monitored for future development, but, at this stage, do not require mitigation.

6.2.848 There is potential for interaction between construction vessels and other marine vessel users, this may lead to consenting and legal implications. Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.849 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 22 cables.

6.2.850 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within the study area. There are shipping routes and fishing grounds within this strategic option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.851 There are four major settlements present within this strategic option: Maesteg, Porthcawl, Pyle and Bridgend.

6.2.852 Skewen is located in the north west of this strategic option. The major settlements of Briton Ferry, Baglan, Baglan Moors, Aberavon and Port Talbot are spread across the south east of this strategic option.

6.2.853 Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.854 Routeing through these settlements is not possible.

6.2.855 Standard protection measures should be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties should be carefully routed around and avoided.

6.2.856 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.857 With appropriate mitigation measures in place, it is unlikely that there would be residual effects to these receptors.

6.2.858 There are unlikely to be adverse effects on the features identified within the study area. Settlements are present within this strategic option however due to the temporary nature of the construction works and with careful routeing, these areas could be avoided.

Tourism and Recreation

6.2.859 There are no areas of National Trust Land, however, there is one National Cycle Network route, National Cycle Network route 5, which cannot be avoided.

6.2.860 Crossing this route would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping or diverting Cycle Network. This could lead to timeline delays.

6.2.861 If it is not possible to avoid a National Cycle Network route, standard protection measures should be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods (such as HDD) the impacts would not be permanent.

6.2.862 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.863 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of cabling works) when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.864 Across the study area of Strategic Option AC6-9, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided.
- Two OHLs will require crossing.

6.2.865 There is potential for temporary impacts to occur on the land use assets, however, all assets can be directly avoided with careful routeing of the cable. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration, operational disruption and visual impacts.

6.2.866 Cables cannot route through or be in close proximity to Airports and Ports. Mitigation would require careful routeing to avoid impacts to land use assets and standard protection measures should be applied during the construction phase. Early engagement with Airport and Port authorities may be required if construction works are within the area. Height restrictions on construction vehicles and standard protection measures will be employed during construction practices and coordination will be required with NG authorities to notify that work is within close proximity to OHLs to minimise disruption.

6.2.867 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is applied.

6.2.868 Regarding suitability for the additional converter station, the study area for the proposed converter station falls outside of the area where the Airport and Ports are located, however, multiple Historic Landfill Sites and two OHLs fall within this area. Construction is unlikely to be a constraint for routeing and siting of the converter station although careful routeing around these landfill sites and OHLs will be required within this strategic option.

Summary of the technical appraisal

6.2.869 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-9 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.870 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at a new South Wales West Connection Node B 400 kV substation in the Bridgend area in South Wales. It has been triggered by the Celtic Sea project which will look to connect 1.5 GW into the substation. AC6-9 would require two bays at this substation to facilitate the connection. Should the Celtic Sea project not proceed, the ten-bay substation would be required as part of the Project scope of works and has been included in this appraisal to account for this eventuality.
- A new 525 kV DC converter station at the Bridgend area would be required and the proposed South Wales Connection Node B 400 kV substation would need to accommodate the bay extensions required for AC6-9 to connect at this substation.

- As for all south Wales connections, AC6-9 would require an uprating of the 400 kV cables within the Severn Cable Tunnel.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.871 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable
b) 525 kV HVDC subsea cable and converter stations

6.2.872 Strategic Option AC6-9 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Currently, there is no existing substation infrastructure in the Bridgend area. The substation that AC6-9 would be connecting into is, as of now, being triggered by different projects in the area; Should these projects not proceed, the ten-bay substation would be required as part of the Project scope of works and has, hence, been included in the cost appraisal to account for this eventuality.
    - In the case where the SWCN B substation is triggered by planned projects in the Bridgend area, AC6-9 would only require to utilise two bays at the site.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at the SWCN B substation.

6.2.873 Table 6.17 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.17 - Capital Costs for Strategic Option AC6-9

Item	Capital Cost	
Substation and Wider Works	£179.4m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (630 km)	£26,923.2m	£4,323.4m
Total Capital Cost	**£27,102.6m**	**£4,502.8m**

6.2.874 Table 6.18 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.18 - Lifetime cost by subsea technology option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£26,923.2m	£4,323.4m
NPV of Cost of Losses over 40 years	£632.0m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£145.5m	£75.5m
Lifetime Cost of New Circuits	**£27,701m**	**£4,556m**

6.2.875 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has the lowest NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.876 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-9 is a 630 km connection, configured as an HVDC subsea circuit, between T-Point and a new South Wales West Connection Node B substation. In light of this analysis, our starting presumption for further development of this option should it be selected, would be for an HVDC subsea connection.

Strategic Option AC6-10 – Connah's Quay

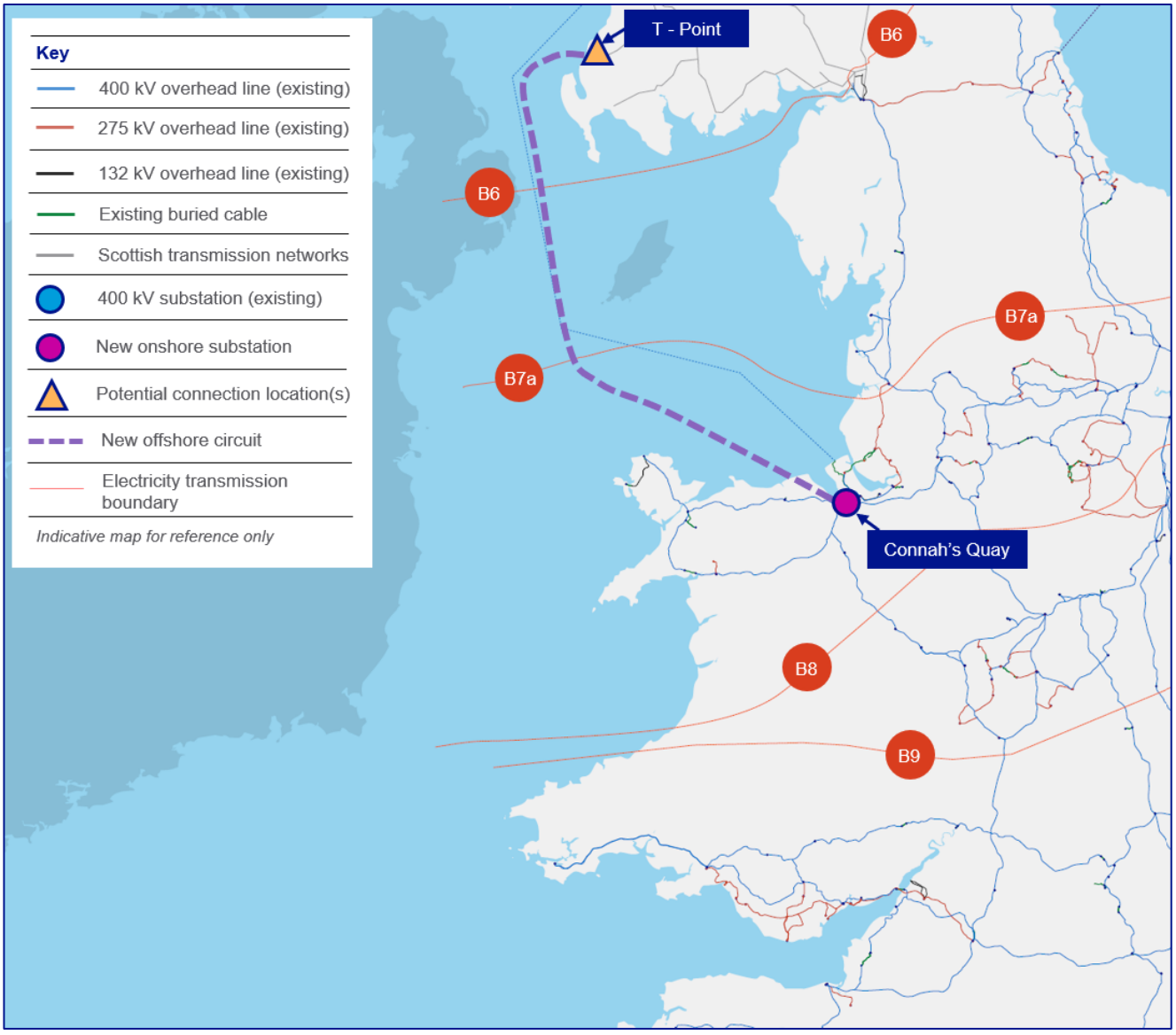
Description of the strategic option AC6-10

6.2.877 Strategic Option AC6-10 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) to the proposed Connah's Quay 400 kV substation in the Deeside area in North Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the northern Welsh coastline.

6.2.878 For the purposes of the appraisal of Strategic Option AC6-10, consideration has been given to the additional costs or impacts of accommodating the Project connection at the proposed Connah's Quay 400 kV substation.

6.2.879 Figure 6.11 below presents an indicative map for Strategic Option AC6-10 (for illustrative purposes only and does not denote viable development route).

Figure 6.11 - Indicative study area of Strategic Option AC6-10



6.2.880 The circuit distance for this connection is 330 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Connah's Quay substation.

6.2.881 This strategic option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Connah's Quay. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project, which falls within NGET's licence area. Approximately 40 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.882 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, our appraisal shows that:

- There is one SPA which cannot be avoided – Liverpool Bay SPA.
- There are two SACs which are unlikely to be avoided - North Channel SAC and North Anglesey Marine SAC.
- SSSI sites along the coastline could be avoided.
- All MCZs could be avoided.
- There is one MPA which cannot be avoided - The Clyde Sea Sill MPA.
- Annex I habitats (reefs) are reported along this coastline. Reefs, sandbanks, and submarine structures are present within this route, but these may be avoided.

6.2.883 This strategic option passes through one unavoidable SPA at the point of potential landfall, and two likely unavoidable SACs, one between Wales and Isle of Man and the other off the coast of Ireland. There is one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations.

6.2.884 Although other designated sites in this strategic option can be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.885 Where features cannot be avoided there is potential for habitat loss or damage due to construction activities (e.g. cable burial, cable protection). Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods could also be used to avoid direct impacts to Annex I habitats, where appropriate.

6.2.886 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SPA(s), SAC(s), and or an MPA(s)), a Habitats Regulation Assessment (HRA) may be required.

Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.887 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects to the marine environment.

6.2.888 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through design and construction methods. However, it will remain likely, and therefore it is anticipated that there will be consenting implications related to these designated sites such as potential seasonal restrictions.

6.2.889 It should be noted that there are currently 33 cables which cross the Liverpool Bay SPA, eight cables which cross the North Anglesey Marine SAC, nine cables which cross The North Channel SAC and six that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible.

Marine Historic Environment

6.2.890 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided. During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.891 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.892 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.893 At this stage, it cannot be confirmed that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.894 Sediment type and depth throughout this strategic option are variable, with areas of exposed bedrock being present.

6.2.895 The beach width around the potential Bodelwyddan landfall area is less than 500 m, with the exception of near the mouth of the River Clwyd which could be avoided. Areas with a beach width less than 500 m are suitable for landfall. The coastal height is mostly less than 30 m so may be suitable for landfall.

6.2.896 The Clyde Sea Sill MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed'. It cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.897 This study area has complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.898 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.899 Additional cable protection methods are likely to be required where the sediment is not of sufficient type and/or depth for burial. Geotechnical and geophysical surveys will help to inform routeing and micro siting activities which could help to avoid complex geomorphological features and shallow/mobile sediments.

6.2.900 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be relatively small and potential effects from construction are anticipated to be primarily temporary and transient in nature.

6.2.901 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.902 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

6.2.903 It should be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.904 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, our appraisal shows that:

- There are four SACs, one SPAs, one Ramsar site, ten SSSIs, six LNRs, Common Land, one RSPB Reserve and Ancient Woodland within this strategic option.
- All receptors can be avoided with detailed routeing.

6.2.905 There is potential for impacts to designated features of one or more designated sites (Ancient Woodlands, SPA, SAC, Ramsar, LNR, and SSSIs) that may not be able to be avoided, associated with construction activities of the cable. However, these features are present at the eastern most point of the strategic option thus, if the cable was to make landfall to the northwest of Abergele then these designations could be avoided.

6.2.906 Although Ancient Woodlands, SPA, SAC, Ramsar, LNR, and SSSIs can be avoided, there is still potential for direct and indirect impacts these receptors.

6.2.907 Mitigation in relation to the designated sites may include surveys to confirm habitat and root presence/location, micro routeing and/or trenchless installation methods, sediment and erosion control measures. If routeing and landfall was to occur to the northwest of Abergele then it is not anticipated that there would be any residual effects on other protected sensitive ecology receptors (i.e. SPA, SAC, Ramsar, LNR etc). Ancient

Woodlands and SSSIs would have temporary impacts, and careful routeing would be required.

6.2.908 There is potential to avoid some of the designated sites within this strategic option. Early engagement with all potential regulatory parties to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.909 It is not anticipated that there would be any long term adverse outcomes associated with the presence of sensitive ecology receptors within this strategic option. The likely mitigation measures are considered to be standard and in line with other cable laying projects. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.910 Regarding suitability for the additional converter station, the study area for the proposed converter station contains statutory designated ecological designations (i.e. a SSSI, SAC and Ancient Woodlands), however, within the 5 km radius, there are large areas clear of these designations. Thus, careful siting will be required to place the converter station so that no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.911 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.912 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 1, 2, 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites. From these, some Grade 1 land may not be avoided and Grade 2 and 3 Agricultural land cannot be avoided, however, peatland and Regionally Important Geodiversity Sites can be avoided.

6.2.913 There may be a need to route through high value agricultural land if other areas are heavily constrained. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration and loss of agricultural productivity.

6.2.914 Where possible, routeing should aim to avoid high value agricultural land, by routeing away from St Asaph, Prestatyn and Abergele. If routeing through high value agricultural land is unavoidable, then standard protection measures should be applied during the construction phase to minimise impacts on soils.

6.2.915 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data. With these mitigation measures put in place, it is unlikely that there would be residual effects to these receptors.

6.2.916 Whilst there are areas of Grade 1 and 2 agricultural land within this strategic option, these areas can be avoided through detailed routeing.

6.2.917 Regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on agricultural land, particularly Grades 1 and 2 land. Large areas around the substation are classified as Grade 4 or lower, which, including ‘non-agricultural’ land, are more suitable locations for the converter station. However, within this strategic option, the converter station may require being located in Grade 3 land and mitigation measures may still be necessary to reduce any adverse effects.

Landscape and Visual Amenity

6.2.918 Landscape and Visual Amenity constraints have been identified across this strategic option’s study area.

6.2.919 More specifically, there is one New 'Proposed' National Park, one Coastal Path (Wales Coast Path), one National Trail (Offa's Dyke) and one AONB which cannot be avoided. There are four LandMAP aspects rated as High and one rated as Outstanding within this strategic option.

6.2.920 There is a potential that the designations listed above will likely require crossing and would result in potential temporary visual impacts to users of these designations.

6.2.921 There would likely be consenting implications in regard to crossing a National Park, AONB and Coastal/Nation Trails as a result of closing, stopping up or diverting PRoW, which could lead to timeline delays.

6.2.922 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and careful routeing, as well as likely implementing erosion control measures.

6.2.923 Mitigation measures would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), AONBs, National Trails and Coastal Paths where possible.

6.2.924 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.925 Regarding suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase can be mitigated through standard landscaping and visual screening measures. Although the proposed new National Park site in north-east Wales is present within the 5 km radius of the converter station, there are several parcels of land that are free from this constraint.

Historic Environment

6.2.926 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-10 study area.

6.2.927 All Listed Buildings (Grade I and II*), SMs, Registered Parks and Gardens, Conservation Areas and RLOSIs could be avoided with detailed routeing.

6.2.928 There is potential for temporary impacts to occur on designated heritage assets, however, all assets can be directly avoided with careful routeing of the cable.

6.2.929 This strategic option is densely populated with Historic Environment assets, which flags that a lot of routeing will be required to divert around several assets. When making landfall northwest of Abergele, a registered park and garden are located immediately as landfall is made, as well as SMs in close proximity. These could be avoided but careful routeing is required. All impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration and visual impacts.

6.2.930 There are unlikely to be adverse effects on the designated assets within the strategic option's study area when careful routeing and site selection is applied.

6.2.931 Regarding suitability for the additional converter station, siting the proposed converter station will require careful consideration of the area surrounding the substation to avoid impacts to the RLOSI area to south of the substation, Parks and Gardens, Listed Buildings and Conservation Areas. This is necessary to minimise the potential impacts to setting on the designated assets. The 5 km radius surrounding the substation is densely populated with assets within this strategic option, hence, careful setting and siting would be required.

Hydrology

6.2.932 Strategic Option AC6-10's study area includes three main rivers that cannot be avoided.

6.2.933 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.934 Mitigation would require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely an FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.935 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies would ensure effects to the water environment are minimised.

6.2.936 With these mitigation measures put in place, it is unlikely that there would be any significant residual effects to these receptors.

6.2.937 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.938 Regarding suitability for the additional converter station, permanent impacts from the construction of a converter station near a river may include alteration of the hydrological patterns. These changes can lead to long-term effects due to potential risks to the river's water quality and surrounding ecosystems due to changes in surface runoff and sedimentation. Potential mitigation may be through careful placement of drainage infrastructure to manage water flow and prevent pollution.

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.939 Throughout Strategic Option AC6-10, the following receptors have been considered to potentially have an effect; Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are six pipelines which may require crossing depending on where landfall is made. Three of these pipelines cannot be avoided.
- There is one wind site and another two potential wind sites, which are in the concept/early planning stage, within this strategic option. All these sites may be avoided.
- There are 25 cables which may require crossing depending on where landfall is made. 18 of these cables cannot be avoided.
- There is one active disposal site, which could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.
- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.940 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.941 The disposal site off the coast of Scotland could be avoided via routeing and siting.

6.2.942 The one active wind site could be avoided via routeing and siting.

6.2.943 There is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications.

6.2.944 Early engagement with cable and pipeline owners/responsible parties could help mitigate any potential timeline delays of legal implications.

6.2.945 The two potential wind sites could be monitored for future development, but at this stage do not require mitigation.

6.2.946 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from interactions with fisheries and other vessel users in this strategic option.

6.2.947 Under any strategic option selected, there will be a requirement to cross at least three pipelines and at least 18 cables. Under worst case scenarios, this may involve crossing six pipelines and 25 cables. The one wind site and disposal site can be avoided via routeing and siting mitigation.

6.2.948 This strategic option benefits from having no oil or gas wells, aggregate site agreements, or offshore military areas within its study area.

6.2.949 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.950 There are nine major settlements within this strategic option, namely, St. Asaph, Abergele, Kinmel Bay, Rhyl and Prestatyn, Flint, Holywell, Bagillt and Connah's Quay. With smaller settlements dispersed around the strategic option, this study area is dense in settlements.

6.2.951 These settlements can be avoided through detailed routeing. Routeing in close proximity around urban areas would have adverse effects on residential and commercial receptors, i.e. road closures, noise and vibration and other disruptors.

6.2.952 Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.953 Routeing directly through or under these settlements is not possible.

6.2.954 Standard protection measures could be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties could be carefully routed around and avoided.

6.2.955 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.956 With the implementation of appropriate mitigation measures, it is unlikely that there would be residual effects to these receptors.

Tourism and Recreation

6.2.957 National Trust land could be avoided.

6.2.958 There are three National Cycle Network routes, of which, National Cycle Network route 5 and 84 cannot be avoided.

6.2.959 Crossing these routes would result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There would likely be consenting implications as a result of temporarily closing, stopping up or diverting the Cycle Network. This could lead to timeline delays.

6.2.960 If it is not possible to avoid a National Cycle Network route, standard protection measures should be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods such as HDD, the impacts would not be permanent.

6.2.961 Early engagement with responsible parties to seek crossing agreements would be required. There is potential that there may be legal and/or commercial implications associated with this.

6.2.962 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area (due to the temporary nature of the cabling works) when carrying out detailed routeing and siting, stakeholder engagement and implementation of appropriate mitigation measures.

Land Use and Other Infrastructure

6.2.963 Across Strategic Option AC6-10, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours can be avoided.
- One OHL and one cable may require crossing.

6.2.964 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.965 Regarding suitability for the additional converter station, the study area for the proposed converter station includes a Historic Landfill Site, OHL, cables, Heliport, Ports and Military area therefore, careful placement is required. However, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.966 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-10 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.967 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at a New Connah's Quay 400 kV substation in the Deeside area in North Wales.
- A new 525 kV DC converter station at Connah's Quay would be required and a new Connah's Quay substation would be required on Brown field site next to the existing 132 kV Deeside substation.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.968 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable

b) 525 kV HVDC subsea cable and converter stations

6.2.969 Strategic Option AC6-10 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Construction of a new 400 kV Connah's Quay 10 bay Substation, of which two bays will accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or

- HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at Connah's Quay new substation.

6.2.970 Table 6.19 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.19 - Capital Costs for Strategic Option AC6-10

Item	Capital Cost	
Substation and Wider Works	£179.4m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (330 km)	£14,063.2m	£2,814.4m
Total Capital Cost	**£14,242.6m**	**£2,993.8m**

6.2.971 Table 6.20 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.20 - Lifetime cost by Subsea Technology Option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£14,063.2m	£2,814.4m
NPV of Cost of Losses over 40 years	£322.2m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£75.3m	£74.4m
Lifetime Cost of New Circuits	**£14,461m**	**£3,046m**

6.2.972 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has a reasonable NPV of Operations & Maintenance costs over a forty-year projection.

- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.973 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-10 is a 330 km connection, configured as an HVDC subsea circuit, between T-Point and the new 400 kV Connah's Quay Substation. In light of this analysis, our starting presumption for further development of this option, should it be selected, would be for a HVDC subsea connection.

Strategic Option AC6-11 – Bryncir

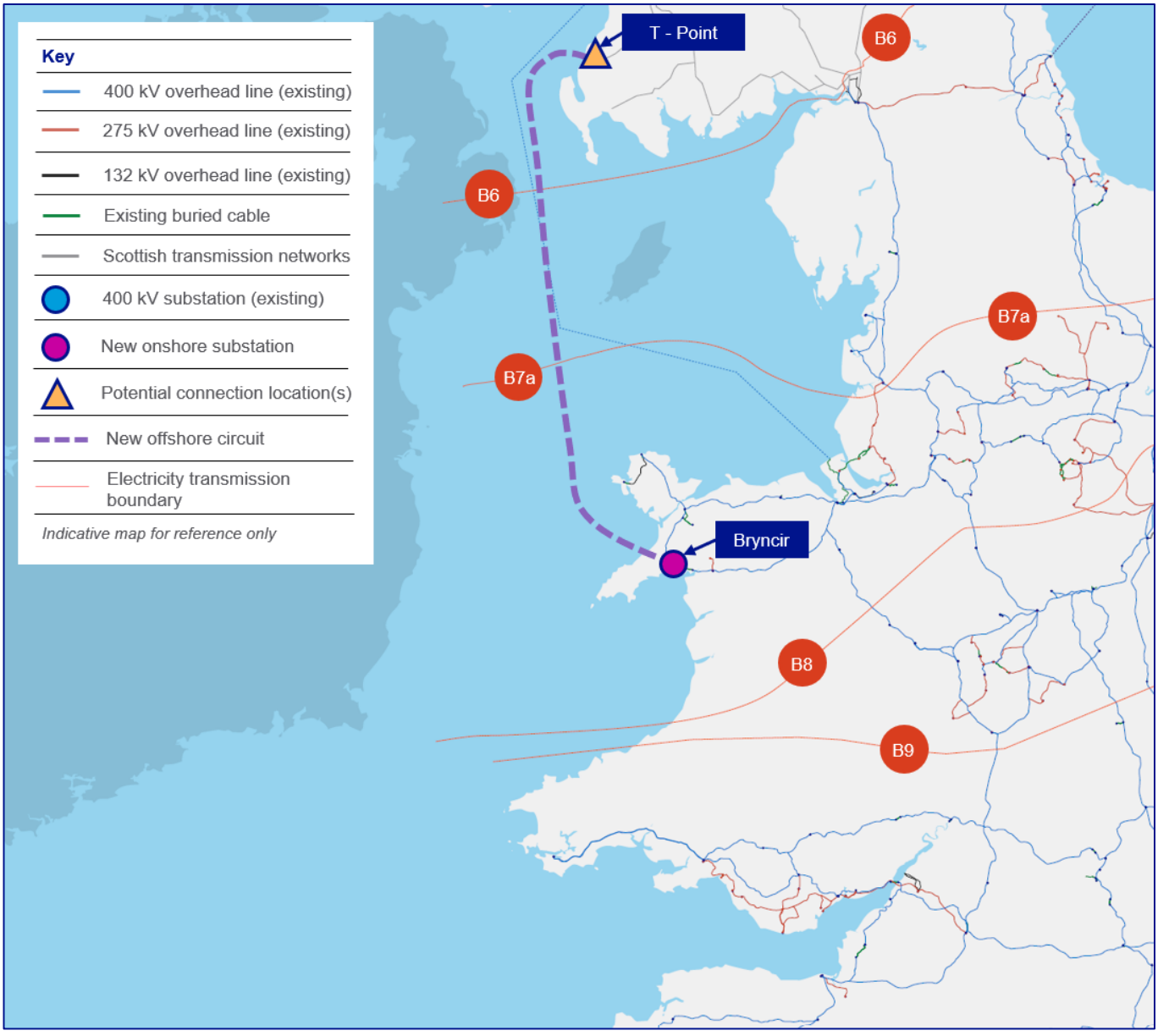
Description of the strategic option AC6-11

6.2.974 Strategic Option AC6-11 involves the development of a new transmission circuit from the Central/South Ayrshire (T-Point) to the proposed Bryncir 400 kV substation in North Wales. The majority of the new circuit would be routed within the Irish Sea, making landfall on the northern Welsh coastline.

6.2.975 For the purposes of the appraisal of Strategic Option AC6-11, consideration has been given to the additional costs or impacts of accommodating the Project connection at the proposed Bryncir 400 kV substation.

6.2.976 Figure 6.12 below presents an indicative map for Strategic Option AC6-11 (for illustrative purposes only and does not denote viable development route).

Figure 6.12 - Indicative study area of Strategic Option AC6-11



6.2.977 The circuit distance for this connection is 303 km. This is based on:

- a subsea cable route distance, based on a preliminary cable routeing study, from T-Point in the Central/South Ayrshire to the landfall location on the northern Welsh coastline; and
- a straight-line distance from the landfall to the Bryncir Substation.

6.2.978 This strategic option is formed of an HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the South of Scotland and one at Bryncir. The converter stations each have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C). This SOR only considers the converter station element on the southern end of the Project connection, which falls within NGET's licence area. Approximately 15 km of onshore underground HVDC cables would be required from the landfall to the converter station.

Summary of the environmental appraisal – Marine

Marine Ecology

6.2.979 There are a number of international and national designated marine ecology sites present throughout the study area comprising SPAs, SACs, SSSIs, MCZ, MPAs and Annex I Habitats (sandbanks, reefs and submarine structures). In summary and regarding the above, our appraisal shows that:

- All SPAs, SSSIs, MCZs and Annex I habitats can be avoided.
- There are two SACs - The North Anglesey Marine SAC which cannot be avoided and The North Channel SAC that is unlikely to be avoided.
- There is one MPA – The Clyde Sea Sill MPA – that cannot be avoided.

6.2.980 This strategic option passes through one unavoidable SAC in Wales, one likely unavoidable SAC off the coast of Ireland and one unavoidable MPA in Scotland. This could result in direct loss of habitat and potential direct impacts to protected species associated with these designations. Regarding the SPAs, although they can be avoided, there is still potential for direct and indirect impacts to protected species due to migratory and foraging ranges.

6.2.981 Where features cannot be avoided, there is potential for habitat loss or damage as a result of construction activities (e.g. cable burial, cable protection). Detailed cable routeing could be used to avoid designations. Micro siting and trenchless construction methods at landfall could also be used to avoid direct impacts to Annex I habitats, where appropriate.

6.2.982 Pre-construction surveys and consultation with relevant nature bodies will likely be required. Where there is potential for interaction with designated sites (i.e., SAC and MPA), a Habitats Regulation Assessment (HRA) may be required. Detailed assessment and engagement with the relevant regulator(s) will be carried out to identify the necessary work required.

6.2.983 Construction activities would benefit from having defined working areas (cable corridors) and appropriate pollution control measures implemented (e.g. CEMP) to reduce the potential for effects on the marine environment.

6.2.984 Effects on European Protected Species and/or Annex I habitats are likely to be unavoidable due to the presence of unavoidable designated sites within this strategic option. Direct impacts could be mitigated through appropriate design and construction methods. However, it will remain likely, and therefore it is anticipated that there will be consenting implications related to these designated sites, such as potential seasonal restrictions.

6.2.985 It should be noted that there are currently nine cables which cross The North Channel SAC and North Anglesey Marine SAC, and six that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, both of these sites are likely to require crossing.

Marine Historic Environment

6.2.986 Marine wrecks are scattered throughout the study area of this strategic option, all of which could be avoided.

6.2.987 During construction, there is the potential for accidental direct physical effects to the marine historic environment due to the potential for unknown wrecks or archaeological features. It is considered that marine wrecks could be avoided through detailed routeing and micro-siting. A precautionary exclusion zone could be applied to wrecks, within which no temporary or permanent works should take place.

6.2.988 It is likely that a Marine Archaeological Written Scheme of Investigation and Protocol for Archaeological Discoveries will be required by regulators.

6.2.989 Geophysical and geotechnical surveys will likely be required prior to construction which will help identify any unknown/unlisted features.

6.2.990 It cannot be confirmed, at this stage, that all effects on wrecks will be ruled out completely due to the possibility of unknown/unlisted features being present. However, it is likely that all of these will be avoidable via detailed routeing and micro siting.

Marine Geology

6.2.991 Throughout this strategic option, sediment type and depth are variable, with areas of exposed bedrock being present.

6.2.992 The landfall area around Pentir has a beach width less than 500 m and a coastal height which is mostly less than 30 m so it may be suitable for landfall.

6.2.993 A designation present within Strategic Option AC6-11’s study area is the Clyde Sea Sill MPA. This MPA is partially designated for its 'circalittoral and offshore sand and coarse sediment communities' and 'marine geomorphology of the Scottish shelf seabed' and cannot be avoided. Sediments and geological features within the Clyde Sea Sill MPA are likely to be disturbed as a result of cable installation activities. Construction activities may result in direct geological impacts.

6.2.994 This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort’s Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

6.2.995 There is potential that cables may not be fully buried due to the variable sediment type and depth.

6.2.996 Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required.

6.2.997 Best practice methods for cable burial could be used to help mitigate potential sediment resuspension and disturbance effects within the MPA. The area of impact footprint from construction activities is anticipated to be primarily temporary and transient in nature.

6.2.998 Overall, additional cable protection methods required are likely to be unavoidable and will be a technical and engineering consideration under this strategic option.

6.2.999 The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts could be mitigated through design and construction methods. It will remain likely, however, that there will be consenting implications related to this designated site.

6.2.1000 It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.

Summary of the environmental appraisal – Terrestrial

Terrestrial Ecology

6.2.1001 There are a number of international and national designated terrestrial ecology sites present throughout the study area comprising SPAs, SACs, Ramsar sites, SSSIs, NNRs, Country Parks, LNRs and Registered Common Land. In summary, and regarding the above, our appraisal shows that:

- There are no Ramsar sites within the study area of this strategic option.
- There is one SAC – the Lleyn Peninsula SAC – which cannot be avoided.
- There is one SSSI – the Black Rock SSSI – which cannot be avoided.
- There is one SPA – the Northern Cardigan Bay SPA – which cannot be avoided.
- All other receptors can be avoided.

6.2.1002 There is potential for impacts to designated feature Black Rock SSSI, Northern Cardigan Bay SPA and Lleyn Peninsula SAC that may not be avoidable. The SAC and SSSI will likely require crossing which could likely result in habitat loss, loss of vegetation, as well as visual and biodiversity impact.

6.2.1003 There are other designated sites including SACs, SPA and SSSIs which will most likely be in close proximity to the cable. This may result in temporary adverse effects and have potential for direct and indirect impacts to protected species.

6.2.1004 Mitigation in relation to SPAs, SACs and SSSIs may include surveys to confirm habitats present, micro routeing and/or trenchless installation methods. While routeing underground cables through or near these designated sites could be mitigated through careful planning, the use of advanced technologies, and ecological management practices, some residual effects may persist. It is not anticipated that there would be any residual effects on other protected sensitive ecology receptors (i.e. SPAs, NNR and SSSI etc).

6.2.1005 There is potential to avoid some of the designated sites within this strategic option through detailed routeing and siting. Early engagement with all potential regulatory bodies to discuss any protected sites which cannot be avoided would aid in minimising potential timeline delays associated with multiple consenting regimes being used.

6.2.1006 The proposed strategic option intersects with several sensitive ecological sites, including SACs, SPAs, SSSIs, and Ancient Woodlands, with key areas near Criccieth and Glaslyn.

6.2.1007 Potential impacts include habitat loss, noise, and visual disturbance, particularly in the southern areas, while the northern areas present fewer ecological constraints. Mitigation measures, such as careful routeing, advanced construction methods, like HDD, and habitat restoration will minimise impacts.

6.2.1008 Residual effects are expected to be temporary and localised, with no long-term impacts if mitigations are applied. The overall outcome is neutral, with the feasibility enhanced by routeing options that avoid the most sensitive areas. Further environmental assessments (e.g. HRA) may be required in association with this strategic option.

6.2.1009 Regarding suitability for the additional converter station, The study area for the proposed converter station only contains a number of statutory designated ecological designations (i.e. SSSIs to the north and southeast of the converter station approximately 3 km away from the converter substation) however within the 5 km radius there are areas clear of these designations thus, no impacts are anticipated as a result of its construction or operation.

Air Quality

6.2.1010 Within this strategic option, no AQMAs have been identified, hence air quality is not considered to prevent further consideration of this strategic solution.

Geology and Soils

6.2.1011 Throughout the study area of this strategic option, underlying geology has identified Agricultural Land of Classification Grades 3, 4 and 5, as well as peatlands, geoparks and Regionally Important Geodiversity Sites.

6.2.1012 From these, Grade 3, 4 and 5 of Agricultural lands, and peatland cannot be avoided, however, geoparks and Regionally Important Geodiversity Sites can be avoided.

6.2.1013 There may be a need to route through high value agricultural land if other areas are heavily constrained. There is potential for adverse effects on agricultural land and soils. This may present scrutiny from technical consultees during the planning stage.

6.2.1014 Large areas of Peatlands cannot be avoided, and these cannot be routed through. There may be a need to route near peatland areas in Wales if other routes are heavily constrained, but routeing through peatland areas is not permissible due to their ecological and carbon storage significance.

6.2.1015 Potential adverse effects include soil disturbance, hydrological changes, and damage to the peatland's ability to act as a carbon sink, which could attract scrutiny from environmental consultees during the planning stage. Construction on this land may lead to soil compaction, which reduces soil permeability and aeration and loss of agricultural productivity.

6.2.1016 It is advisable to avoid routeing through Peatland areas. If routeing through these areas is unavoidable then standard protection measures should be applied during the construction phase to minimise impacts on soils.

6.2.1017 Construction methods such as low-ground-pressure machinery to minimise soil compaction. Implementation of controlled traffic strategies to limit the movement of heavy vehicles to designated areas may be required. Additional surveys may be required to verify desk-based data.

6.2.1018 Peatland areas must be entirely avoided when routeing HVDC cables. If unavoidable constraints necessitate proximity to peatlands, standard protection measures should be implemented to minimise indirect impacts. This includes employing trenchless construction methods, such as HDD, and using low-ground-pressure machinery to prevent soil compaction. Controlled traffic strategies and hydrological monitoring may also be necessary to maintain peatland composition. With these mitigation measures put in place, it is unlikely that there could be residual effects to these receptors.

6.2.1019 Whilst some areas of agricultural land may not be avoidable, due to the temporary nature of construction works and the implementation of construction mitigation measures to sustainably manage and protect soils, it is unlikely there could be adverse long term impacts to deem this strategic option unfeasible.

6.2.1020 Regarding suitability for the additional converter station, construction of the converter station near a peatland area can result in irreversible changes to the peatland's ability to function as a carbon sink. Peatlands are located within a 5 km radius of the proposed substation and further construction may cause soil compaction and changes to hydrological systems leading to long-term damage to the peatland ecosystem. It may also lead to the release of stored carbon and loss of biodiversity.

6.2.1021 While impacts can be partially mitigated through buffer zones, low-impact construction techniques, and hydrological management, careful routeing and placement of the converter station are critical. Proximity to peatland should be avoided wherever possible to prevent significant and lasting ecological harm.

Landscape and Visual Amenity

6.2.1022 Landscape and Visual Amenity constraints have been identified across this strategic option’s study area.

6.2.1023 More specifically, there is one Coastal Path which cannot be avoided – the Wales Coast Path. National Parks, Heritage Coasts and AONBs can be avoided (however may require crossing). There are four LandMAP aspects rated as Outstanding and several rated as High within this strategic option largely along the coastline.

6.2.1024 There are no National Trails or Biosphere Reserves within this strategic option.

6.2.1025 There is a potential that the Coastal Path listed will likely require crossing and would result in potential temporary visual impacts to their users.

6.2.1026 There would likely be consenting implications as a result of closing, stopping or diverting PRoW. This could lead to timeline delays.

6.2.1027 Although National Parks, Heritage Coasts and AONBs can be avoided, there is still potential for direct and indirect impacts to landscape and visual receptors.

6.2.1028 Mitigation measures would likely include cabling via trenchless installation methods (such as HDD) and routeing as well as likely implementing erosion control measures.

6.2.1029 Mitigation measures in relation to these landscape and visual features would likely include the underground cable to be routed to avoid key views, long-distance open views (particularly from high ground), National Parks, AONBs and Coastal Paths, where possible.

6.2.1030 Further mitigation measures also include detailed route alignment around these LandMAP categories, where appropriate, along with the utilisation of landforms and other landscape features to provide visual screening of the construction and installed system, thereby mitigating indirect impacts from outward views in these areas.

6.2.1031 Regarding suitability for the additional converter station, permanent impacts from the converter station during the construction and operational phase could be mitigated through standard landscaping and visual screening measures. However, careful routeing is required around the National Park as this falls within the 5 km radius of the proposed substation.

Historic Environment

6.2.1032 There are international and national designated or important historic environment and cultural heritage sites present throughout the AC6-11 study area. All of these can be avoided.

6.2.1033 There is potential for temporary impacts to occur on designated heritage assets, however, most assets can be directly avoided with careful routeing of the cable. There are multiple SMs, RLOSI and Listed Buildings within close proximity to the potential routeing line, however, all impacts are associated with construction activities of the cable; these are temporary impacts i.e. noise, vibration and visual impacts. There are limited assets that are present within this strategic option.

6.2.1034 Mitigation could require careful routeing to avoid impacts to designated heritage assets. Standard protection measures should be applied during the construction phase. Screening and vibration monitoring mitigation measures may be implemented during the construction phase to reduce impact to Scheduled Monuments and Listed Buildings in close proximity.

6.2.1035 With appropriate mitigation measures put in place, it is unlikely that there could be residual effects to these receptors due to the temporary and transient nature of the construction works and the long term visual impact is low risk due to avoiding the use of OHLs.

6.2.1036 There are unlikely to be adverse effects on the designated assets within the study area when careful routeing and site selection is applied.

6.2.1037 Regarding suitability for the additional converter station, the proposed converter station requires careful consideration of location surrounding the substation to avoid impacts to the RLOSI, Conservations Areas, Listed Buildings and SMs this is necessary to minimise the impact to setting on the designated assets. However, there are limited assets situated within the 5 km radius of the proposed substation.

Hydrology

6.2.1038 Strategic Option AC6-11’s study area includes three main rivers that cannot be avoided.

6.2.1039 There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life) within this strategic option.

6.2.1040 Mitigation could require careful routeing to avoid impacts on rivers, surface water bodies and floodplains. Standard protection measures should be applied during the construction phase (for example, sediment and erosion control measures, pollution prevention measures, monitoring and adaptive management and most likely a FRA and management). The appropriate consents should be applied for to undertake works in close proximity to rivers, surface water bodies, within the floodplain and near flood defences.

6.2.1041 Adopting sensitive construction techniques at river crossing and ensuring appropriate pollution controls are in place when working close to Main Rivers and surface water bodies could ensure effects to the water environment are minimised.

6.2.1042 With these mitigation measures put in place, it is unlikely that there could be residual effects to these receptors.

6.2.1043 There is not anticipated to be any long term adverse outcomes associated with hydrology within this strategic option due to the temporary nature of the construction works. With careful planning and the implementation of effective mitigation measures, such as trenchless routeing methods (HDD or tunnelling) and FRA, the long-term adverse effects on hydrology are unlikely to be significant.

6.2.1044 Regarding suitability for the additional converter station, permanent impacts from the construction of a converter station near a river may include alteration of the hydrological patterns. These changes can lead to long-term effects due to potential risks to the river's water quality and surrounding ecosystems due to changes in surface runoff and sedimentation. Potential mitigation may be through careful placement of drainage infrastructure to manage water flow and prevent pollution.

Summary of the socio-economic appraisal – Marine

Offshore Land Use and Other Infrastructure

6.2.1045 Throughout Strategic Option AC6-11, the following receptors have been considered: Subsea and surface wells, Pipelines, Windfarms, Cables, Aggregate extraction sites, Disposal sites, Military areas, Shipping routes and Commercial fisheries. From these;

- There are no subsea or surface oil and gas wells.
- There are three pipelines which cannot be avoided.
- There are no currently consented wind/wave/or tidal site agreements within this strategic option. There are, however, two potential wind sites which are in the concept/early planning stage. These sites may be avoided.
- There are 18 cables which cannot be avoided.
- There is one active disposal site which could be avoided.
- There are several key ferry routes and shipping corridors which cross this study area in an east to west direction between England and Ireland and Scotland and Ireland and a north to south direction across the Irish and Celtic Seas.

- There are several areas of fishing activity within this strategic option, most notably between Ireland and the Isle of Man and around the Isle of Arran.

6.2.1046 Crossing of pipelines and cables is unavoidable within this strategic option. This may result in legal/commercial implications due to crossing agreement requirements.

6.2.1047 The disposal site off the coast of Scotland could be avoided via routeing and siting.

6.2.1048 There is potential for interaction between construction vessels and other marine vessel users, this may lead to consenting and legal implications.

6.2.1049 Early engagement with cable and pipeline owners/responsible parties would help mitigate against any potential timeline delays of legal implications.

6.2.1050 The two potential wind sites should be monitored for future development, but at this stage do not require mitigation.

6.2.1051 Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate against potential effects arising from interactions with fisheries and other vessel users in this strategic option's study area.

6.2.1052 Under any strategic option selected, there will be a requirement to cross three pipelines and at least 18 cables. The Caernarfon Bay (Pentir) approach has amongst the fewest crossings that will be required.

6.2.1053 This option benefits from having no oil or gas wells, aggregate site agreements, consented wind/wave/tidal sites, or offshore military areas within the study area.

6.2.1054 There are shipping routes and fishing grounds within this option which will likely require mitigation and consultation.

Summary of the socio-economic appraisal – Terrestrial

Settlement and Population

6.2.1055 There are six major settlements within this strategic option, Clynnog Fawr, Trefor, Criccieth and Porthmadog. With smaller settlements dispersed around the strategic option, this study area is dense in settlements.

6.2.1056 These can be avoided through detailed routeing. Routeing around urban areas could have adverse effects on residential and commercial receptors. Effects include disruption to local communities and traffic congestion, through increased construction traffic and dust from construction vehicles.

6.2.1057 Routeing through these settlements is not possible.

6.2.1058 Standard protection measures should be applied during the construction phase to mitigate impacts on residential and commercial receptors. Individual properties should be carefully routed around and avoided.

6.2.1059 Implementation on CTMP may be needed, as well as early engagement with communities to reduce disruption. Other mitigation methods include N&V control measures and potential screening.

6.2.1060 With the implementation of appropriate mitigation measures, it is unlikely that there would be residual effects to these receptors.

6.2.1061 There are unlikely to be adverse effects on the features identified within the study area. The limited settlements that are present within this strategic option are unlikely to have adverse effects due to the temporary nature of the construction works and with careful routeing, these areas could be avoided.

Tourism and Recreation

6.2.1062 National Trust land can be avoided.

6.2.1063 There are three National Cycle Network routes from which National Cycle Network route 8 cannot be avoided.

6.2.1064 Crossing this route could result in potential temporary visual impacts to users of the Cycle Network and temporary diversions. There could likely be consenting implications as a result of closing, stopping up or diverting Cycle Network. This could lead to timeline delays.

6.2.1065 If it is not possible to avoid a National Cycle Network route, standard protection measures should be applied during the construction phase to mitigate impacts on users and the asset itself. Due to the temporary nature of the construction works and cabling via trenchless installation methods, such as HDD, the impacts would not be permanent.

6.2.1066 Early engagement with responsible parties to seek crossing agreements could be required. There is potential that there may be legal and/or commercial implications associated with this. With appropriate mitigation in place, it is unlikely residual effects will be experienced.

6.2.1067 Crossing a National Cycle Network route is unavoidable, however, there are unlikely to be adverse effects on the asset or users within the study area when detailed routeing, stakeholder engagement and mitigation measures are applied.

Land Use and Other Infrastructure

6.2.1068 Across the study area of Strategic Option AC6-11, the following receptors have been identified.

- All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours can be avoided.
- One OHL may require crossing.

6.2.1069 There are unlikely to be adverse effects on the land use assets within the study area if careful routeing and site selection is undertaken.

6.2.1070 Regarding suitability for the additional converter station, the study area for the proposed converter station falls within the area where the Historic Landfill Site and OHL are located thus, careful placement is required. However, construction is unlikely to be a constraint for routeing and siting of the converter station within this strategic option.

Summary of the technical appraisal

6.2.1071 Alongside the environmental and socio-economic appraisal of the option, a technical appraisal has established that Strategic Option AC6-11 would satisfy the NETS SQSS, whilst achieving the need case to increase transmission capacity across boundaries B6 and B7a.

6.2.1072 Technical analysis of this strategic option is as follows:

- This subsea connection starts from T-Point in Scotland and terminates at a New Bryncir 400 kV substation in North Wales.
- A new 525 kV DC converter station at Bryncir would be required and a new Bryncir substation would be required.
- This strategic option meets the needs case crossing the critical boundaries B6 and B7a.

Summary of the cost appraisal

6.2.1073 As set out in Chapter 5, NGET undertook a cost evaluation of the following two technologies for subsea options evaluation:

a) 400 kV alternating current (AC) subsea cable

b) 525 kV HVDC subsea cable and converter stations

6.2.1074 Strategic Option AC6-10 requires the following transmission works to satisfy the requirements of the SQSS:

- Substation Works
    - Construction of a new 400 kV Bryncir 10 bay Substation, of which two bays will accommodate new circuits.
- New Circuit Requirements
    - AC subsea connections circuit options use high-capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,930 MW; or
    - HVDC subsea connection options use 525 kV 2 GW voltage source links, which would require a new converter station at each end of each circuit, similar in size to a large warehouse. In this case, one 2 GW link would require two converter stations in total, with one of the converters located at new Bryncir Substation.

6.2.1075 Table 6.21 below sets out the capital cost for the new circuit technology options. The new circuit costs are different for each circuit technology.

Table 6.21 - Capital Costs for Strategic Option AC6-11

Item	Capital Cost	
Substation and Wider Works	£179.4m	
New Circuits	**Subsea AC Cable**	**Subsea HVDC**
New Circuit (303 km)	£12,922.5m	£2,590.1m
Total Capital Cost	**£13,101.9m**	**£2,769.5m**

6.2.1076 Table 6.22 below sets out the lifetime cost for the new circuit technology options. The lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in Appendix D.

Table 6.22 - Lifetime cost by Subsea Technology Option

Subsea Based Option	AC Subsea Cable	Subsea HVDC
Capital Cost of New Circuits	£12,922.5m	£2,590.1m
NPV of Cost of Losses over 40 years	£300.8m	£157.1m
NPV of Operation & Maintenance Costs over 40 years	£69.1m	£74.3m
Lifetime Cost of New Circuits	**£13,292m**	**£2,821m**

6.2.1077 Based on the data in the above tables and with reference to the terminology covered in paragraph 6.1.8, the following conclusions can be drawn:

- Subsea HVDC has the lowest capital cost of new circuits.
- Subsea HVDC has the lowest NPV of Cost of Losses over a forty-year projection.
- Subsea HVDC has a reasonable NPV of Operations & Maintenance costs over a forty-year projection.
- Subsea HVDC has the lowest lifetime cost of new circuits.

6.2.1078 From the environmental and technical appraisal considered, alongside capital and circuit lifetime costs, the preferred technology option for Strategic Option AC6-11 is a 303 km connection, configured as an HVDC subsea circuit, between T-Point and the new 400 kV Bryncir Substation. In light of this analysis, our starting presumption for further development of this option, should it be selected, would be for a HVDC subsea connection.

7. Comparison of the appraisal of the strategic options

7.1 Overview

7.1.1 For the strategic options appraised in Section 6.2, this next chapter of the report considers the following comparative points:

- Environmental and Socio-Economic constraints
- Technical benefit and associated technical considerations
- Capital and lifetime costs of options

7.1.2 This chapter summarises and compares the above considerations across all eleven strategic options to facilitate the identification of a preferred strategic option.

7.2 Marine Environmental Considerations

Marine Ecology Considerations

7.2.1 In terms of marine ecology, there are two common designated areas across all eleven strategic options. The Clyde Sea Sill MPA cannot be avoided across all options and the North Channel SAC is unlikely to be able to be avoided across all options.

7.2.2 Further marine ecology considerations for each of the eleven strategic options are highlighted below.

7.2.3 With the exception of the two common designated areas, majority of marine ecology designated sites can be avoided for strategic option AC6-1 (T-Point to Pentir). However, the North Anglesey Marine SAC is unlikely to be avoidable for strategic option AC6-1.

7.2.4 Further to the two common designated areas, strategic option AC6-2 (T-Point to Wylfa South) would have to cross two additional designated sites, the Anglesey Terns SPA and the North Anglesey Marine SAC.

7.2.5 Further to the two common designated areas, strategic option AC6-3 (T-Point to Bodelwyddan) would have to cross an additional designated site – the Liverpool Bay SPA. This strategic option would have to make landfall within this SPA. The North Anglesey Marine SAC would be unlikely to be avoided.

7.2.6 Further to the two common designated areas, strategic option AC6-4 (T-Point to Pembroke) would have to cross five additional designated sites - Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and the North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided.

7.2.7 Further to the two common designated areas, strategic option AC6-5 (T-Point to Llanteg) would have to cross seven additional designated sites – Carmarthen Bay SPA, Skomer, Skokholm, and the Seas Off Pembroke SPA, Carmarthen Bay and Estuaries SAC, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided.

7.2.8 From a marine ecology perspective, strategic option AC6-6 (T-Point to Carmarthen) has the same constraints as AC6-5. However, it raises one additional unavoidable SAC - Pembrokeshire Marine SAC, within which one cable is present that has triggered IROPI and may pose a notable consenting risk, hence raising the consenting risk of this strategic option.

7.2.9 Strategic option AC6-7 (T-Point to Swansea North) is identical to AC6-6 in terms of marine ecology considerations.

7.2.10 Further to the two common designated areas, strategic option AC6-8 (T-Point to Baglan Bay) would have to cross five additional designated sites – Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that cross the Pembrokeshire Marine SAC, which triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided.

7.2.11 Further to the two common designated areas, strategic option AC6-9 (T-Point to South Wales West Connection Node B) would have to cross five additional designated sites - Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and the North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk.

7.2.12 Strategic option AC6-10 (T-Point to Connah’s Quay) is identical to AC6-3 in terms of marine ecology considerations.

7.2.13 Strategic option AC6-11 (T-Point to Bryncir) is mostly identical to AC6-1 in terms of marine ecology considerations; however, the main difference between the two strategic options is that AC6-11 cannot avoid the North Anglesey Marine SAC, whereas AC6-1 is unlikely to avoid the same designation.

7.2.14 All of the South Wales connection options (AC6-4, AC6-5, AC6-6, AC6-7, AC6-8, AC6-9), will need to cross the Pembrokeshire Marine SAC, which currently contains one cable: the Greenlink Interconnector, which has triggered IROPI and may pose a consenting risk associated with these strategic options. AC6-6 and AC6-7 are the most constrained in terms of marine ecology, with at least 11 designated areas to potentially cross through. AC6-1 is likely to require crossing the fewest number of designated areas.

Marine Historic Environment Considerations

7.2.15 Across all strategic options no unavoidable marine wrecks have been identified. For all instances it is expected if any submarine structures are identified, these will be avoided though detailed routeing based on geophysical and marine surveys.

Marine Geology Considerations

7.2.16 As discussed within the Marine Ecology section above, all strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site.

7.2.17 Each of the study areas include complex seabed geomorphology, including glacial bedform features and prominent toughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works.

7.2.18 NGET note that the additional cable protection methods would likely be unavoidable across all strategic options. This will be a technical and engineering consideration.

7.2.19 For AC6-1, AC6-2 and AC6-11, with the exception of the common considerations mentioned above, there are no further marine geology considerations that may act as differentiating factors within this appraisal.

7.2.20 For AC6-3 and AC6-10, the area around the River Clwyd mouth has an intertidal zone of greater than 500 m in width, so may not be suitable for construction. However, this can be avoided, with the remainder of the landfall study area considered to be suitable for landfall.

7.2.21 For AC6-4 and AC6-5, the coastal height at the potential Pembroke landfall area is generally less than 30 m. However, there are areas, which are considered to be avoidable at this stage, with a coastal height greater than 30 m, which would make landfall more difficult.

7.2.22 For AC6-6 and AC6-7, there is a wide intertidal zone (1.5 km) at the landfall study area, which may lead to challenges with the construction works. Further technical and engineering inputs would be required to determine the significance of these challenges.

7.2.23 For AC6-8, the beach width around the potential Baglan Bay landfall area is generally less than 500 m with the exception of the mouth of the River Neath which exceeds 1 km. This wider area may cause construction challenges, but NGET expect that it may be avoided. However, there are potential terrestrial constraints which may restrict this.

7.2.24 AC6-9 has a beach width around the potential Bridgend landfall area generally less than 500 m with the exception of the area around the Traeth yr Afon mouth which has a wider intertidal zone so may not be suitable for construction. However, NGET expect that this area can be avoided. The coastal height is generally less than 30 m, so may be suitable for landfall, however there are areas greater than 30 m, which can be avoided.

7.2.25 For all options, The Clyde Sea Sill MPA cannot be avoided and will require crossing. Direct impacts can be mitigated through design and construction methods. It will remain likely though that there will be consenting implications related to this designated site. Strategic Options AC6-3, AC6-8 and AC6-9 are both impacted by wide river mouths, but these can be avoided through construction methods.

7.2.26 Strategic options AC6-1, AC6-2 and AC6-11 are the least constrained from a marine geology perspective, with suitable coastal width or depth and no other immediate geological constraints. AC6-6 and AC6-7 are considered most challenging, due to the wide intertidal zone at the landfall study area, which may pose issues for cable construction.

7.3 Terrestrial Environmental Considerations

Terrestrial Ecology Considerations

7.3.1 With regards to terrestrial ecology across Strategic Option AC6-1, there are no SPAs or Ramsar sites, however, this strategic option cannot avoid crossing one SAC and one SSSI. There are other designated sites including SACs, NNRs and SSSIs which will most likely be in close proximity to the cable, which may result in temporary adverse effects upon them.

7.3.2 AC6-2 will affect the same number of ecological receptors as AC6-1 and may also temporarily impact on other designated sites during construction.

7.3.3 There are no unavoidable designated sites or receptors within the AC6-3 study area. Impacts on designated features can be avoided through careful routeing.

7.3.4 There are five receptors within the AC6-4 study area that cannot be avoided - one SAC, one SPA, two SSSIs and one NNR.

7.3.5 There is one unavoidable receptor within the AC6-5 study area - a SSSI which cannot be avoided along the coastline.

7.3.6 There is one unavoidable receptor within the AC6-6 and AC6-7 study areas - a SSSI which cannot be avoided along the coastline. Both of these strategic options may also have to cross a country park and/or a dedicated forest.

7.3.7 There are no unavoidable designated sites or receptors within the AC6-8 and AC6-9 study areas. Impacts on designated features can be avoided through careful routeing.

7.3.8 There are no unavoidable designated sites or receptors within the AC6-10 study area. Construction activities-related impacts on designated features can be avoided through careful routeing, if the cable was to make landfall to the northwest of Abergele.

7.3.9 There are three receptors within the AC6-11 study area that cannot be avoided - one SAC, one SPA, and one SSSI.

7.3.10 AC6-4 will have to cross the greatest number of designated areas – five, whereas there are no unavoidable receptors within the study areas of AC6-3, AC6-8, AC6-9, and AC6-10.

Air Quality Considerations

7.3.11 For majority of the strategic options, there are no Air Quality Management Areas (AQMAs) identified, with the exception of AC6-4 and AC6-8.

7.3.12 For AC6-4, the Pembroke AQMA falls just within the study area of the strategic option but could be avoided. For AC6-8, the Neath Port Talbot AQMA is located in the southeast of the study area and it is generally advisable to avoid construction traffic through Port Talbot.

7.3.13 In general, routeing and cabling through AQMAs could cause increased pollution during excavation due to dust and increased emission from construction vehicles and machinery. Mitigation strategies and implementation of a CTMP would be anticipated to prevent long term adverse outcomes associated with the two aforementioned AQMAs of the two strategic options.

Geology and Soils Considerations

7.3.14 For AC6-1, some areas of Grade 2 and Grade 3 agricultural land cannot be avoided, whilst Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.15 For AC6-2, Grade 1 and 2 agricultural land may not be avoided and Grade 3 Agricultural land cannot be avoided. GeoMôn UNESCO Global Geopark is a Geopark covering the entire island of Anglesey and will have to be crossed for this strategic option. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.16 For AC6-3, some Grade 1 and 2 agricultural land may not be avoided and Grade 3 Agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.17 For AC6-4, Grade 1 Agricultural land may not be avoidable. The majority of land within the study area is Grade 2 and Grade 3 Agricultural land, which cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.18 For AC6-5, Grade 3 Agricultural land cannot be avoided, whilst Regionally Important Geodiversity Sites within the area could be avoided.

7.3.19 For AC6-6, Grade 3 Agricultural land cannot be avoided, whilst peatland within the area could be avoided.

7.3.20 For AC6-7, Grade 3 Agricultural land cannot be avoided, whilst Grade 2 Agricultural Land could be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.21 For AC6-8, Grade 3 Agricultural land cannot be avoided, whilst large areas of peatland within the area could be avoided.

7.3.22 For AC6-9, Grade 3 Agricultural land cannot be avoided, whilst Grades 1 and 2 Agricultural Land could be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.23 For AC6-10, some Grade 1 agricultural land may not be avoided and Grade 2 and 3 agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided.

7.3.24 For AC6-11, Grade 3, 4, and 5 agricultural land and large peatland sites cannot be avoided. There is no Grade 1 or 2 agricultural land within this strategic option.

7.3.25 The most notable outcome from the geology and soil appraisal is the challenges that strategic option AC6-2 would incur in relation to the requirement of crossing the GeoMôn UNESCO Global Geopark. Apart from AC6-11, which does not pass through any Grade 1 or 2 agricultural land, there are no other strategic options where Grade 1 agricultural land can be avoided, and AC6-1 and AC6-4 would have to cross Grade 2 agricultural land.

Landscape and Visual Amenity

7.3.26 The Wales Coast Path is a designated trail, owned by Natural Resources Wales, that spans the entire coast of mainland Wales. In addition, the Isle of Anglesey Coastal Path (Llwybr Arfordirol Ynys Môn) spans the coast of Anglesey. Based on this, each of the eleven strategic options will need to cross at least one of these Coastal Paths.

7.3.27 The study area of AC6-1 includes both of these Coastal Paths, whilst the remainder of the strategic options will need to cross one of the Coastal Paths. AC6-2 will need to cross the Isle of Anglesey Coastal Path (Llwybr Arfordirol Ynys Môn), whilst the other strategic options will need to cross the Wales Coast Path.

7.3.28 These coast paths will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way.

7.3.29 Strategic option AC6-2 cannot avoid Anglesey (Ynys Môn) AONB, whilst AC6-4 cannot avoid the Pembrokeshire Coast National Park. Mitigation measures, such as the use of underground cables may be required within these study areas.

7.3.30 If AC6-3 makes landfall near the Dee at Talacre, it would require traversing the newly proposed National Park. Mitigation in relation to this may require making landfall to the southwest of Abergele within the Liverpool Bay SPA, which would in turn require crossing a Registered Park.

7.3.31 Strategic option AC6-10 cannot avoid a newly proposed National Park, one Coastal Path (Wales Coast Path), one National Trail (Offa's Dyke) and one AONB.

Historic Environment

7.3.32 Across the Strategic Options, designated or important historical environment and cultural heritage sites have been identified. This includes Listed Buildings (Grade I and II), Scheduled Monuments, Registered Parks and Gardens, Conservation Areas and Registered Landscapes of Outstanding and of Special Interest (RLOSI). Each strategic option will require careful consideration to minimise impacts on any historic environment receptors within the study area.

7.3.33 Strategic option AC6-1 cannot avoid one RLOSI. There are multiple Listed Buildings and Scheduled Monuments within the study area, however, these can be identified and avoided through detailed routeing.

7.3.34 There are designated heritage assets within AC6-2 and AC6-11 study areas. However, all assets can be directly avoided with careful routeing.

7.3.35 Both of the AC6-3 and AC6-10 study areas are densely populated with historic environment assets. However, all assets can be directly avoided with careful routeing.

7.3.36 Both AC6-4 and AC6-5 cannot avoid one RLOSI. There are also Scheduled Monuments and Conservation Areas within the study areas of these strategic options. However, all assets can be directly avoided with careful routeing.

7.3.37 For both AC6-6 and AC6-7, there is one RLOSI that cannot be avoided. All other designated heritage assets can be avoided for these strategic options.

7.3.38 Both AC6-8 and AC6-9 can avoid all international and national designated or important historic environment and cultural heritage sites.

7.3.39 Five out of the eleven strategic options will not be able to avoid crossing a RLOSI – these are strategic options AC6-1, AC6-4, AC6-5, AC6-6 and AC6-7. The remainder of the historic environment assets across the strategic options can be avoided through careful routeing.

Hydrology

7.3.40 The study areas for strategic options AC6-1, AC6-2, AC6-10 and AC6-11 each include three main rivers that cannot be avoided.

7.3.41 The study areas for strategic options AC6-3, AC6-5 and AC6-9 each include one main river that cannot be avoided.

7.3.42 AC6-4 and AC6-8 are the only strategic options which can avoid all main rivers.

7.3.43 The study area for strategic option AC6-6 include four main rivers that cannot be avoided.

7.3.44 AC6-7 cannot avoid two main rivers, there are additionally two that may be avoided with careful routeing.

7.3.45 With the exception of AC6-4 and AC6-8, which is not expected to cross any main rivers, for each strategic option, there is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology across the strategic options.

7.3.46 For AC6-4, there are unlikely to be adverse effects on the features identified within the study area when careful routeing and site selection is applied.

7.4 Marine Socio-Economic Considerations

Offshore Land Use and Other Infrastructure

7.4.1 For each strategic option, there is potential for interaction between construction vessels and other marine user vessels, which may lead to consenting and legal implications. Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users.

7.4.2 Four strategic options, AC6-1, AC6-2, AC6-4, and AC6-11, cannot avoid crossing three pipelines and 18 cables. Three strategic options, AC6-5, AC6-6, and AC6-7, cannot avoid crossing three pipelines and 19 cables.

7.4.3 Both AC6-3 and AC6-10, may require crossing six pipelines and 25 cables, out of these crossing three pipelines and 18 cables cannot be avoided.

7.4.4 Both AC6-8 and AC6-9 cannot avoid crossing three pipelines and 22 cables.

7.4.5 Crossing cables and pipelines may result in legal/commercial implications due to crossing agreement requirements. Both AC6-3 and AC6-10 have the greatest number of pipelines and cables to cross, increasing the risk associated with the strategic option's legal and commercial implications.

7.4.6 Further to the pipelines and cables, this appraisal considered the potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable.

7.5 Terrestrial Socio-Economic Considerations

Settlement and Population

7.5.1 Throughout the study area of AC6-1, there are two notable settlements, Bangor and Caernarfon, that can both be avoided.

7.5.2 AC6-2 only contains one major settlement, Amlwch, which can be avoided.

7.5.3 There are five major settlements within AC6-3 study area: St. Asaph, Abergele, Kinmel Bay, Rhyl and Prestatyn. With smaller settlements dispersed around the strategic option, this study area is dense in settlements. The siting of the converter station may cause long term visual effect on surrounding settlements, specifically St Asaph, with mitigation measures needed, once further assessments are undertaken.

7.5.4 For AC6-4 there are three major settlements: Milford Haven, Pembroke and Pembroke Dock, all of which are likely to be avoided. From landfall, further individual settlements will require careful routeing.

7.5.5 Throughout the AC6-5 study area, there are no major settlements present, however there are individual properties that will require avoiding through detailed routeing.

7.5.6 The AC6-6 study area includes has two major settlements, Kidwelly and Burry Port, as well as smaller settlements scattered throughout the study area.

7.5.7 The AC6-7 study area includes three major settlements, Kidwelly, Burry Port and North Swansea, as well as smaller settlements scattered throughout the study area.

7.5.8 For AC6-8 there are eight major settlements within the study area.

7.5.9 There are four major settlements present within the AC6-9 study area. These are Maesteg, Porthcawl, Pyle and Bridgend.

7.5.10 For AC6-10 there are nine major settlements within the study area.

7.5.11 For AC6-11 there are six major settlements within the study area.

7.5.12 AC6-5 has the least amount of Settlement and Population constraints, whilst AC6-10 would have the greatest number of settlements (nine) to avoid.

Tourism and Recreation

7.5.13 AC6-1 will cross National Cycle Network Route 8 and has the potential to cross three others. There are no areas of National Trust Land within the study area.

7.5.14 For AC6-2's study area, National Cycle Network Route 5 and 8 may not be avoidable, depending on landfall location, whilst National Trust Land could be avoided.

7.5.15 AC6-3 will cross National Cycle Network Route 5, which is unavoidable, it may also cross over another, dependent on routeing. National Trust Land could be avoided.

7.5.16 National Trust land may require crossing as part of AC6-4, near Stackpole Coast. This strategic option may also cross one National Cycle Network Route, but this can be avoided. Crossing National Trust Land would result in potential temporary visual impacts to users of the land and temporary closures.

7.5.17 AC6-5 cannot avoid National Cycle Network 4, whilst National Trust Land could be avoided.

7.5.18 For AC6-6, National Cycle Network Route 4 cannot be avoided. There are no areas of National Trust Land within the study area.

7.5.19 For AC6-7 there are no areas of National Trust Land. There are three National Cycle Network routes, of which National Cycle Network Route 4 and 47 cannot be avoided.

7.5.20 Neither National Trust Land nor the National Cycle Network would be affected by strategic option AC6-8.

7.5.21 AC6-9 will cross National Cycle Route 5, which is unavoidable.

7.5.22 AC6-10 will cross National Cycle Network Route 5 and 84, which is unavoidable, it may also cross over another, dependent on routeing. National Trust Land could be avoided.

7.5.23 AC6-11 will cross National Cycle Network Route 8 and has the potential to cross two others. National Trust Land could be avoided.

7.5.24 Strategic option AC6-8 would have the least impact from a Tourism and Recreation point of view, avoiding all National Trust Land and National Cycle Networks. All other strategic options either may have to, or will have to, cross either National Trust Land and/or National Cycle Networks.

Land Use and Other Infrastructure

7.5.25 Strategic options AC6-1, AC6-4, AC6-5 and AC6-6 may require crossing two OHLs each. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for these strategic options.

7.5.26 AC6-2 and AC6-11 may require crossing one OHL. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.

7.5.27 AC6-3 and AC6-10 may require crossing one OHL and one cable. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.

7.5.28 AC6-7 may require crossing one or more OHLs. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.

7.5.29 AC6-8 could avoid all OHLs and cables. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could also be avoided for this strategic option.

7.5.30 AC6-9 will require crossing two OHLs. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.

7.5.31 Most of the strategic options are similar when considering land use and other infrastructure, with most strategic options able to avoid all receptors apart from OHLs. Whilst AC6-8 does not cross any OHLs, the impact and expected mitigating actions associated with crossing OHLs for the other strategic options are not considered significant enough to provide a clear distinction between AC6-8 and the other strategic options from this perspective.

7.6 Technical Benefit and Considerations

7.6.1 All eleven shortlisted strategic options considered for AC6, satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case, set out in Chapter 4, by crossing boundaries B6 and B7a.

7.6.2 All these strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations have an approximate footprint of 6 ha (an indicative diagram is provided in Appendix C).

7.6.3 Onshore underground HVDC cables would be required from the landfall point to the converter station at each proposed substation option.

7.6.4 Strategic options AC6-1, AC6-2, AC6-3, AC6-4, AC6-7 and AC6-8 would connect to existing or proposed substations; however, these strategic options would require bay extensions to facilitate the AC6 project.

7.6.5 The other strategic options (AC6-5, AC6-6, AC6-9) propose utilising two bays at substations which do not currently exist, but which are proposed as part of other projects. Should these projects not proceed, the ten-bay substation would be required as part of the AC6 scope of works and has, hence, been included in the cost appraisal of each of these strategic options to account for this eventuality.

7.6.6 In the case where these substations are triggered by planned projects in the respective areas of these strategic options, they would only require to utilise two bays at the site.

7.6.7 For each South Wales strategic option (AC6-4 through to AC6-9) there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the Project connecting at any of the South Wales substations.

7.6.8 Out of the eleven strategic options, NGET does not expect that the majority of these would trigger significant reinforcement works to the local network(s). This is with the exception of strategic option AC6-8. This is the only strategic option which includes the connection to a 275 kV substation (as opposed to a 400 kV substation). This would trigger a substantial amount of reinforcement works to the south Wales network, including the rebuild of Margam and Pyle 275 kV substations and the reconductoring of 275 kV OHL routes to 400 kV.

7.6.9 Strategic option AC6-2 is expected to have the shortest circuit length (approximately 252 km), whilst AC6-9 is expected to have the longest circuit length (approximately 630 km).

7.7 Cost Considerations

7.7.1 Table 7.1 below sets out an overview of the capital and lifetime cost impacts of each Strategic Option. This table provides a comparison of strategic options based on the most economical technology choice for each option, namely HVDC.

Table 7.1 - Capital and Lifetime Cost Impact - All Strategic Options

Options	AC6-1 – Pentir	AC6-2 – Wylfa South	AC6-3 – Bodelwyddan	AC6-4 – Pembroke	AC6-5 – South Wales West Connection Node C	AC6-6 – Carmarthen Bay	AC6-7 – Swansea North	AC6-8 – Baglan Bay	AC6-9 – South Wales West Connection Node B	AC6-10 – Connah's Quay	AC6-11 – Bryncir
Economic Technology	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC	Subsea HVDC
Route Length	288 km	252 km	306 km	504 km	552 km	576 km	612 km	612 km	630 km	330 km	303 km
Total capital cost	£2,582.4m	£2,325.4m	£2,604.2m	£3,664.7m	£4,060.7m	£4,195.3m	£4,308.7m	£4,215.8m	£4,502.8m	£2,993.8m	£2,769.5m
40-year lifetime NPV cost	£2,732m	£2,536m	£2,815m	£3,876m	£4,114m	£4,248m	£4,521m	£4,428m	£4,556m	£3,046m	£2,821m

7.7.2 Option AC6-9, from T-Point to South Wales West Connection Node B, has the highest capital cost at £4,502.8m and the highest lifetime cost at £4,556m. Option AC6-9 requires the longest indicative route length at 630 km, resulting in this option being the most expensive among the options considered.

7.7.3 Strategic Option AC6-2 has the lowest capital cost at £2,325.4m and the lowest lifetime cost at £2,536m.

7.8 Summary of Strategic Options Appraisals

Table 7.2 - Overview of Strategic Options Appraisal

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
AC6-1 – Pentir	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-1 strategic option cannot avoid crossing three pipelines and 18 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** Throughout the study area of AC6-1, there are two notable settlements, Bangor and Caernarfon, that can both be	The route length for Strategic Option AC6-1 is 288 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £12,279.2m. The NPV of the cost of losses is £280.7m whilst the NPV of operation and maintenance costs over a 40-year period is £66.0m. This leads to a lifetime cost of £12,626m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £2,500.4m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £74.3m. This leads to a lifetime cost of £2,732m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, 2 bay extension with associated substation works would be	**Offshore**: There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Other than the two common designated areas, the North Anglesey Marine SAC is unlikely to be avoidable for strategic option AC6-1. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no SPAs or Ramsar sites with the option, however, this strategic option cannot avoid crossing one SAC and one SSSI. There are other designated sites including SACs, NNRs and SSSIs	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 12 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-1 proposes connecting into the existing Pentir 400 kV substation, requiring bay extensions at this substation. This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the required converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	avoided. This strategic option will cross National Cycle Network Route 8 and has the potential to cross 3 others. There are no areas of National Trust Land within the study area. AC6-1 may require crossing two OHLs. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for these strategic options.	required at Pentir substation, adding a capital cost of £82.0m. Further breakdown of the costs can be found in Appendix D.	which will most likely be in close proximity to the cable, which may result in temporary adverse effects upon them. There are no Air Quality Management Areas (AQMAs) identified within this study area. Some areas of Grade 2 and Grade 3 agricultural land cannot be avoided, whilst Peatland and Regionally Important Geodiversity Sites within the area could be avoided. The study area of AC6-1 includes both Anglesey Coastal Path (Llwybr Arfordirol Ynys Môn) and the Wales Coast Path. It will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. AC6-1 cannot avoid one RLOSI. There are multiple Listed Buildings and Scheduled Monuments within the study area, however, these can be identified and avoided through detailed routeing. There are three main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	options.
AC6-2 – Wylfa South	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal	The route length for Strategic Option AC6-2 is 252 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable.	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoidable across all strategic options.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-2 strategic option cannot avoid crossing three pipelines and 18 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** AC6-2 only contains one major settlement, Amlwch, which could be avoided. For this strategic option's study area, National Cycle Network Route 5 and 8 may not be avoidable, depending on landfall location, whilst National Trust Land could be avoided. AC6-2 may require crossing one OHL. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.	The **AC subsea** technology has an associated capital cost of £10,731.0m. The NPV of the cost of losses is £249.1m whilst the NPV of operation and maintenance costs over a 40-year period is £56.9m. This leads to a lifetime cost of £11,037m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £2,304.9m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £74.1m. This leads to a lifetime cost of £2,536m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, two bays would be required at the proposed Wylfa South 400 kV Substation with a capital cost of £20.5m. This substation is yet to be built however it outside of the AC6 scope. Further breakdown of the costs can be found in Appendix D.	Further to the two common designated areas, strategic option AC6-2 would have to cross two additional designated sites, the Anglesey Terns SPA and the North Anglesey Marine SAC. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no SPAs or Ramsar sites with the option, however, this strategic option cannot avoid crossing one SAC and one SSSI. There are other designated sites including SACs, NNRs and SSSIs which will most likely be in close proximity to the cable, which may result in temporary adverse effects upon them. AC6-2 may also temporarily impact other designated sites during construction. Strategic Option AC6-2 there are no Air Quality Management Areas (AQMAs) identified within it study area. Grade 1 and 2 agricultural land may not be avoided and Grade 3 Agricultural land cannot be avoided. GeoMôn UNESCO Global Geopark is a Geopark covering the entire island of Anglesey and will have to be crossed for	crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 11 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-2 proposes utilising two bays at a substation, Wylfa South 400 kV which does not currently exist, additionally this construction is outside of the AC6 scope. This strategic option requires a double turn in of existing Pentir – Wylfa circuits. This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. AC6-2 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			this strategic option. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. This strategic option cannot avoid Anglesey (Ynys Môn) AONB. Mitigation measures, such as the use of underground cables may be required within this study area. Crossing Anglesey Coastal Path (Llwybr Arfordirol Ynys Môn) with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. In addition, there are designated heritage assets within the AC6-2 study area. However, all assets can be directly avoided with careful routeing. There are three main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-3 - Bodelwyddan	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-3 strategic option cannot avoid	The route length for Strategic Option AC6-3 is 306 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £13,040.1m. The NPV of the cost of losses is £301.1m whilst the NPV of operation and maintenance costs over a 40-year period is £69.6m. This leads to a	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-3 would have to cross an additional designated site – the Liverpool Bay SPA. This strategic option would have to make landfall within this SPA. The North Anglesey Marine SAC would be unlikely to be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	crossing six pipelines and 25 cables. The number of crossing cables and pipelines increasing the risk associated with legal/commercial implications due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** There are five major settlements within AC6-3, St. Asaph, Abergele, Kinmel Bay, Rhyl and Prestatyn. With smaller settlements dispersed around the strategic option, this study area is dense in settlements. The siting of the converter station may cause long term visual effect on surrounding settlements, specifically St Asaph, with mitigation measures needed once further assessments are undertaken. This strategic option will cross National Cycle Network Route 5, which is unavoidable, it may also cross over another, dependent on routeing. National Trust Land could be avoided. AC6-3 may require crossing one OHL and one cable. All Historic	lifetime cost of £13,411m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £2,583.7m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £74.3m. This leads to a lifetime cost of £2,815m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, bay extensions would be required at the existing Bodelwyddan adding a capital cost of £20.5m. Further breakdown of the costs can be found in Appendix D.	All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For the AC6-3 the area around the River Clwyd mouth has an intertidal zone of greater than 500 m in width, so may not be suitable for construction. However, this could be avoided. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no unavoidable designated sites or receptors within the AC6-3 study area. Impacts on designated features could be avoided through careful routeing. Strategic Option AC6-3 there are no Air Quality Management Areas (AQMAs) identified within it study area. Some Grade 1 and 2 agricultural land may not be avoided, and Grade 3 Agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way.	in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 8 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-3 would connect to an existing substation at Bodelwyddan; however, it would require bay extensions to facilitate the AC6 project. This site is highly constrained, which may lead to challenges with the substation extension. This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. AC6-3 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.		If AC6-3 makes landfall near the Dee at Talacre, it would require traversal of the new proposed National Park. Mitigation, in relation to this, may require making landfall to the southwest of Abergele within the Liverpool Bay SPA, which would in turn require crossing a Registered Park. The AC6-3 study area is densely populated with historic environment assets. However, all assets can be directly avoided with careful routeing. There is one main river that cannot be avoided within this this strategic option's study area. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-4 – Pembroke	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-4 strategic option cannot avoid crossing three pipelines and 19 cables. Crossing cables and	The route length for Strategic Option AC6-4 is 504 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £21,544.1m. The NPV of the cost of losses is £507.4m whilst the NPV of operation and maintenance costs over a 40-year period is £116.5m. This leads to a lifetime cost of £22,168m for the AC subsea option.	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-4 would have to cross five additional designated sites - Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and the North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha.

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** For AC6-4 there are three major settlements, Milford Haven, Pembroke and Pembroke Dock, all of which are likely to be avoided. From landfall, further individual settlements will require careful routeing. National Trust Land may require crossing as part of this strategic option, near Stackpole Coast. It may also cross one National Cycle Network Route, but this can be avoided. Crossing National Trust Land would result in potential temporary visual impacts to users of the land and temporary closures. AC6-4 may require crossing two OHLs each. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for these strategic options.	The **HVDC subsea** technology has an associated capital cost of £3,644.2m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £75.1m. This leads to a lifetime cost of £3,876m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, bay extensions would be required at the existing Pembroke Substation adding a capital cost of £20.5m. Further breakdown of the costs can be found in Appendix D.	There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For AC6-4, the coastal height at the potential Pembroke landfall area is generally less than 30 m. However, there are areas, which are considered to be avoidable at this stage. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are five receptors within the AC6-4 study area that cannot be avoided - one SAC, one SPA, two SSSIs and one NNR, which is crossing the greatest amount of designated areas within all strategic options. A high number of associated projects are seeking landfall within the Pembroke area, which poses additional constraints. There are no Air Quality Management Areas (AQMAs) identified within this study area. Grade 1 Agricultural land may not be avoidable. The majority of land within the study area is Grade 2 and Grade 3 Agricultural land, which cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. AC6-4 cannot avoid the Pembrokeshire Coast National Park. Mitigation measures, such as the use of	Approximately 9 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-4 would connect to the existing Pembroke 400 kV substation; however, it would require bay extensions to facilitate the AC6 project. The existing Pembroke 400 kV substation is an indoor Air-Insulated Substation (AIS) and it would be challenging to extend the site further to accommodate the Project's HVDC connection. This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the South Wales substations. AC6-4 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			underground cables may be required within this study area. Crossing the Wales Coast Path with correct mitigating actions, there should be no lasting effects on the Public Right of Way. AC6-4 cannot avoid one RLOSI. There are also Scheduled Monuments and Conservation Areas within the study areas of these strategic options. However, all assets can be directly avoided with careful routeing. Within this this strategic option's study area all main rivers could be avoided. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-5 - South Wales West Connection Node C	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-5 strategic option cannot avoid crossing three pipelines and 19 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land	The route length for Strategic Option AC6-5 is 552 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £23,591.0m. The NPV of the cost of losses is £588.8m whilst the NPV of operation and maintenance costs over a 40-year period is £127.1m. This leads to a lifetime cost of £24,277m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £3,881.3m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-5 would have to cross seven additional designated sites – Carmarthen Bay SPA, Skomer, Skokholm, and the Seas Off Pembroke SPA, Carmarthen Bay and Estuaries SAC, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 3 km of onshore underground HVDC cables would be required from the landfall point to the converter station.

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** Throughout the AC6-5 study area, there are no major settlements present, however there are individual properties that will require avoiding through detailed routeing. This strategic option cannot avoid National Cycle Network 4, whilst National Trust Land could be avoided. AC6-5 may require crossing two OHLs. There are no Historic Landfill Sites, Airports, Military Areas and Ports and Harbours within the study area of this strategic option.	maintenance costs over a 40-year period is £75.3m. This leads to a lifetime cost of £4,114m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, the construction of the new 400 kV South Wales West Connection Node C 10 bay substation, has been included in this cost appraisal, at a cost of £179.4m, to account for the eventuality of the substation construction being a part of the AC6 scope, as covered in the technical appraisal summary column for this strategic option. Further breakdown of the costs can be found in Appendix D.	impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For AC6-5, the coastal height at the potential Pembroke landfall area is generally less than 30 m. However, there are areas, which are considered to be avoidable at this stage. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There is one unavoidable receptor within the AC6-5 study area - a SSSI which cannot be avoided along the coastline. Strategic Option AC6-5 there are no Air Quality Management Areas (AQMAs) identified within it study area. Grade 3 Agricultural land cannot be avoided, whilst Regionally Important Geodiversity Sites within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. AC6-5 cannot avoid one RLOSI. There are also Scheduled Monuments and Conservation Areas within the study areas of these strategic options. However, all assets can be directly avoided with careful routeing.	AC6-5 proposes utilising two bays at the South Wales West Connection Node C 400 kV Substation. This substation is trigged by different connection projects. Should these projects not proceed, the ten-bay substation would be required as part of the AC6 scope of works and has been included in this appraisal to account for this eventuality. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the south Wales substations. It will also require a double turn in of the existing 400 kV Pembroke-Swansea North circuits.

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			There is one main river that cannot be avoided within this within this strategic option's study area. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-6 – Carmarthen Bay	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-6 strategic option cannot avoid crossing three pipelines and 19 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas,	The route length for Strategic Option AC6-6 is 576 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £24,614.1m. The NPV of the cost of losses is £579.9 m whilst the NPV of operation and maintenance costs over a 40-year period is £132.8m. This leads to a lifetime cost of £25,327m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £4,015.9m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £75.3m. This leads to a lifetime cost of £4,248m for the HVDC subsea option.	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-6 would have to cross seven additional designated sites – Carmarthen Bay SPA, Skomer, Skokholm, and the Seas Off Pembroke SPA, Carmarthen Bay and Estuaries SAC, Carmarthen Bay Dunes SAC, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 5 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-6 proposes utilising two bays at the proposed Llandyfaelog 400 kV substation. This substation is trigged by a different connection project. Should that project not

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** The AC6-6 study area includes has two major settlements, Kidwelly and Burry Port, as well as smaller settlements scattered throughout the study area. For this strategic option, National Cycle Network route 4 cannot be avoided. There are no areas of National Trust Land within the study area. AC6-6 may require crossing two OHLs each. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for these strategic options.	The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology option chosen, the construction of the new 400 kV Llandyfaelog 10 bay substation has been included in this cost appraisal, at a cost of £179.4m, to account for the eventuality of the substation construction being a part of the AC6 scope, as covered in the technical appraisal summary column for this strategic option. Further breakdown of the costs can be found in Appendix D.	related to this designated site. For AC6-6, there is a wide intertidal zone at the landfall study area, which may pose issues for cable construction. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. Due to the wide intertidal zone within this strategic option further technical and engineering inputs would be required to determine if construction is sufficient. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There is one unavoidable receptor within the AC6-6 study areas - a SSSI which cannot be avoided along the coastline. This strategic option may also have to cross a country park and/or a dedicated forest. Strategic Option AC6-6 there are no Air Quality Management Areas (AQMAs) identified within it study area. Grade 3 Agricultural land cannot be avoided, whilst peatland within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. For AC6-6 there is one RLOSI that cannot be avoided. All other designated heritage assets can be avoided for these strategic options. There are four main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water	proceed, the ten-bay substation would be required as part of the AC6 scope of works and has been included in this appraisal to account for this eventuality. This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the south Wales substations. AC6-6 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-7 – Swansea North	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-7 strategic option cannot avoid crossing three pipelines and 19 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be	The route length for Strategic Option AC6-7 is 612 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £26,163.0m. The NPV of the cost of losses is £620.8m whilst the NPV of operation and maintenance costs over a 40-year period is £141.1m. This leads to a lifetime cost of £26,925m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £4,288.2m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £75.5m. This leads to a lifetime cost of £4,521m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-7 Further to the two common designated areas, strategic option AC6-6 would have to cross seven additional designated sites – Carmarthen Bay SPA, Skomer, Skokholm, and the Seas Off Pembroke SPA, Carmarthen Bay and Estuaries SAC, Carmarthen Bay Dunes SAC, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For AC6-7, there is a wide intertidal zone at the landfall study area, which may pose issues for cable construction.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 30 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-7 would connect to the existing Swansea North substation; however, it would require bay extensions to facilitate the AC6 project. There are currently two 400 kV double circuits leaving the substation. This strategic option does not

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	avoidable. **Onshore:** The AC6-7 study area includes three major settlements, Kidwelly, Burry Port and North Swansea, as well as smaller settlements scattered throughout the study area. For this strategic option, there are no areas of National Trust Land. There are three National Cycle Network routes, of which National Cycle Network route 4 and 47 cannot be avoided. AC6-7 may require crossing one or more OHLs. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.	assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, bay extensions would be required at the existing Swansea North 400 kV Substation adding a capital cost of £20.5m. Further breakdown of the costs can be found in Appendix D.	This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. Due to the wide intertidal zone within this strategic option further technical and engineering inputs would be required to determine if construction is sufficient. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There is one unavoidable receptor within the AC6-6 study areas - a SSSI which cannot be avoided along the coastline. This strategic option may also have to cross a country park and/or a dedicated forest. Strategic Option AC6-7 there are no Air Quality Management Areas (AQMAs) identified within it study area. Grade 3 Agricultural land cannot be avoided, whilst Grade 2 Agricultural Land could be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. For AC6-6 there is one RLOSI that cannot be avoided. All other designated heritage assets can be avoided for these strategic options. There are four main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and	trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the south Wales substations. AC6-7 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-8 – Baglan Bay	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-8 strategic option cannot avoid crossing three pipelines and 22 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be	The route length for Strategic Option AC6-8 is 612 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £26,163.0m. The NPV of the cost of losses is £620.8m whilst the NPV of operation and maintenance costs over a 40-year period is £141.1m. This leads to a lifetime cost of £26,925m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £4,195.3m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £75.5m. This leads to a lifetime cost of £4,428m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option.	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-8 would have to cross five additional designated sites – Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For AC6-8, the beach width around the mouth of the River Neath may cause construction challenges, but it may be avoided. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing boundaries B6 and B7a. There are currently two 400 kV double circuits leaving the substation. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 1 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-8 would connect to the existing Baglan Bay 400 kV substation; however, it would require bay extensions to facilitate the AC6 project.

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	avoidable. **Onshore:** For AC6-8 there are eight major settlements within the study area. Neither National Trust Land nor the National Cycle Network would be affected by strategic option. AC6-8 could avoid all OHLs and cables. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could also be avoided for this strategic option.	Additionally, regardless of subsea technology chosen, bay extensions would be required at the existing Baglan Bay adding a capital cost of £20.5m. Further breakdown of the costs can be found in Appendix D.	and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no unavoidable designated sites or receptors within the AC6-8 study areas. Impacts on designated features can be avoided through careful routeing. There are no Air Quality Management Areas (AQMAs) identified within this study area. Grade 3 Agricultural land cannot be avoided, whilst large areas of peatland within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. AC6-8 could avoid all international and national designated or important historic environment and cultural heritage sites. There are four main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	This strategic option does not trigger a new substation that would form a part of the AC6 project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the south Wales substations. AC6-8 includes the connection to a 275 kV substation (as opposed to a 400 kV substation). This would trigger a substantial amount of reinforcement works to the south Wales network, including the rebuild of Margam and Pyle 275 kV substations and the reconductoring of 275 kV OHL routes to 400 kV. Other enabling works include; • Upgrade of 132 kV circuits up to 275 kV • Cable section replacement in Baglan Bay – Swansea & Baglan Bay – Margam circuits • Reconductoring of two 275 kV circuits from Baglan Bay substation • Bay extension at Swansea North 400 kV substation to accommodate a new 400/275 kV transformer.

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
				• SGT replacement at Swansea North.
AC6-9 – South Wales West Connection Node B	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-9 strategic option cannot avoid crossing three pipelines and 22 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** There are four major settlements present within the AC6-9 study area. These are Maesteg, Porthcawl, Pyle and Bridgend. This strategic option will cross National Cycle Route 5, which is unavoidable.	The route length for Strategic Option AC6-9 is 630 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £26,923.2m. The NPV of the cost of losses is £632.0m whilst the NPV of operation and maintenance costs over a 40-year period is £145.5m. This leads to a lifetime cost of £27,701m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £4,323.4m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £75.5m. This leads to a lifetime cost of £4,556m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, the construction of the new 400 kV South Wales West Connection Node B 10 bay substation, has been included in this cost appraisal, at a cost of £179.4m, to account for the eventuality of the	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Further to the two common designated areas, strategic option AC6-9 would have to cross five additional designated sites – Skomer, Skokholm, and the Seas Off Pembroke SPA, Bristol Channel Approaches SAC, Pembrokeshire Marine SAC, West Wales Marine SAC, and North Anglesey Marine SAC. There is currently one cable that crosses the Pembrokeshire Marine SAC, which has triggered IROPI and may pose a notable consenting risk. There are also SSSIs across the coastline, which cannot be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For AC6-9, the beach width around the mouth of the River Neath may cause construction challenges, but it may be avoided. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 11 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-9 proposes utilising two bays at the proposed South Wales West Connection Node B 400 kV substation. The construction of this is proposed as part of another project's scope. It has been triggered by the Celtic Sea project which will look to connect 1.5 GW into the substation. Should the Celtic Sea project not proceed, the ten-bay substation would be required as part of the AC6 scope of works and has been included in this appraisal to account for this eventuality. At this stage, the converter station works are not considered a key differentiating factor between the

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	AC6-9 will require crossing two OHLs. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.	substation construction being a part of the AC6 scope, as covered in the technical appraisal summary column for this strategic option. Further breakdown of the costs can be found in Appendix D.	**Onshore:** There are no unavoidable designated sites or receptors within the AC6-9 study areas. Impacts on designated features can be avoided through careful routeing. Strategic Option AC6-9 there are no Air Quality Management Areas (AQMAs) identified within it study area. Grade 3 Agricultural land cannot be avoided, whilst Grades 1 and 2 Agricultural Land could be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. This strategic option will need to cross the Wales Coast Path, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. AC6-9 could avoid all international and national designated or important historic environment and cultural heritage sites. There is one main river that cannot be avoided within this strategic option's study area. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	strategic options, as a similar level of works would be required across each of the strategic options. For this strategic option there would be a requirement for the uprating of the 400 kV cables within the Severn Cable Tunnel to be completed prior to the AC6 project connecting at any of the south Wales substations. AC6-9 would not expect to trigger significant reinforcement works to the local network(s).
AC6-10 – Connah's Quay	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which	The route length for Strategic Option AC6-10 is 330 km. Two technologies were appraised for	**Offshore:** There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	may lead to consenting and legal implications. Notice to mariners, engagement with Fisheries Liaison Officers (FLOs), and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users. AC6-10 strategic option cannot avoid crossing six pipelines and 25 cables. The number of crossing cables and pipelines increasing the risk associated with legal/commercial implications due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** There are nine major settlements within AC6-10 including St. Asaph, Abergele, Kinmel Bay, Rhyl and Prestatyn, Flint, Holywell, Bagillt and Connah's Quay. With smaller settlements dispersed around the strategic option, this study area is dense in settlements. These settlements can be avoided through detailed routing. This strategic option will cross National Cycle Network Route 5 and 84, which are unavoidable, it	this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £14,063.2m. The NPV of the cost of losses is £322.2m whilst the NPV of operation and maintenance costs over a 40-year period is £75.3m. This leads to a lifetime cost of £14,461m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £2,814.4m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £74.4m. This leads to a lifetime cost of £3,046m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, the construction of the new 400 kV Connah's Quay 10 bay substation, has been included in this cost appraisal, at a cost of £179.4m, to account for the eventuality of the substation construction being a part of the AC6 scope, as covered in the technical appraisal summary column for this strategic option. Further breakdown of the costs can be found in Appendix D.	Further to the two common designated areas, strategic option AC6-10 would have to cross an additional designated site – the Liverpool Bay SPA. This strategic option would have to make landfall within this SPA. The North Anglesey Marine SAC would be unlikely to be avoided. There are no unavoidable marine wrecks that have been identified across any strategic option. All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. For the AC6-10 the area around the River Clwyd mouth has an intertidal zone of greater than 500 m in width, so may not be suitable for construction. However, this could be avoided. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no unavoidable designated sites or receptors within the AC6-10 study area. Impacts on designated features could be avoided through careful routeing. Strategic Option AC6-10 there are no Air Quality Management Areas (AQMAs) identified within it study area.	crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 40 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-10 proposes the construction of a New 400 kV Connah's Quay 10 bay Substation, of which two bays are to accommodate new circuits from this project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. AC6-10 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	may also cross over another, dependent on routeing. National Trust Land could be avoided. AC6-10 may require crossing one OHL and one cable. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for this strategic option.		Some Grade 1 Agricultural land may not be avoided, and Grade 2 and 3 Agricultural land cannot be avoided. Peatland and Regionally Important Geodiversity Sites within the area could be avoided. This strategic option will need to cross the Wales Coast Path, Offa's Dyke, one AONB and a newly proposed National Park, which will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. The AC6-10 study area is densely populated with historic environment assets. However, all assets can be directly avoided with careful routeing. There are three main rivers that cannot be avoided within this this strategic option's study area. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	
AC6-11– Bryncir	**Offshore:** For each strategic option there is potential for interaction between construction vessels and other marine vessel users, which may lead to consenting and legal implications. Notice to mariners, engagement with FLOs, and consultation would likely be required to mitigate potential effects arising from fisheries and other marine vessel users.	The route length for Strategic Option AC6-11 is 303 km. Two technologies were appraised for this option: AC subsea cable and HVDC subsea cable. The **AC subsea** technology has an associated capital cost of £12,922.5m. The NPV of the cost of losses is £300.8m whilst the NPV of operation and maintenance costs over a 40-year	**Offshore**: There are two common designated areas across all strategic options. The Clyde Sea Sill MPA cannot be avoided and the North Channel SAC is unlikely to be avoided across all strategic options. Other than the two common designated areas, the North Anglesey Marine SAC, cannot be avoided for strategic option AC6-11. There are no unavoidable marine wrecks that have been identified across any strategic option.	All strategic options satisfy the critical requirement for being compliant with NGET SQSS as well as meeting the needs case by crossing critical boundaries B6 and B7a. All strategic options are formed of a HVDC link which would require a pair of HVDC cables. Moreover, two converter stations would be required, one in the Ayrshire in

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
	AC6-11 strategic option cannot avoid crossing three pipelines and 18 cables. Crossing cables and pipelines may result in legal/commercial implication due to crossing agreement requirements. All strategic options considered potential impacts of other key land users of infrastructure within the various study areas. These were: subsea and surface wells, windfarms, aggregate extraction sites, disposal sites, military areas, shipping routes and commercial fisheries. Where these were identified across the strategic options, they were considered to be avoidable. **Onshore:** Throughout the study area of AC6-11, there are six major settlements (Clynnog Fawr, Trefor, Criccieth and Porthmadog) with some smaller settlements dispersed around the strategic option. This study area is dense in settlements, but all these settlements can be avoided with detailed routing. This strategic option will cross National Cycle Network Route 8 and has the potential to cross two others. The areas of National Trust Land within the study area could be avoided. AC6-11 may require crossing one OHL. All Historic Landfill Sites, Airports, Military Areas and Ports and Harbours could be avoided for these strategic options.	period is £69.1m. This leads to a lifetime cost of £13,292m for the AC subsea option. The **HVDC subsea** technology has an associated capital cost of £2,590.1m including converter stations at each end. The NPV of the cost of losses is £157.1m whilst the NPV of operation and maintenance costs over a 40-year period is £74.3m. This leads to a lifetime cost of £2,821m for the HVDC subsea option. The most cost-effective option is HVDC, and this would be considered the starting assumption for further exploration of this option. Additionally, regardless of subsea technology chosen, the construction of the new 400 kV Bryncir 10 bay substation, has been included in this cost appraisal, at a cost of £179.4m, to account for the eventuality of the substation construction being a part of the AC6 scope, as covered in the technical appraisal summary column for this strategic option. Further breakdown of the costs can be found in Appendix D.	All strategic options will have to cross the Clyde Sea Sill MPA, which is designated for geological features. Direct impacts could be mitigated through appropriate design and construction methods. It will remain likely, and therefore it is anticipated that there will be consenting implications related to this designated site. This study area has complex seabed geomorphology, including glacial bedform features and prominent troughs (e.g. North Channel, Beaufort's Dyke, Manx Depression). These may be avoided through routeing and geotechnical and geophysical survey works. Where the sediment is not of sufficient type and/or depth for burial, additional cable protection methods are likely to be required. It should also be noted that there are currently six cables that cross The Clyde Sea Sill MPA indicating that consent within these areas is possible. Under any strategic option selected, this site will require crossing. **Onshore:** There are no Ramsar sites with the option, however, this strategic option cannot avoid crossing one SAC, one SSSI, and one SPA. There are other designated sites including SACs, SPA and SSSIs which will most likely be in close proximity to the cable, which may result in temporary adverse effects upon them. There are no Air Quality Management Areas (AQMAs) identified within this study area. Grade 3, Grade 4 and Grade 5 agricultural lands, and Peatland within the study area of this strategic option cannot be avoided. Geopark and Regionally Important Geodiversity Sites within the area could be avoided. There is no Grade 1 or 2 Agricultural land within this strategic option. The study area of AC6-11 includes the Wales Coast Path. It will have minor effects from construction activities, but with the correct mitigating actions, there should be no lasting effects on the Public Right of Way. There are multiple Listed Buildings and Scheduled	Scotland and one in the vicinity of each proposed substation location in Wales. The converter stations would have an approximate footprint of 6 ha. Approximately 15 km of onshore underground HVDC cables would be required from the landfall point to the converter station. AC6-11 proposes the construction of a New 400 kV Bryncir 10 bay Substation, of which two bays are to accommodate new circuits from this project. At this stage, the converter station works are not considered a key differentiating factor between the strategic options, as a similar level of works would be required across each of the strategic options. AC6-11 would not expect to trigger significant reinforcement works to the local network(s).

Option	Appraisal			
	Socio-economic	Cost	Environment	Technical
			Monuments, Conservation Areas, RLOSI, WHS' and Registered Parks and Gardens within the study area could be identified and avoided through detailed routeing. There are three main rivers, within this strategic option's study area, that cannot be avoided. There is potential for adverse effects on the water environment (i.e. water quality degradation, impacting natural river flow and disturbance to aquatic life). However, careful planning and the use of effective mitigation measures will minimise the long-term adverse effects on hydrology. Across all strategic options, regarding suitability for the additional converter station, the proposed converter station must carefully consider the surrounding area to minimise impacts on statutory designated ecological sites, air quality management areas, agricultural land, hydrology, historic environment sites, as well as any landscape and visual amenity implications.	

8. Conclusions and next steps

8.1 Overview of identifying the strategic options

8.1.1 This SOR presents the findings of NGET's options appraisal process for the Project and is intended to provide a clear justification and evidence for NGET's decision-making of a preferred strategic option. This report demonstrates that NGET has used the Needs Case to consider the ways in which the project could be delivered by generating a number of potential strategic options. Technical feasibility considerations have been applied to make sure that all of the potential strategic options considered would work on the network, rejecting any that would not meet technical standards or would not work in practice. The number of options was then reduced to the proposed strategic options list by applying the benefits filter to make sure that the proposed strategic options taken forward for detailed appraisal have some benefit over another similar options. The report concludes with the identification of a preferred strategic option, which will be taken forward for further consideration.

8.1.2 NGET have a key role in providing a transmission system which benefits all consumers in England and Wales. Where new network infrastructure is needed, NGET must work within the regulatory, legislative and policy framework that is set by the government on behalf of consumers and society in developing proposals. That means considering the various benefits and impacts that potential works could have, including environmental, socio-economic, technical, and cost factors.

8.1.3 This SOR has considered options to meet the Needs Case set out in Chapter 4. A requirement has been identified for transmission circuit reinforcements that contribute to NETS SQSS compliance.

8.1.4 NGET have considered the information which is available at this stage of the process and have outlined how data has been gathered and evaluated for each option. In addition, NGET have also considered its duties under the Electricity Act 1989 to develop efficient, co-ordinated and economical solutions, their duty to have regard to the environment in Schedule 9 of the 1989 Act, and the policy, advice and guidance provided by Government through the adopted and emerging National Policy Statements.

8.2 The case for the selection of the strategic option

8.2.1 To meet the need to increase capacity across boundaries B6 and B7a, plus assessing any impact of strategic options upon new West Coast generation group infrastructure, NGET's proposal at the current stage is to take forward strategic option AC6-1 for further consideration. AC6-1 involves the development of a new transmission circuit from Central/South Ayrshire and connecting it to the transmission network at Pentir.

8.2.2 The majority of the new circuit for this strategic option would be routed within the Irish Sea, making landfall on the northern Welsh coastline. The circuit distance for AC6-1 indicative study area spans approximately 288 km. This connection length is based on a preliminary cable routeing study for the offshore elements and a straight-line distance

from the landfall area to the relevant connecting substation. This is set out in further detail in Sections 5.6 and 6.2.

8.2.3 NGET provides its rationale for taking forward this strategic option in the following sections.

Environmental and Socio-Economic factor

8.2.4 For Strategic Option AC6-1, landing in Pentir includes the fewest amount of marine designation related receptors. In addition, from an onshore perspective, it is the most favourable strategic option when considering landfall options and sensitive receptors within its study area, avoiding National Parks and AONBs.

8.2.5 Strategic Option AC6-2 is characterised by consenting challenges associated with the requirement of crossing the GeoMôn UNESCO Global Geopark. The Geopark covers the entirety of Anglesey and the associated AONB covers the entire coast and requires crossing.

8.2.6 If Strategic Option AC6-3 made landfall near the Dee at Talacre, this would involve traversing the proposed new National Park in north-east Wales. To mitigate this, making landfall southwest of Abergele within the Liverpool Bay SPA may be required, which would require crossing a Registered Park.

8.2.7 AC6-4 includes a high number of projects that are seeking landfall in the Pembroke area, as well as a high proportion of Annex I habitats. The onshore area upon landfall is highly constrained and would require crossing an SSSI and National Park

8.2.8 Strategic Option AC6-5 involves the highest amount of marine designated area crossings and the overall highest number of potential receptors. Landfall would be made in an SPA and two SACs, with the Carmarthen Estuaries SAC being characterised by a high proportion of Annex I habitats. This strategic option would also require crossing a SSSI at landfall.

8.2.9 Strategic Options AC6-6 and AC6-7 involve a large intertidal width of 1.5 km (which could pose technical constraints related to installation activities) and require crossing three main marine designations (Carmarthen Bay SPA, Carmarthen Bay Dunes SAC and Pembrokeshire Marine SAC) which has one cable currently crossing it, which has triggered IROPI and may pose a notable consenting risk. These consenting issues would be a result of the potential implication of damaging and causing the permanent loss of habitats, as well as water quality degradation that may occur within these marine designations. In addition, Pembrey Airport would be in proximity to the landfall location and may pose a potential issue for the converter station location.

8.2.10 Strategic Options AC6-8 and AC6-9 involve one designated site which has one cable currently crossing it, which has triggered IROPI and may pose a notable consenting risk. AC6-8 may potentially include a wide intertidal zone and for AC6-9, onshore routeing to the substation would require careful routeing around sensitive receptors. The terrain surrounding the proposed location for the South Wales Connection Node B substation in the Bridgend area is hilly and would necessitate crossing terrain of more than 200m of elevation. The strategic options require crossing up to five constraints.

8.2.11 Strategic option AC6-10 has one SPA and one MPA that cannot be avoided. The sediment type throughout this strategic option is variable, and the study area features complex seabed geomorphology. The potential landfall area near Bodelwyddan cannot avoid the Clyde Sea Sill MPA. Regarding the terrestrial environment, there are nine

unavoidable constraints: one proposed National Park, one Coastal Path, one National Trail, one Area of Outstanding Natural Beauty (AONB), agricultural land, and three main rivers.

8.2.12 Strategic option AC6-11, while largely similar to AC6-1 from an offshore perspective, has one significant constraint: the North Anglesey Marine Special Area of Conservation (SAC), which cannot be avoided. From an onshore perspective, there are large areas of peatlands that cannot be avoided. The construction of the converter station near these peatland areas could lead to irreversible changes in the peatland's ability to function as a carbon sink.

8.2.13 Overall, the holistic assessment of the environmental and socio-economic performance of all strategic options, considering both the marine and terrestrial elements, has brought out Strategic Option AC6-1 as the best-performing option for the Project.

Technical factor

8.2.14 All the shortlisted strategic options satisfy the critical requirement of being compliant with the NETS SQSS and meet the project need case by providing additional transmission capacity across boundaries B6 and B7a. The proposed technology for all the strategic options (subsea HVDC) is adequately established and does not add any uncertainty risk when implemented onto the Project.

8.2.15 In terms of substation infrastructure, all strategic options are formed of an HVDC link which would require a pair of HVDC cables and two bays to connect into at either an existing or a proposed substation. Strategic options AC6-1, AC6-2, AC6-3, AC6-4, AC6-7, AC6-8, AC6-10 and AC6-11 would connect to existing or proposed substations, however, AC6-5, AC6-6 and AC6-9 propose utilising two bays at substations which do not currently exist, but which are proposed as part of other projects. Should these projects not proceed, the ten-bay substation would be required as part of the Project scope of works and has, hence, been included in the cost appraisal of each of these strategic options to account for this eventuality.

8.2.16 All strategic options will require two 525 kV converter stations; one near the connecting substation in Wales (within NGET's licence area), and the other one at the starting point of the connection in Ayrshire in Scotland (within SPEN's licence area).

8.2.17 Regarding the HVDC subsea cable lengths for each strategic option, AC6-1 and AC6-2 are the only two options with cable lengths less than 300 km (288 km and 252 km, accordingly). AC6-7, AC6-8 and AC6-9 on the other hand, are characterised by cable lengths of more than 600 km, specifically 612 km for AC6-7 and AC6-8, and 630 km for AC6-9. Increased cable lengths deem the technical delivery more challenging and add a layer of complexity to the strategic option.

8.2.18 AC6-8 would trigger significant reinforcement works across the south Wales transmission network, as the HVDC link would be connecting into the 275 kV network, in constrast to the 400 kV substations that all other strategic options would connect into. This would add technical complexity to the delivery of this strategic option.

8.2.19 For all the South Wales strategic options (AC6-4 – AC6-9), the Severn Cable Tunnel uprating works would be a prerequisite and would need to be completed prior to the Project connecting in South Wales.

8.2.20 Strategic option AC6-8 is considered least preferred from a technical perspective, as it requires one of the longest circuit lengths, whilst also triggering significant reinforcement works across south Wales. The amount of required infrastructure associated with the facilitation of this strategic option would lead to increased technical complexity and constructability risks.

8.2.21 With regard to the rest of the strategic options, the main differentiating factors are the cable circuit length and substation works required. AC6-2 and AC6-1 offer the only HVDC links with a length less than 300 km and only require the utilisation of two additional bays at existing substations. On the contrary, AC6-5, AC6-6 and AC6-9 could potentially exhibit the need to construct a new 400 kV substation as part of their scope of works.

Cost factor

8.2.22 The overview of the capital and lifetime cost impacts of each strategic option, as set out in Section 6.2, is summarised below:

- AC6-1: Capital cost of £2,582.4m and lifetime circuit cost of £2,732m
- AC6-2: Capital cost of £2,325.4m and lifetime circuit cost of £2,536m
- AC6-3: Capital cost of £2,604.2m and lifetime circuit cost of £2,815m
- AC6-4: Capital cost of £3,664.7m and lifetime circuit cost of £3,876m
- AC6-5: Capital cost of £4,060.7m and lifetime circuit cost of £4,114m
- AC6-6: Capital cost of £4,195.3m and lifetime circuit cost of £4,248m
- AC6-7: Capital cost of £4,308.7m and lifetime circuit cost of £4,521m
- AC6-8: Capital cost of £4,215.8m and lifetime circuit cost of £4,428m
- AC6-9: Capital cost of £4,502.8m and lifetime circuit cost of £4,556m
- AC6-10: Capital cost of £2,993.8m and lifetime circuit cost of £3,046m
- AC6-11: Capital cost of £2,769.5m and lifetime circuit cost of £2,821m

8.2.23 Overall, Strategic Option AC6-2 is characterised by the lowest capital and lifetime circuit costs among all options taken forward for the appraisal as it has the shortest HVDC cable length. On the other hand, Strategic Option AC6-9 presents the highest capital and lifetime costs, as its landfall (Bridgend area) is the furthest away from the starting point in South Scotland (T-Point) and, hence, AC6-9 includes the longest connection length out of all strategic options. Therefore, from a cost perspective and considering the values presented above as well as associated connection lengths, the best performing strategic option is AC6-2, followed by AC6-1.

Conclusion

8.2.24 Following the appraisal set out within this SOR, to meet the need to increase capacity across boundaries B6 and B7a, NGET's proposal at the current stage is to take forward Strategic Option AC6-1 as the preferred option for the Project as it performs the best when making landfall in North or South Wales. AC6-1 proposes a new HVDC transmission connection between T-Point in South Scotland and Pentir in North Wales. This strategic option offers the most optimal balance between the four factors considered for the detailed appraisal presented in Section 6.2 (environmental, socio-economic, technical and cost).

8.2.25 AC6-1 includes the second shortest circuit length, at 288 km, and performs the best when considering environmental and socio-economic elements, with this strategic option avoiding significant designations, such as AONBs, National Parks and Geoparks. It includes the least amount of marine designation related receptors, requiring crossing the fewest number of marine ecology receptors and characterised by suitable coastal width or depth, with no immediate constraints from a marine geology perspective. In addition, AC6-1 is the most preferred from an onshore perspective as well, considering landfall options and sensitive receptors. In addition, it is costed as the second least expensive strategic option, both from a capital as well as a lifetime circuit cost perspective.

8.2.26 For this reason, NGET has deemed AC6-1 as the preferred strategic option and the recommended way forward. NGET will continue to review the work, including any notable changes in circumstances, and will have regard to consultation responses.

8.3 Next steps

8.3.1 The Project will now be taken forward to the next stage of development. This involves preliminary routeing and siting work, identification of a preliminary preferred route corridor and siting choice for the converter station and preparation of a graduated swathe, which indicates a more likely location for the development. This will be consulted on at consultation to seek feedback from consultees and help shape the further development of the project. This SOR will be subject to continuous back-check and review throughout the development stages. The evaluation that has been undertaken and is presented in this document will be revisited as the project progresses and further information becomes available or as circumstances evolve.

Appendix

Appendix A Summary of National Grid Electricity Transmission Legal Obligations

1.1 Electricity Transmission Licence

1.1.1 The Electricity Act 1989 (the 'Electricity Act') defines transmission of electricity within Great Britain and its offshore waters, as a prohibited activity, which cannot be carried out without permission by a transmission licence granted under Section 6(1)(b) of the Electricity Act (a 'Transmission Licence').

1.1.2 NGET has been granted a Transmission Licence that permits transmission owner activities in respect of the electricity transmission system NGET owns, develops and maintains in England and Wales.

1.1.3 Each Transmission Licence includes conditions which define the scope of the permission granted to carry out a prohibited activity in terms of duties, obligations, restrictions and rights. The generic conditions that apply to any holder of a Transmission Owner licence type are set out in Sections A, B and D of the Standard Conditions of the Transmission Licence. Conditions that only apply to a specific licensee are set out as Special Conditions of that Transmission Licence.

1.1.4 NGET is therefore bound by the legal obligations primarily set out in the Electricity Act and its Transmission Licence. The following list provides a summary overview of requirements that are considered when developing proposals to construct new transmission system infrastructure.

1.2 Electricity Act Duties

1.2.1 In accordance with Section 9 of the Electricity Act, National Grid is required to develop and maintain an efficient, coordinated and economical system of electricity transmission.

1.2.2 Schedule 9 of the Electricity Act requires National Grid, when formulating proposals for new lines and other works, to:

"…have regard to the desirability of preserving natural beauty, of conserving flora, fauna, and geological or physiographical features of special interest and of protecting sites, buildings and objects of architectural, historic or archaeological interest; and to do what [it] reasonably can to mitigate any effect which the proposals would have on the natural beauty of the countryside or on any such flora, fauna, features, sites, buildings or objects".

1.2.3 National Grid's Stakeholder, Community and Amenity Policy ('the Policy') sets out how the company will meet this Schedule 9 duty. The commitments within the Policy include:

- only seeking to build new lines and substations where the existing transmission infrastructure cannot be upgraded technically or economically to meet transmission security standards;
- where new infrastructure is required, seeking to avoid areas that are nationally or internationally designated for their landscape, wildlife or cultural significance, and

- minimising the effects of new infrastructure on other sites valued for their amenity.

1.2.4 The Policy also refers to the application of best practice methods to assess the environmental impacts of proposals and identify appropriate mitigation and/or offsetting measures. Effective consultation with stakeholders and the public is also promoted by the Policy.

1.3 National Grid's Transmission Licence Requirements

1.3.1 Condition B12: System Operator – Transmission Owner Code

All Transmission Licensees are required to have the System Operator Transmission Owner Code ('STC') in place that defines the arrangements within the transmission sector and sets out how the transmission system operator can access and use transmission services provided by transmission owners.

The STC structure aligns with key activities within the transmission sector including:

- Planning Co-ordination (of transmission system development works and construction);
- Provision of transmission services within different operational timescales, and
- Payments from transmission system operator to providers of transmission services (after service has been delivered).

1.3.2 Condition B16: Electricity Network Innovation Strategy

All Transmission Licensees are required to have a joined-up approach to innovation and develop an Electricity Network Innovation Strategy that is reviewed every two years.

1.3.3 Condition D2: Obligation to provide transmission services

Each transmission owner is required to provide transmission services to the transmission system operator as defined in the STC. Transmission services provided to the transmission system operator include:

- enabling use to be made of existing transmission owner assets, and
- responding to requests for the construction of additional transmission system capacity (including system extension, disconnections and/or reinforcement).

1.3.4 Condition D3: Transmission system security standard and quality of service

Transmission owners are required to at all times plan, develop the transmission system in accordance with the National Electricity Transmission System Security and Quality of Supply Standard ('NETS SQSS').

A transmission owner with supporting evidence, may ask the Authority to grant derogation from the requirements set out in the NETS SQSS. Any decision in respect of NETS SQSS derogations are subject to the Authority's consideration of all relevant factors.

1.3.5 Condition D17: Whole Electricity System Obligations

Transmission owners are required to coordinate and cooperate with Transmission Licensees and electricity distributors in order to build common understanding of where

actions taken by one could have cross-network impacts. A transmission owner should implement actions or processes that are identified that:

- will not have a negative impact on its network, and
- are in the interest of the efficient and economical operation of the total system.

Appendix B Energy Transmission Significant Infrastructure Supporting Policy

1.1 Electricity network infrastructure developments

1.1.1 Developing the electricity transmission system in England and Wales subject to the type and scale of the project, may require one or more statutory consents which may include:

- planning permission under the Town and Country Planning Act 1990;
- a marine licence under the Marine and Coastal Access Act 2009;
- a consent under the Infrastructure (Wales) Act 2024;
- purchase of land where not able to do so through negotiation, under the Planning and Compulsory Purchase Act 2004; and/or
- a variety of consents under related legislation.

1.1.2 As noted in Chapter 3, this Project is currently programmed to seek consent, within the UK, via a combination of the Town and Country Planning Act 1990 with Compulsory Purchase Order (under the Electricity Act 1989) routes in onshore Wales, and Marine Licence and Marine Infrastructure Consent for offshore elements. At the same time, the Project is keeping open the option to seek consent via the Infrastructure Wales Act 2024, which could relate to the Welsh terrestrial scheme and the Welsh marine scheme out to 12nm. To follow this route, the Project would need to be recognised by Welsh Ministers as being of national significance to Wales[33]. In addition, in the territories which are not subject to MaCAA, such as the Isle of Man, consent for development will be sought through a Marine Infrastructure Consent.

1.1.3 Local Planning Authority(s) will consider, when determining planning application, the geographically relevant national policies outlined in Section 3.5, alongside local planning policies. NGET also requests that the National Policy Statements (NPSs) are considered where appropriate, given their role as a statement of Government policy on the provision of energy infrastructure and the importance of electricity transmission in supporting the decarbonisation of the UK (whether or not a DCO is being sought under the Planning Act 2008).

1.1.4 The suite of energy National Policy Statements (NPSs), which currently comprises seven NPSs, was first designated by the Secretary of State for Energy and Climate Change in July 2011. For electricity transmission infrastructure, the principal National Policy Statements are the Overarching National Policy Statement for Energy (EN-1) and the National Policy Statement for Electricity Networks Infrastructure (EN-5), which are to be read together. EN-1 establishes the overarching need case and general assessment principles for nationally significant energy infrastructure, while EN-5 provides technology-specific policy and assessment guidance for electricity networks infrastructure. The current versions of EN-1 and EN-5 came into force on 6 January

[33] The Infrastructure (Wales) Act 2024 provides for a new consenting process that will enable the Welsh Ministers to determine applications for significant infrastructure projects. The Act contains the framework for the overall process, with the finer details to be prescribed in Regulations.

2026 and provide the primary national policy framework for the assessment and determination of applications for development consent orders for electricity transmission infrastructure.

1.1.5 Part 3 of EN-1 sets out Government policy on the need for new nationally significant energy infrastructure projects. Paragraphs 3.2.1 and 3.2.2 confirm that the UK needs a range of the types of energy infrastructure covered by the NPS to ensure the supply of energy always remains secure, reliable, affordable, and consistent with achieving net zero emissions in 2050 for a wide range of future scenarios. Paragraph 3.2.9 states that "substantial weight" should be given to the urgent need for the types of infrastructure covered by the NPS when considering applications for DCOs.

1.1.6 Description of the need for:

- new electricity transmission infrastructure is set out in EN-1 and EN-5
- new offshore/onshore wind generation is set out in EN-1 and EN-3, and
- new nuclear generation is set out in EN-1, EN-6, and EN-7.

1.1.7 The need for new transmission infrastructure for this project is described in section 3.2 of this Report.

1.1.8 It is requested that the NPSs form part of the Welsh Government and Local Authority(-ies) consideration, in tandem with local planning policy as a material consideration for decisions on other types of development consent in Wales (including offshore wind generation projects) for planning applications under the Town and Country Planning Act 1990.

Appendix C Technology Overview

1.1 Introduction

1.1.1 This section provides an overview of the technologies available when the strategic options described in this Report were identified. It provides a high-level description of the relevant features of each technology. The costs for each technology are presented in Appendix D.

1.1.2 The majority of electricity systems throughout the world are AC systems. Consumers have their electricity supplied at different voltages depending upon the amount of power they consume e.g. 230V for domestic customers and 11 kV for large factories and hospitals. The voltage level is relatively easy to change when using AC electricity, which means a more economical electricity network can be developed for customer requirement. This has meant that the electrification of whole countries could be and was delivered quickly and efficiently using AC technology.

1.1.3 Direct current (DC) electricity did not develop as the means of transmitting large amounts of power from generating stations to customers because DC is difficult to transform to a higher voltage and bulk transmission by low voltage DC is only effective for transporting power over short distances. However, DC is appropriate in certain applications such as the extension of an existing AC system or when providing a connection to the transmission system.

1.1.4 In terms of voltage, the transmission system in England and Wales operates at both 275 kV and 400 kV. The majority of National Grid's transmission system is now constructed and operated at 400 kV, which facilitates higher power transfers and lower transmission losses.

1.1.5 There are a number of different technologies that can be used to provide transmission connections. These technologies have different features which affect how, when and where they can be used. The main technology options for electricity transmission are:

- Overhead lines (OHL)
- Underground cables
- Gas Insulated Lines ("GIL"), and
- High Voltage Direct Current (HVDC).

This appendix provides generic information about each of these four technologies.

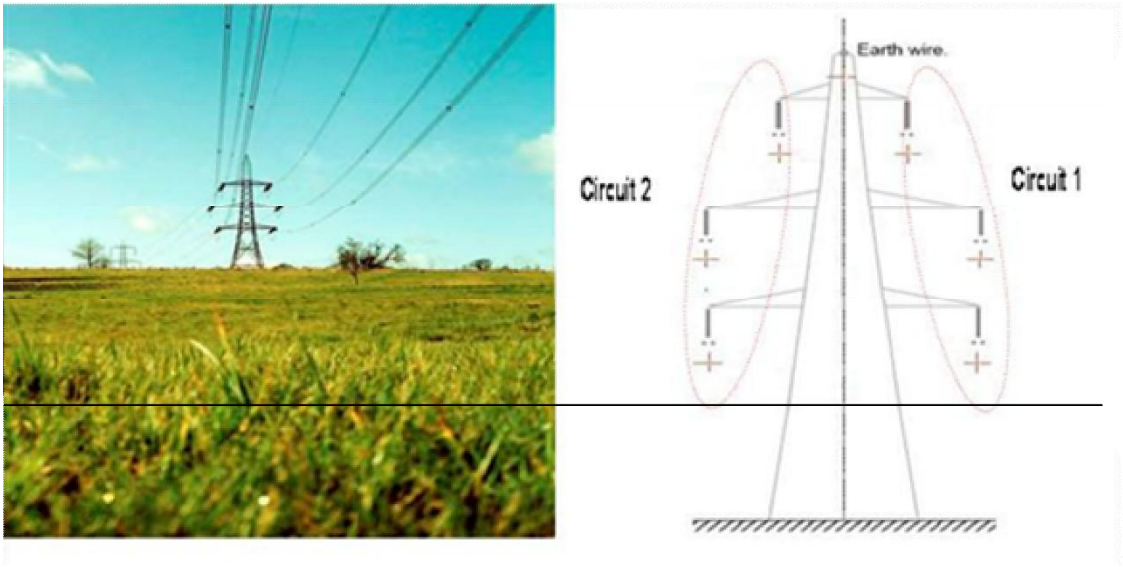
1.2 Overhead lines

1.2.1 Overhead lines form the majority of the existing transmission system circuits in Great Britain and in transmission systems across the world. As such there is established understanding of their construction and use.

1.2.2 Overhead lines are made up of three main component parts which are; conductors (used to transport the power), pylons (used to support the conductors) and insulators (used to safely connect the conductors to pylons).

1.2.3 Figure C.1 shows a typical pylon used to support two 275 kV or 400 kV overhead line circuits. This type of pylon has six arms (three either side), each carrying a set (or bundle) of conductors.

Figure C.1 – Example of a 400 kV Double-circuit Tower



1.2.4 The number of conductors supported by each arm depends on the amount of power to be transmitted and will be either two, three or four conductors per arm. Technology developments have increased the capacity that can be carried by a single conductor and therefore, new overhead lines tend to have two or three conductors per arm.

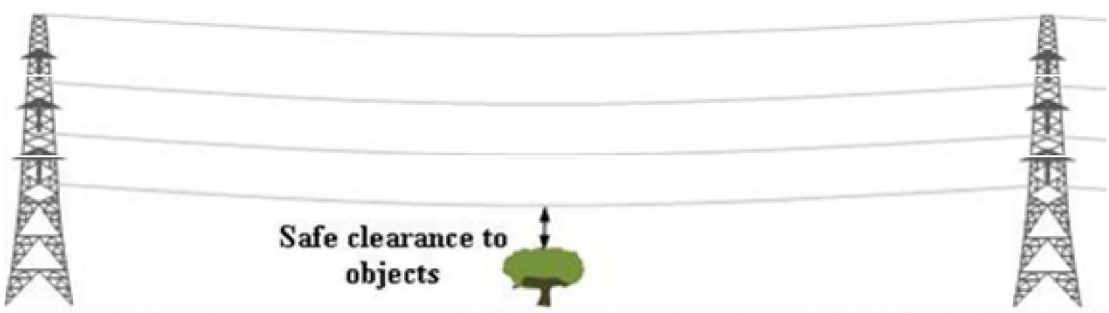
1.2.5 With the conclusion of the Royal Institute of British Architects (RIBA) pylon design competition[34] and other recent work with manufacturers to develop alternative pylon designs, National Grid is now able to consider a broader range of pylon types, including steel lattice and monopole designs. The height and width is different for each pylon type, which may help National Grid to manage the impact on landscape and visual amenity better. Figure C.2, below, shows an image on the monopole design called the T-pylon that was developed by National Grid.

[34] Pylon Design an RIBA competition, https://www.architecture.com/awards-and-competitions-landing-page/competitions-landing-page/pylon

Figure C.2 – The T-pylon

1.2.6 Pylons are designed with sufficient height to ensure that the clearances between each conductor and between the lowest conductor and the ground, buildings or structures are adequate to prevent electricity jumping across. The minimum clearance between the lowest conductor and the ground is normally at the mid-point between pylons. There must be sufficient clearance between objects and the lowest point of the conductor as shown in Figure C.3.

Figure C.3 – Safe height between lowest point of conductor and other obstacle ("Safe Clearance")



1.2.7 The distance between adjacent pylons is termed the 'span length'. The span length is governed by a number of factors, the principal ones being pylon height, number and size of conductors (i.e. weight), ground contours and changes in route direction. A balance must therefore be struck between the size and physical presence of each tower versus the number of towers; this is a decision based on both visual and economic aspects. The typical 'standard' span length used by National Grid is approximately 360m.

1.2.8 Lower voltages need less clearance and therefore the pylons needed to support 132 kV lines are not as high as traditional 400 kV and 275 kV pylons. However, lower voltage circuits are unable to transport the same levels of power as higher voltage circuits.

1.2.9 National Grid has established operational processes and procedures for the design, construction, operation and maintenance of overhead lines. Circuits must be taken out of service from time to time for repair and maintenance. However, shorter emergency restoration times are achievable on overhead lines as compared, for example, to underground cables. This provides additional operational flexibility if circuits need to be rapidly returned to service to maintain a secure supply of electricity when, for example, another transmission circuit is taken out of service unexpectedly.

1.2.10 In addition, emergency pylons can be erected in relatively short timescales to bypass damaged sections and restore supplies. Overhead line maintenance and repair therefore does not significantly reduce security of supply risks to end consumers.

1.2.11 Each of the three main components that make up an overhead line has a different design life, which are:

- Between 40 and 50 years for overhead line conductors
- 80 years for pylons
- Between 20 and 40 years for insulators.

1.2.12 National Grid expects an initial design life of around 40 years, based on the specified design life of the component parts. However, pylons can be easily refurbished, and so substantial pylon replacement works are not normally required at the end of the 40 year design life.

1.3 Underground Cables

1.3.1 Underground cables at 275 kV and 400 kV make up approximately 10% of the existing transmission system in England and Wales, which is typical of the proportion of underground to overhead equipment in transmission systems worldwide. Most of the underground cable is installed in urban areas where achieving an overhead route is not feasible. Examples of other situations where underground cables have been installed, in preference to overhead lines, include crossing rivers, passing close to or through parts of nationally designated landscape areas and preserving important views.

1.3.2 Underground cable systems are made up of two main components – the cable and connectors. Connectors can be cable joints, which connect a cable to another cable, or overhead line connectors in a substation.

1.3.3 Cables consist of an electrical conductor in the centre, which is usually copper or aluminium, surrounded by insulating material and sheaths of protective metal and plastic. The insulating material ensures that although the conductor is operating at a high voltage, the outside of the cable is at zero volts (and therefore safe). Figure C.4 shows a cross section of a transmission cable and a joint that is used to connect two underground cables.

Figure C.4 – Cable Cross-Section and Joint

1.3.4 Underground cables can be connected to above-ground electrical equipment at a substation, enclosed within a fenced compound. The connection point is referred to as a cable sealing end. Figure C.5 shows two examples of cable sealing end compounds.

Figure C.5 – Cable Sealing End Compounds

1.3.5 An electrical characteristic of a cable system is capacitance between the conductor and earth. Capacitance causes a continuous ‘charging current’ to flow, the magnitude of which is dependent on the length of the cable circuit (the longer the cable, the greater the charging current) and the operating voltage (the higher the voltage the greater the current). Charging currents have the effect of reducing the power transfer through the cable.

1.3.6 High cable capacitance also has the effect of increasing the voltage along the length of the circuit, reaching a peak at the remote end of the cable.

1.3.7 National Grid can reduce cable capacitance problems by connecting reactive compensation equipment to the cable, either at the ends of the cable, or, in the case of longer cables, at regular intervals along the route. Specific operational arrangements and switching facilities at points along the cable circuit may also be needed to manage charging currents.

1.3.8 Identifying faults in underground cable circuits often requires multiple excavations to locate the fault and some repairs require removal and installation of new cables, which can take a number of weeks to complete.

1.3.9 High voltage underground cables must be regularly taken out of service for maintenance and inspection and, should any faults be found and depending on whether cable excavation is required, emergency restoration for security of supply reasons typically takes a lot longer than for overhead lines (days rather than hours).

1.3.10 The installation of underground cables requires significant civil engineering works. These make the construction times for cables longer than overhead lines.

1.3.11 The construction swathe required for two AC circuits comprising two cables per phase will be between 35-50 m wide.

1.3.12 Each of the two main components that make up an underground cable system has a design life of between 40 and 50 years.

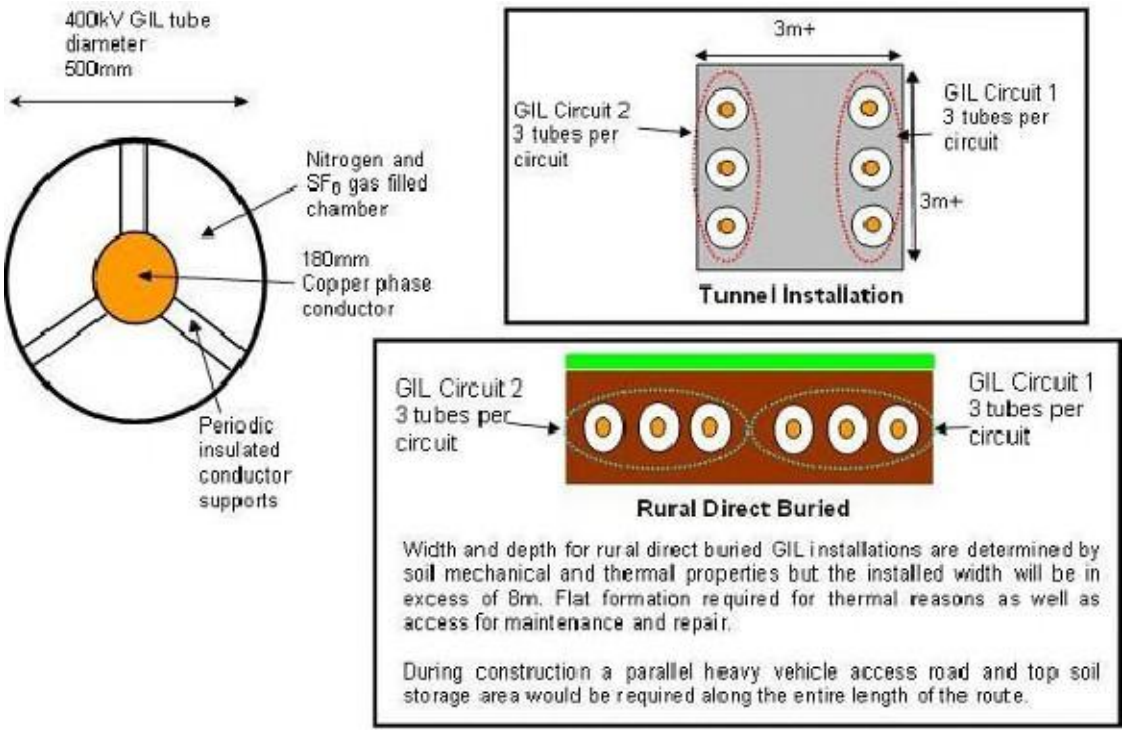
1.3.13 Asset replacement is generally expected at the end of design life. However, National Grid's asset replacement decisions (that are made at the end of design life) will also take account of actual asset condition and may lead to actual life being longer than the design life.

1.4 Gas Insulated Lines ("GIL")

1.4.1 GIL is an alternative to underground cable for high voltage transmission. GIL has been developed from the well-established technology of gas-insulated switchgear, which has been installed on the transmission system since the 1960s.

1.4.2 GIL uses a mixture of nitrogen and sulphur hexafluoride (SF6) gas to provide the electrical insulation. GIL is constructed from welded or flanged metal tubes with an aluminium conductor in the centre. Three tubes are required per circuit, one tube for each phase. Six tubes are therefore required for two circuits, as illustrated in Figure C.6 below.

Figure C.6 – Key Components of GIL



1.4.3 GIL tubes are brought to site in 10 – 20 m lengths and they are joined in situ. It is important that no impurities enter the tubes during construction as impurities can cause the gas insulation to fail. GIL installation methods are therefore more onerous than those used in, for example, natural gas pipeline installations.

1.4.4 A major advantage of GIL compared to underground cable is that it does not require reactive compensation.

1.4.5 The installation widths over the land can also be narrower than cable installations, especially where more than one cable per phase is required.

1.4.6 GIL can have a reliability advantage over cable in that it can be re-energised immediately after a fault (similar to overhead lines) whereas a cable requires investigations prior to re-energisation. If the fault was a transient fault, it will remain energised and if the fault was permanent the circuit will automatically and safely de-energise again.

1.4.7 There are environmental concerns with GIL as the SF_6[35] gas used in the insulating gas mixture is a potent 'greenhouse gas'. Since SF6 is an essential part of the gas mixture GIL installations are designed to ensure that the risk of gas leakage is minimised.

1.4.8 There are a number of ways in which the risk of gas leakage from GIL can be managed, which include:

- use of high-integrity welded joints to connect sections of tube;
- designing the GIL tube to withstand an internal fault; and

[35] SF_6 is a greenhouse gas with a global warming potential, according to the Intergovernmental Panel on Climate Change, Working Group 1 (Climate Change 2007, Chapter 2.10.2), of 22,800 times that of CO2. www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

- splitting each GIL tube into a number of smaller, discrete gas zones that can be independently monitored and controlled.

1.4.9 At decommissioning the SF_6 can be separated out from the gas mixture and either recycled or disposed of without any environmental damage.

1.4.10 GIL is a relatively new technology and therefore has limited historical data, meaning that its operational performance has not been empirically proven. National Grid has two GIL installations on the transmission system which are 545 m and 150 m long[36]. These are both in electricity substations; one is above ground and the other is in a trough. The longest directly buried transmission voltage GIL in the world is approximately one kilometre long and was recently installed on the German transmission system around Frankfurt Airport.

1.4.11 In the absence of proven design life information, and to promote consistency with assessment of other technology options, National Grid assesses GIL over a design life of up to 40 years.

1.5 High Voltage Direct Current ("HVDC")

1.5.1 HVDC technology can provide efficient solutions for the bulk transmission of electricity between AC electricity systems (or between points on an electricity system).

1.5.2 There are circumstances where HVDC has advantages over AC, generally where transmission takes place over very long distances or between different, electrically-separate systems, such as between Great Britain and countries in Europe such as France, Belgium, The Netherlands, Ireland etc…

1.5.3 HVDC links may also be used to connect a generating station that is distant from the rest of the electricity system. For example, very remote hydro-electric schemes in China are connected by HVDC technology with overhead lines.

1.5.4 Proposed offshore wind farms to be located over 60 km from the coast of Great Britain are likely to be connected using HVDC technology as an alternative to an AC subsea cable. This is because AC subsea cables over 60 km long have a number of technical limitations, such as high charging currents and the need for mid-point compensation equipment.

1.5.5 The connection point between AC and DC electrical systems has equipment that can convert AC to DC (and vice versa), known as a converter. The DC electricity is transmitted at high voltage between converter stations. Convertor stations can use two types of technology. "Classic" or Current Source Convertors (CSC) were the first type of HVDC technology developed and this design was used for National Grid's Western Link. Voltage Source Convertors (VSC) are a newer design and offer advantages over the previous CSC convertors, as they can better support weaker systems and offer more flexibility in the way they operate, including direction of power flow.

[36] The distances are based on initial manufacturer estimates of tunnel and buried GIL dimensions which would be subject to full technical appraisal by National Grid and manufacturers to achieve required ratings which may increase the separation required. It should be noted that the diagram does not show the swathe of land required during construction. Any GIL tunnel installations would have to meet the detailed design requirements of National Grid for such installations.

Figure C.7 – VSC converter Station

1.5.6 HVDC can offer advantages over AC underground cable, such as:

- a minimum of two cables per circuit is required for HVDC whereas a minimum of three cables per circuit is required for AC.
- reactive compensation mid-route is not required for HVDC.
- cables with smaller cross sectional areas can be used (compared to equivalent AC system rating).
- This allows HVDC cables to be more easily installed for subsea applications than AC cables for a given capacity.

1.5.7 HVDC cables are generally based upon two technology types Mass Impregnated and Extruded technologies. VSC technology may utilise either technology type, whereas CSC technology tends to be limited to Mass Impregnated cables due to the way poles are reversed for change of power flow direction.

Figure C.8 – HVDC Cable Laying Barge at transition between shore and sea cables

1.5.8 HVDC systems have a design life of about 40 years. This design life period is on the basis that large parts of the converter stations (valves and control systems) would be replaced after 20 years.

Appendix D Economic Appraisal

1.1 Introduction

1.1.1 As part of the economic appraisal of Strategic Options, National Grid makes comparative assessments of the lifetime costs associated with each technology option that is considered to be feasible.

1.1.2 This section provides an overview of the methods that National Grid uses to estimate lifetime costs as part of the economic appraisal of a Strategic Option. It also provides a summary of generic capital cost information for transmission system circuits for each technology option included in Appendix C and an overview of the method that National Grid uses to assess the Net Present Value ("NPV") of costs that are expected to be incurred during the lifetime of new transmission assets.

1.1.3 The Institution of Engineering and Technology (IET) produced a report "A Comparison of Electricity Transmission Technologies" in 2025[37]. This IET report, presents cost information in size of transmission circuit capacity categories for each circuit design that was considered as part of the independent study in a 2023 cost base. To aid comparison between the cost data presented in the IET Report and that used by National Grid for appraisal of Strategic Options, this appendix includes cost estimates using National Grid cost data for circuit designs that are equivalent to those considered as part of the independent study. Examples in this Appendix are presented using the category size labels of "Low", "Medium" and "High" used in the IET Report.

1.2 Financial Year 2025/26 RIIO-T3 Update

1.2.1 National Grid is about to start a new regulatory transmission funding period known as RIIO-T3, The Office of Gas and Electricity Markets (OFGEM) set these periods to review the funding for the next 5 years from April 1st, 2026, to March 31st, 2031. As part of this period National Grid submits an updated business plan that provides updated cost information. As part of Our Strategic Options process, we revise our comparative cost information at the start of each period.

1.2.2 The following section explains all the changes that have occurred to transmission costs since our previous cost base 2020/21 used in our previous Strategic Options Reports and their Updates. And provides a transparent mechanism to explain how cost have changed over the period and how numbers can be translated between 2020/21 base to a 2025/26 historical base cost.

1.2.3 Table D.1 below shows the inflation rate applied across financial years to National Grid Cost Base, as provided in our RIIO-T3 submission to Ofgem. This inflation table is used to inflate costs form our previous 2020/21 cost base to the new RIIO-T3 period cost base of 2025/26.

[37] https://www.theiet.org/media/axwkktkb/100110238_001-rev-j-electricity-transmission-costs-and-characteristics_final-full.pdf

Table D.1 – Inflation Adjustment Between 2020/21 cost base and 2025/26 cost base

Annual Financial Year Inflation Rate from previous Base 2020/21 cost to new 2025/26 Base Cost						
2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	**New Base Overall Increase**
Previous Base	4.47%	8.77%	5.55%	3.29%	3.41%	**28.11%**

1.2.4 In addition to the general inflation set out in Table D.1 above there have also been technology-based increases above the rate of inflation that have occurred over the period. Table D.2 provides a technology-based overview of overall percentage cost increases seen between 2020/21 and 2025/26.

Table D.2 – Overall Above Inflation Percentage Increase by technology between 2020/21 cost base and 2025/26 cost base

Technology Type	Above Inflation Increase (%)
Overhead line	6%
Underground Cable	8%
Gas Insulated Line (GIL)	25%
Cable Mid-Point Switching Stations	15%
Reactors	25%
Interbus Super Grid Transformers (SGT) (400/275 kV)	25%
HVDC Convertors	35%
HVDC Cables	35%

1.2.5 The increases in the above technologies are due to many factors, including above inflation rises in materials and commodity costs; higher labour costs; limited manufacturing capacity and high demand; higher energy costs. Material and Energy intensive technologies have seen the highest rises. Whilst High Voltage Direct Current (HVDC) technologies, which are material intensive, have also seen high market demand which has caused increased costs with lots of worldwide projects competing for limited manufacturing capacity.

1.2.6 As part of our update, we have also undertaken development work of a number of major HVDC projects over the past 5 years including the EGL 1 and 2 projects. Detailed development of these projects and subsequent tender processes has identified clearly the costs between subsea HVDC cable installation and on-shore HVDC cable installation. Table D.3 below shows the cost increase to install cables on-shore compared to the offshore base cost.

Table D.3 – HVDC Cable Percentage Cost increase for On-shore Installation

Subsea HVDC cable Installation	On-shore HVDC Cable Installation increase (%)
Base	60%

1.2.7 On-shore installation costs are 60% higher due to the increased costs involved installing cables on-shore. Subsea cables are installed using ocean going vessels caring circa 100 km of HVDC cable per campaign. On-shore cables have to be delivered by road in lengths of circa 1 km due to the weight and size of the cable drums. They require more groundworks and more jointing of the sorter cable sections. Along with management road, rail and river crossings often requiring more expensive installation techniques such as directional drilling. All of these factors led to the observed on-shore installation costs 60% higher than subsea being seen as part of our fully developed projects.

1.3 Lifetime Costs for Transmission

1.3.1 For each technology option appraised within a Strategic Option, National Grid estimates total lifetime costs for the new transmission assets. The total lifetime cost estimate consists of the sum of the estimates of the:

- initial capital cost of developing, procuring, installing and commissioning the new transmission assets, and
- net present value ("NPV") of costs that are expected to be incurred during the lifetime of these new transmission assets

1.4 Capital Cost Estimates

1.4.1 At the initial appraisal stage, National Grid prepares indicative estimates of the capital costs. These indicative estimates are based on the high-level scope of works defined for each Strategic Option in respect of each technology option that is considered to be feasible. As these estimates are prepared before detailed design work has been carried out, National Grid takes account of equivalent assumptions for each option. Final project costs for any solution taken forward following detailed design and risk mitigation will be in excess of any high-level appraisal cost. However, all options would incur these increases in the development of a detailed solution.

1.4.2 This section considers the capital costs in two parts, firstly the AC technology costs are discussed, followed by HVDC technologies. Each of these technologies is described in Appendix C in more detail.

1.5 AC Technology Capital Cost Estimates

1.5.1 Table D.4 shows the category sizes that are relevant for AC technology circuit designs:

Table D.4 – AC Technology Circuit Designs

Category	Design	Rating
Low	Two AC circuits of 1,595 MVA	3,190 MVA
Medium	Two AC circuits of 3,190 MVA	6,380 MVA
High	Two AC circuits of 3,465 MVA	6,930 MVA

1.5.2 Table D.5 provides a summary of technology configuration and capital cost information (in financial year 2025/26 prices) for each of the AC technology options that National Grid considers as part of an appraisal of Strategic Options.

Table D.5 – AC Technology Configuration and National Grid Capital Costs by Rating

IET, PB/CCI Report short-form label	Circuit Ratings by Voltage		Technology Configuration			Capital Costs		
	275 kV AC Technologies	400 kV AC Technologies	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)
	Total rating for two Circuits (2 x rating of each circuit)	Total rating for two Circuits (2 x rating of each circuit)	No. of Conductors Sets "bundles" on each arm/circuit of a pylon	No. of Cables per phase	No of direct buried GIL tubes per phase	Cost for a "double" two circuit pylon route (Cost per circuit, of a double circuit pylon route)	Cost for a two circuit AC cable route (Cost per circuit, of a two circuit AC cable route)	Cost for a two circuit GIL route (Cost per circuit, of a two circuit GIL route)
Lo	3190MVA (2 x 1595MVA) [2000MVA 2 x 1000MVA for AC Cable only]	3190MVA (2 x 1595MVA)	2 conductor sets per circuit (6 conductors per circuit)	1 Cable per Phase (3 cables per circuit)	1 tube per phase (3 standard GIL tubes per circuit)	£4.51m/km (£2.25m/km)	£22.61m/km (£11.30m/km)	£42.95m/km (£21.47m/km)
Med	N/A	6380MVA (2 x 3190MVA)	2 conductor sets per circuit (6 conductors per circuit)	2 Cables per Phase (6 cables per circuit)	1 tube per phase (3 "developing" new large GIL tubes per circuit)	£4.94m/km (£2.47m/km)	£39.18m/km (£19.59m/km)	£49.83m/km (£24.92m/km)
Hi	N/A	6930MVA (2 x 3465MVA)	3 conductor sets per circuit (9 conductors per circuit)	3 Cables per Phase (9 cables per circuit)	2 tubes per phase (6 standard GIL tubes per circuit)	£5.40m/km (£2.70m/km)	£55.20m/km (£27.60m/km)	£69.27m/km (£34.64m/km)

Notes: -

1. Capital Costs for all technologies are based upon rural/arable land installation with no major obstacles (examples of major obstacles would be Roads, Rivers, Railways etc…)
2. All underground AC Cable and GIL technology costs are for direct buried installations only. AC cable and GIL Tunnel installations would have a higher capital installation cost than direct buried rural installations. However, AC cable or GIL replacement costs following the end of conductor life would benefit from re-use of the tunnel infrastructure.
3. AC cable installation costs exclude the cost of reactors and mid point switching stations, which are described later in this appendix.
4. 275 kV circuits will often require Super-Grid Transformers (SGT) to allow connection into the 400 kV system, SGT capital costs are not included above but described later in this appendix.
5. 275 kV AC cable installations above 1000 MVA, as indicated in the table above, would require 2 cables per phase to be installed to achieve ratings of 1595 MVA per circuit at 275 kV.

1.5.3 Table D.5 provides a summary of the capital costs associated with the key[38] components of transmission circuits for each technology option. Additional equipment is required for technology configurations that include new:

- AC underground cable circuits
- Connections between 400 kV and 275 kV parts of the National Grid's transmission system.

1.5.4 The following sections provide an overview of the additional requirements associated with each of these technology options and indicative capital costs of additional equipment.

1.6 AC Underground Cable additional equipment

1.6.1 Appendix C of this Report provides a summary of the electrical characteristics of AC underground cable systems and explains that reactive gain occurs on AC underground cables.

1.6.2 Table D.6 provides a summary of the typical reactive gain within AC underground cable circuits forming part of the National Grid's transmission system.

Table D.6 – Reactive Gain Within AC underground cable circuits

Category	Voltage	Design	Reactive Gain per circuit
Lo	275 kV	One 2500 mm^2 cable per phase	5 Mvar/km
Med	275 kV	Two 2500 mm^2 cable per phase	10 Mvar/km
Lo	400 kV	One 2500 mm^2 cable per phase	10 Mvar/km
Med	400 kV	Two 2500 mm^2 cable per phase	20 Mvar/km
Hi	400 kV	Three 2500 mm^2 cable per phase	30 Mvar/km

1.6.3 National Grid is required to ensure that reactive gain on any circuit that forms part of its transmission system does not exceed 225 Mvar. Above this limit, reactive gain would lead to unacceptable voltages (voltage requirements as defined in the NETS SQSS). In order to manage reactive gain and therefore voltages, reactors are installed on AC underground cable circuits to ensure that reactive gain in total is less than 225 Mvar.

1.6.4 For example a 50 km "Med" double circuit would have an overall reactive gain of 1000 Mvar per circuit (2000 Mvar in total for two circuits). The standard shunt reactor size installed at 400 kV on the National Grid transmission system is 200 Mvar. Therefore four 200 Mvar reactors (800 Mvar) need to be installed on each circuit or eight 200 Mvar

[38] Components that are not required for all technology options are presented separately in this Appendix.

reactors (1600 Mvar) reactors for the two circuits. Each of these reactors cost £8.7m adding £69.6m to an overall cable cost for the example double circuit above.

1.6.5 Mid point switching stations may be required as part of a design to meet the reactive compensation requirements for AC underground cable circuit. The need for switching stations is dependent upon cable design, location and requirements which cannot be fully defined without detailed design.

1.6.6 For the purposes of economic appraisal of Strategic Options, National Grid includes a cost allowance that reflects typical requirements for switching stations. These allowances shown in Table D.7 are:

Table D.7 – Switching Station Requirements for Reactive Gain Within AC underground cable circuits

Category	Switching Station Requirement
Lo	Reactive Switching Station every 60 km between substations
Med	Reactive Switching Station every 30 km between substations
Hi	Reactive Switching Station every 20 km between substations

1.6.7 It is noted that more detailed design of AC underground cable systems may require a switching station after a shorter or longer distance than the typical values used by National Grid at the initial appraisal stage.

1.6.8 Table D.8 below shows the capital cost associated with AC underground cable additional equipment.

Table D.8 – Additional costs associated with AC underground cables

Category	Cost per mid point switching station	Cost per 200 Mvar reactor
Lo	£22.2m	£13.9m per reactor
Med	£27.2m	
Hi	£27.2m	

1.7 Connections between AC 275 kV and 400 kV circuits additional equipment

1.7.1 Equipment that transform voltages between 275 kV and 400 kV (a 400/275 kV supergrid transformer or “SGT”) is required for any new 275 kV circuit that connects to a 400 kV part of the National Grid’s transmission system (and vice versa). The number of supergrid transformers needed is dependent on the capacity of the new circuit. National Grid can estimate the number of SGTs required as part of an indicative scope of works that is used for the initial appraisal of Strategic Options.

1.7.2 Table D.9 below shows the capital cost associated with the SGT requirements.

Table D.9 – Additional costs associated with 275 kV circuits requiring connection to the 400 kV system

275 kV Equipment	Capital Cost (SGT - including civil engineering work)
400/275 kV SGT 1100MVA (excluding switchgear)	£9.93m per SGT

1.8 High Voltage Direct Current ("HVDC") Capital Cost Estimates

1.8.1 Conventional HVDC technology sizes are not easily translated into the "Lo", "Med" and "Hi" ratings suggested in the IET, PB/CCI report. Whilst National Grid information for HVDC is presented for each of these categories, there are differences in the circuit capacity levels. As part of an initial appraisal, National Grid's assessment is based on a standard 2GW converter size. Higher ratings are achievable using multiple circuits.

1.8.2 The capital costs of HVDC installations can be much higher than for equivalent AC overhead line transmission routes. Each individual HVDC link, between each converter station, requires its own dedicated set of HVDC cables. HVDC may be more economic than equivalent AC overhead lines where the route length is many hundreds of kilometres.

1.8.3 Table D.10 provides a summary of technology configuration and capital cost information (in financial year 2020/21 prices) for each of the HVDC technology options that National Grid considers as part of an appraisal of Strategic Options.

Table D.10 - HVDC Technology Capital Costs for 2GW installations

HVDC Converter Type	2 GW Total HVDC Link Converter Costs (Converter Cost at Each End)	2GW DC Cable Pair Cost (Offshore Installation)	2GW DC Cable Pair Cost (Onshore installation)
Current Source Technology or "Classic" HVDC	£821.5m HVDC link cost (£410.7m at each end)	£5.34m/km	£8.55m/km
Voltage Source Technology HVDC	£924.2m HVDC link cost (£462.1m at each end)	£5.34m/km	£8.55m/km

Notes:

- Sometimes a different HVDC capacity (different from the required AC capacity) can be utilised for a project due to the different way HVDC technology can control power flow. The capacity requirements for HVDC circuits will be specified in any option considering HVDC. The cost shall be based upon Table D.10 above.
- Where a single HVDC Link is proposed as an option, to maintain compliance with the NETS SQSS, there may be a requirement to install an additional "Earth Return"

DC cable. For example a 2GW Link must be capable of operating at ½ its capacity i.e. 1GW during maintenance or following a cable fault. To allow this operation the additional cable known as an “Earth Return” must be installed, this increases cable costs by a further 50%.

- Capital Costs for HVDC cable installations are based upon large vessel subsea installation for offshore and for onshore installation rural/arable land installation with average expected obstacles (examples of major obstacles would be Subsea Pipelines, Roads, Rivers, Railways etc…)

1.9 Indication of Technology end of design life replacement impact

1.9.1 It is unusual for a part of National Grid’s transmission system to be decommissioned and the site reinstated. In general, assets will be replaced towards the end of the assets design life. Typically, transmission assets will be decommissioned and removed only as part of an upgrade or replacement by different assets.

1.9.2 National Grid does not take account of replacement costs in the lifetime cost assessment.

1.9.3 National Grid’s asset replacement decisions take account of actual asset condition. This may lead to actual life of any technology being longer or shorter than the design life, depending on the environment it is installed in, lifetime loading, equipment family failures among other factors for example.

1.9.4 The following provides a high level summary of common replacement requirements applicable to specific technology options:

- OHL - Based on the design life of component parts, National Grid assumes an initial design life of around 40 years for overhead line circuits. After the initial 40 year life of an overhead line circuit, substantial pylon replacement works would not normally be required. The cost of Pylons is reflected in the initial indicative capital costs, but the cost of replacement at 40 years would not include the pylon cost. As pylons have an 80 year life and can be re-used to carry new replacement conductors. The replacement costs for overhead line circuits at the end of their initial design life are assessed by National Grid as being around 50% of the initial capital cost, through the re-use of pylons.
- AC underground Cable - At the end of their initial design life, circa 40 years, replacement costs for underground cables are estimated to be equal or potentially slightly greater than the initial capital cost. This is because of works being required to excavate and remove old cables prior to installing new cables in their place in some instances.
- GIL - At the end of the initial design life, circa 40 years, estimated replacement costs for underground GIL would be equal to or potentially greater than the initial capital cost. This is because of works being required to excavate and remove GIL prior to installing new GIL in their place in some instances.
- HVDC - It should be noted at the end of the initial design life, circa 40 years, replacement costs for HVDC are significant. This due to the large capital costs for the replacement of converter stations and the cost of replacing underground or subsea DC cables when required.

1.10 Net Present Value Cost Estimates

1.10.1 At the initial appraisal stage, National Grid prepares estimates of the costs that are expected to be incurred during the design lifetime of the new assets. National Grid considers costs associated with:

- Operation and maintenance
- Electrical losses

1.10.2 For both categories, Net Present Value ("NPV") calculations are carried out using annual cost estimates and a generic percentage discount rate over the design life period associated with the technology option being considered.

1.10.3 The design life for all technology equipment is outlined in the technology description in Appendix C. The majority of expected design lives are of the order of 40 years, which is used to assess the following NPV cost estimates below.

1.10.4 In general discount rates used in NPV calculations would be expected to reflect the normal rate of return for the investor. National Grid's current rate of return is 6.25%. However, the Treasury Green Book recommends a rate of 3.5% for the reasons set out below[39]

"Discounting in the public sector allows costs and benefits with different time spans to be compared on a common "present value" basis."

1.10.5 National Grid considered the impact of using the lower Rate of Return (used by UK Government) on lifetime cost of losses assessments for transmission system investment proposals. Using the rate of 3.5% will discount loss costs, at a lower rate than that of 6.25%. This has the overall effect of increasing the 40 year cost of losses giving a more onerous cost of losses for higher loss technologies.

1.10.6 For the appraisal of Strategic Options, National Grid recognises the value of closer alignment of its NPV calculations with the approach set out by government for critical infrastructure projects and aligns with this element but also notes that the totality of the Green Book applies only to public and government bodies.

1.11 Annual Operations and Maintenance Cost

1.11.1 The maintenance costs associated with each technology vary significantly depending upon type. Some electrical equipment is maintained regularly to ensure system performance is maintained. More complex equipment like HVDC converters have a significantly higher cost associated with them, due to their high maintenance requirements for replacement parts. Table D.11 shows the cost of maintenance for each technology, which unlike capital and losses is not dependent on capacity.

[39] The Green Book (2022) sets the government discount rate of 3.5% page 116 https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government

Table D.11 – Annual maintenance costs by Technology

	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	High Voltage Direct Current (HVDC)
Circuit Annual maintenance cost per two circuit km (AC) (Annual cost per circuit Km [AC])	£3,408/km (£1,704/km)	£7,174/km (£3,587/km)	£3,433/km (£1,717/km)	£172/km HVDC Cables
Associated equipment Annual Maintenance cost per item	N/A	£8,583 per reactor £52,525 per switching station	N/A	£1,665,418 per convertor station
Additional costs for 275 kV circuits requiring connection to the 400 kV system				
275/400 kV SGT 1100 MVA Annual maintenance cost per SGT	£8,608 per SGT			N/A

1.12 Annual Electrical Losses and Cost

1.12.1 At a system level annual losses on the National Grid electricity system equate to less than 2% of energy transported. This means that over 98% of the energy entering the transmission system from generators/interconnectors reaches the bulk demand substations where the energy transitions to the distribution system. Electricity transmission voltages are used to reduce losses, as more power can be transported with lower currents at transmission level, giving rise to the very efficient loss level achieved of less than 2%. The calculations below are used to show how this translates to a transmission route.

1.12.2 Transmission losses occur in all electrical equipment and are related to the operation and design of the equipment. The main losses within a transmission system come from heating losses associated with the resistance of the electrical circuits, often referred to as I2R losses (the electrical current flowing through the circuit, squared, multiplied by the resistance). As the load (the amount of power each circuit is carrying) increases, the current in the circuit is larger.

1.12.3 The average load of a transmission circuit which is incorporated into the transmission system is estimated to be 34% (known as a circuit average utilisation). This figure is calculated from the analysis of the load on each circuit forming part of National Grid's transmission system over the course of a year. This takes account of varying generation and demand conditions and is an appropriate assumption for the majority of Strategic Options.

1.12.4 This level of circuit utilisation is required because if a fault occurs there needs to be an alternative route to carry power to prevent wide scale loss of electricity for homes, business, towns and cities. Such events would represent a very small part of a circuit's 40 year life, but this availability of alternative routes is an essential requirement at all times to provide secure electricity supplies to the nation.

1.12.5 In all AC technologies the power losses are calculated directly from the electrical resistance and impedance properties of each technology and associated equipment. Table D.12 provides a summary of circuit resistance data for each AC technology and capacity options considered in this Report.

Table D.12 – AC circuit technologies and associated resistance per circuit

IET, PB/CCI Report short-form label	AC Overhead Line Conductor Type (complete single circuit resistance for conductor set)	AC Underground Cable Type (complete single circuit resistance for conductor set)	AC Gas Insulated Line (GIL) Type (complete single circuit resistance for conductor set)
Lo	2 x 570 mm^2 (0.025 Ω/km)	1 x 2500 mm^2 (0.013 Ω/km*)	Single Tube per phase (0.0086 Ω/km)
Med	2 x 850 mm^2 (0.0184 Ω/km)	2 x 2500 mm^2 (0.0065 Ω/km*)	Single Tube per phase (0.0086 Ω/km)
Hi	3 x 700 mm^2 (0.014 Ω/km)	3 x 2500 mm^2 (0.0043 Ω/km*)	Two tubes per phase (0.0065 Ω/km)
Losses per 200 Mvar Reactor required for AC underground cables			
Reactor Losses	N/A	0.4 MW per reactor	N/A
Additional losses for 275 kV circuits requiring connection to the 400 kV system			
275 kV options only 275/400 kV SGT losses	0.2576 Ω (plus 83 kW of iron losses) per SGT	0.2576 Ω (plus 83 kW of iron losses) per SGT	0.2576 Ω (plus 83 kW of iron losses) per SGT

1.12.6 The process of converting AC power to DC is not 100% efficient. Power losses occur in all elements of the converter station: the valves, transformers, reactive compensation/filtering and auxiliary plant. Manufacturers typically represent these losses in the form of an overall percentage. Table D.13 below shows the typical percentage losses encountered in the conversion process, ignoring losses in the DC cable circuits themselves.

Table D.13 – HVDC circuit technologies and associated resistance per circuit

HVDC Converter Type	2 GW Converter Station losses	2GW DC Cable Pair Losses	2GW Total Link loss
Current Source (CSC) Technology or "Classic" HVDC	0.5% per converter	Ignored	1% per HVDC Link
Voltage Source (VSC) Technology HVDC	1.0% per converter	Ignored	2% per HVDC Link

1.12.7 The example calculation explained in detail below is for "Med" category circuits and has been selected to demonstrate the principles of the mathematics set out in this section. This example does not describe specific options set out within this report. A detailed example explanation of the calculations used to calculate AC losses is included in Appendix E.

1.12.8 The circuit category, for options contained within this report, is set out within each option. The example below demonstrates the mathematics and principles, which is equally applicable to "Lo", "Med" and "Hi" category circuits, over any distance.

1.12.9 The example calculations (using calculation methodology described in Appendix E) of instantaneous losses for each technology option for an example circuit of 40 km "Med" capacity 6380 MVA (two x 3190 MVA).

- Overhead Lines = (2 x 3) x 1565.5 A2 x (40 x 0.0184 Ω/km) = 10.8 MW
- Underground Cable = (2 x 3) x1565.5 A^2 x (40 x 0.0065 Ω/km) + (6 x 0.4 MW) = 6.2 MW
- Gas Insulated Lines = (2 x 3) x 1565.5 A2 x (40 x 0.0086 Ω/km) = 5.1 MW
- CSC HVDC = 34% x 6380 MW x 1% = 21.7 MW
- VSC HVDC = 34% x 6380 MW x 2% = 43.4 MW

1.12.10 An annual loss figure can be calculated from the instantaneous loss. National Grid multiplies the instantaneous loss figure by the number of hours in a year and also by the cost of energy. National Grid uses £60/MWhr.

1.12.11 The following is a summary of National Grid's example calculations of Annual Losses and Maintenance costs for each technology option for an example circuit of 40 km "Med" capacity 6380 MVA (two x 3190 MVA).

- Overhead Line annual loss = 10.8 MW x 24 x 365 x £60/MWhr = £5.7m.
- Underground Cable annual loss = 6.2 MW x 24 x 365 x £60/MWhr = £3.3m.
- Gas Insulated lines annual loss = 5.1 MW x 24 x 365 x £60/MWhr = £2.7m
- CSC HVDC annual loss = 21.7 MW x 24 x 365 x £60/MWhr = £11.4m
- VSC HVDC annual loss = 43.4 MW x 24 x 365 x £60/MWhr = £22.8m

1.13 Example Lifetime costs and NPV Cost Estimate

1.13.1 The annual Operation, Maintenance and loss information is assessed against the NPV model at 3.5% over 40 years and added to the capital costs to provide a lifetime cost for each technology.

1.13.2 Table D.14 shows an example for a “Medum” capacity route 6380 MVA (2 x 3190 MVA) 400 kV, 40 km in length on-shore over 40 years.

Table D.14 – Example Lifetime Cost table (rounded to the nearest £m)

Example 400 kV “Med” Capacity over 40km	Overhead Line (OHL)	AC Underground Cable (AC Cable)	Gas Insulated Line (GIL)	CSC High Voltage Direct Current (HVDC)	VSC High Voltage Direct Current (HVDC)
Capital Cost	£197.6m	£1,622.8m	£1,993.6m	£3,491.3m	£3,797.3m
NPV Loss Cost over 40 years at 3.5% discount rate	£125.0m	£62.6m	£58.4m	£235.6m	£471.2m
NPV Maintenance Cost over 40 years at 3.5% discount rate	£2.99m	£7.07m	£3.02m	£220.02m	£220.02m
Lifetime Cost	£326m	£1,692m	£2,055m	£3,947m	£4,489m

Appendix E Mathematical Principles used for AC Loss Calculation

1.1 Introduction

1.1.1 This Appendix provides a detailed description of the mathematical formulae and principles that NGET applies when calculating transmission system losses. The calculations use recognised mathematical equations which can be found in power system analysis textbooks.

1.1.2 The example calculation explained in detail below is for “Med” category circuits and has been selected to demonstrate the principles of the mathematics set out in this section. This example does not describe specific options set out within this report.

1.1.3 The circuit category, for options contained within this report, is set out within each option. The example below demonstrates the mathematics and principles, which is equally applicable to “Lo”, “Med” and “Hi” category circuits, over any distance.

1.2 Example Loss Calculation (1) – 40 km 400 kV “Med” Category Circuits

1.2.1 The following is an example loss calculation for a 40 km 400 kV “Med” category (capacity of 6,380 MVA made up of two 3,190 MVA circuits).

1.2.2 Firstly, the current flowing in each of the two circuits is calculated from the three-phase power equation of $P= \sqrt{3}V_{LL}I_{LL} \cos \theta$. Assuming a unity power factor ($\cos \theta= 1$), the current in each circuit can be calculated using a rearranged form of the three-phase power equation of:

(In a star (Y) configuration electrical system $I = I_{LL} = I_{LN}$)

$I = P/\sqrt{3}V_{LL}$

Where, P is the circuit utilisation power, which is 34% of circuit rating as set out in Appendix D, which for the each of the two circuits in the “Med” category example is calculated as:

P = 34% x 3190 MVA = 1,084.6 MVA

and, V_{LL} is the line-to-line voltage which for this example is 400 kV.

For this example, the average current flowing in each of the two circuits is:

$I = 1,084.6 \times 106/(\sqrt{3} \times 400 \times 103) = 1,565.5$ Amps

1.2.3 The current calculated above will flow in each of the phases of the three-phase circuit. Therefore, from this value it is possible to calculate the instantaneous loss which occurs at the 34% utilisation loading factor against circuit rating for any AC technology.

1.2.4 For this “Med” category example, the total resistance for each technology option is calculated (from information in Appendix D, Table D.10) as follows:

Overhead Line = 0.0184 Ω/km x 40 km = 0.736 Ω

Cable Circuit[40] = 0.0065 Ω/km x 40 km = 0.26 Ω

Gas Insulated Line = 0.0086 Ω/km x 40 km = 0.344 Ω

These circuit resistance values are the total resistance seen in each phase of that particular technology taking account the number of conductors needed for each technology option.

1.2.5 The following is a total instantaneous loss calculation for the underground cable technology option for the "Med" category example:

Losses per phase are calculated using $P=I^2R$

1,565.52 x 0.26 = 0.64 MW

Losses per circuit are calculated using $P=3I^2R$

3 x 1,565.52 x 0.26 = 1.91 MW

Losses for "Med" category are calculated by multiplying losses per circuit by number of circuits in the category.

2 x 1.91 MW = 3.8 MW

1.2.6 For underground cable circuits, three reactors per circuit are required (six in total for the two circuits in the "Med" category). Each of these reactors has a loss of 0.4 MW. The total instantaneous losses for this "Med" category example with the underground cable technology option are assessed as:

3.8 + (6 x 0.4) = 6.2 MW

1.2.7 The same methodology is applied for the other AC technology option types for the "Med" category example considered in this Appendix. The following is a summary of the instantaneous total losses that were assessed for each technology option:

Overhead Lines = (2 x 3) x 1,565.52 x 0.736 = 10.8 MW

Cables = (2 x 3) x 1,565.52 x 0.26 + (6 x 0.4) = 6.2 MW

Gas Insulated Lines = (2 x 3) x 1,565.52 x 0.344 = 5.1 MW

1.3 Example Loss Calculation (2) – 40 km 275 kV "Lo" Category Circuits Connecting to a 400 kV part of the NGET's transmission system

1.3.1 The following is an example loss calculation for a 40 km 275 kV "Lo" category (capacity of 3,190 MVA made up of two 1,595 MVA circuits) and includes details of how losses of the supergrid transformer ("SGT") connections to 400 kV circuits are assessed. This example assesses the losses associated with the GIL technology option up to a connection point to the 400 kV system.

[40] A 40 km three phase underground cable circuit will also require three reactors to ensure that reactive gain is managed within required limits.

1.3.2 The circuit utilisation power (P) which for the each of the two circuits in the “Lo” category example is calculated as:

$P = 34\% \times 1{,}595 = 542.3$ MVA

For this example, the average current flowing in each of the two circuits is:

$I = 542.3 \times 10^6 / (\sqrt{3} \times 275 \times 10^3) = 1{,}138.5$ Amps

1.3.3 For this “Lo” category example, the total resistance for the GIL technology option is calculated (from information in Appendix D, Table D.10) as follows:

$0.0086\ \Omega/km \times 40\ km = 0.344\ \Omega$

1.3.4 The following is a total instantaneous loss calculation for the GIL technology option for this “Lo” category example:

Losses per circuit are calculated using $P=3I^2R$

$3 \times 1138.5 \times 0.344 = 1.35$ MW

Losses for “Lo” category 275 kV circuits are calculated by multiplying losses per circuit by number of circuits in the category

2×1.35 MW $= 2.7$ MW

1.3.5 SGT losses also need to be included as part of the assessment for this “Lo” category example which includes connection to 400 kV circuits. SGT resistance[41] is calculated (from information in Appendix D, Table D.10) as 0.2576 Ω.

1.3.6 The following is a total instantaneous loss calculation for the SGT connection part of this “Lo” category example:

The average current flowing in each of the two SGT 400 kV winding are calculated as:

$I_{HV} = 542.3 \times 10^6 / (\sqrt{3} \times 400 \times 10^3) = 782.7$ Amps

Losses per SGT are calculated using $P=3I^2R$

SGT Loss $= 3 \times 782.7 \times 0.2576 = 0.475$ MW

Iron Losses in each SGT = 84kW

Total SGT instantaneous loss (one SGT per GIL circuit) = (2 x 0.475) + (2 x 0.084) = 1.1 MW.

1.3.7 For this example, the total “Lo” category loss is the sum of the calculated GIL and SGT total loss figures:

“Lo” category loss = 2.7 + 1.1 = 3.8 MW

[41] Resistance value referred to the 400 kV side of the transformer.

Appendix F Beyond 2030 Publication

1.1 Pathway to 2030 – HND

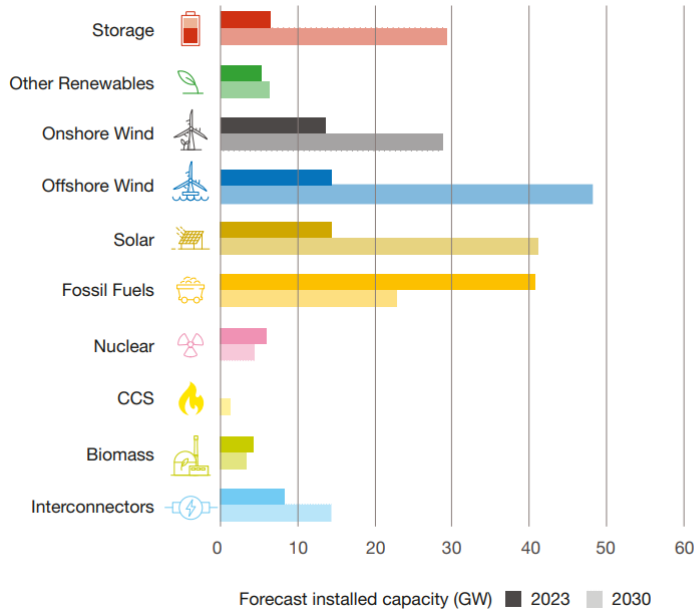
1.1.1 In 2023, 51% of the electricity in GB used was generated by zero-carbon sources. It is expected that by 2030, the electricity system will more commonly run on 100% renewable energy sources for measurable time frames, which will be vital to meet the UK Government's ambition of having an electricity mix consisting of 95% low-carbon power.

1.1.2 Adjacent to the changes in the electricity network, gas consumption has also been projected to fall by 40% by 2030, which will be realised through the potential to replace natural gas with hydrogen where possible, and the potential to create opportunities to make use of economically efficient and reliable electricity for heating and transport.

1.1.3 This transition can be facilitated through the development of large-scale offshore wind generation, a sector that has seen Great Britain arise as a world leader. Within offshore wind, refinement of the approach used can help reduce the effects of increased infrastructure needs to effectively transfer power across the transmission system. The UK government has, hence, established the Offshore Transmission Network Review (OTNR) with the goal of developing a holistic network design that will ensure the delivery of 50 GW of offshore wind by 2030 remains viable.

1.1.4 The bar chart below from the Beyond 2030 report shows the generation mix in 2023 in comparison to the forecasted mix in 2030.

Figure F.1 – Generation mix comparison (2023 and 2030) [source: Beyond 2030, ESO, March 2024]



1.1.5 The ESO's Pathway to 2030 Holistic Network Design (HND) 2022 plan to connect 23 GW of offshore wind in the transmission system seeks to reduce reliance on imports of gas and reduce CO2 emissions by up to two million tonnes between 2030 and 2032. To facilitate this growth in the offshore sector, a recommendation of over £60 billion of

investment into the transmission system has been made. This investment will comprise of offshore network design and 91 reinforcements to the transmission system, resulting in a holistic approach to network planning.

1.1.6 To enable this plan, engagement with the GB energy regulator, Ofgem, was required. It was concluded that a customer benefit of up to £2.1 billion would be expedited through avoidance of network congestion costs, which led Ofgem to agree on the regulatory acceleration of 26 projects in 2022.

1.1.7 The essential transmission opportunities to enable delivery of the plan in 2030 are presented in Figure F.2.

Figure F.2 – Network infrastructure to be delivered by 2030 [source: Beyond 2030, ESO, March 2024]

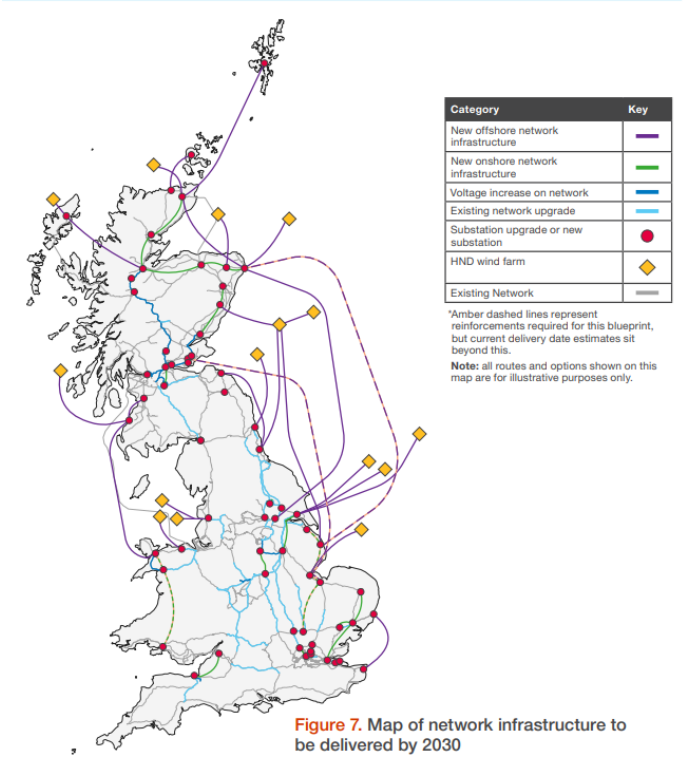


Figure 7. Map of network infrastructure to be delivered by 2030

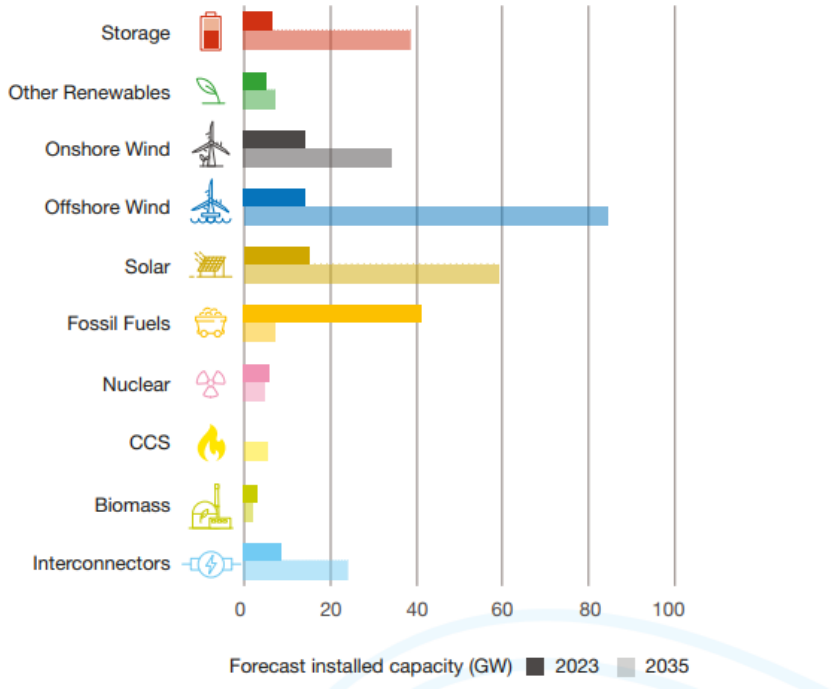
1.2 Beyond 2030 – HND FUE

1.2.1 Scoping beyond 2030, by 2035, several processes will be fully electrified and will be realised even in everyday life activities. New internal combustion engine (ICE) cars will not be sold, with only Electric Vehicles (EVs) and other zero-carbon transport options being newly available for purchase. In addition, domestic gas boilers will not be installed in new homes from 2025. The above will result in an uptake of up to approximately 30 million EVs present and up to 13 million heat pumps installed domestically and within businesses, with overall electricity demand expected to rise by 64%, in comparison to 2023.

1.2.2 The potential realised through innovation in technology development will enable further increase in the renewable energy capacity within power industries. As an example, clean hydrogen is forecasted to have a production capacity of up to 22 GW by 2035.

1.2.3 The bar chart below from the Beyond 2030 report shows the generation mix in 2023 in comparison to the forecasted mix in 2035.

Figure F.3 – Generation mix comparison (2023 and 2035) [source: Beyond 2030, ESO, March 2024]



1.2.4 As it stands, the HND scheme is not sufficient by itself to reinforce the transmission system within the Pathway to 2030, as more electricity will be generated than the network can efficiently support and transport. Therefore, the UK Government requested ESO to further develop the HND and enable a set of recommendations for a greater amount of offshore wind generation to connect to the network.

1.2.5 ESO have undertaken a network assessment of options to facilitate an efficient high-level network design, in cooperation with Great Britain's TOs. This design implements a further 21 GW of offshore wind generation which will establish Great Britain as the owner of the largest offshore fleet in Europe. The design will be a set of holistic recommendations of measurable scale with over three times as much undersea cabling (compared to current infrastructure) needed by 2035. With this in place, power flows can be further balanced across the transmission system, enhancing energy security and reliability of supply.

1.2.6 Development of network infrastructure is required through this network design and will need to consider minimising impacts on the environment and communities. These impacts can be reduced via optimisation of network designs, early community engagement, innovative solutions and sufficient financial incentives and community packages.

1.2.7 The map below depicts the network infrastructure to be delivered beyond 2030 within the transmission system.

Figure F.4 – Network infrastructure to be delivered beyond 2030 [source: Beyond 2030, ESO, March 2024]

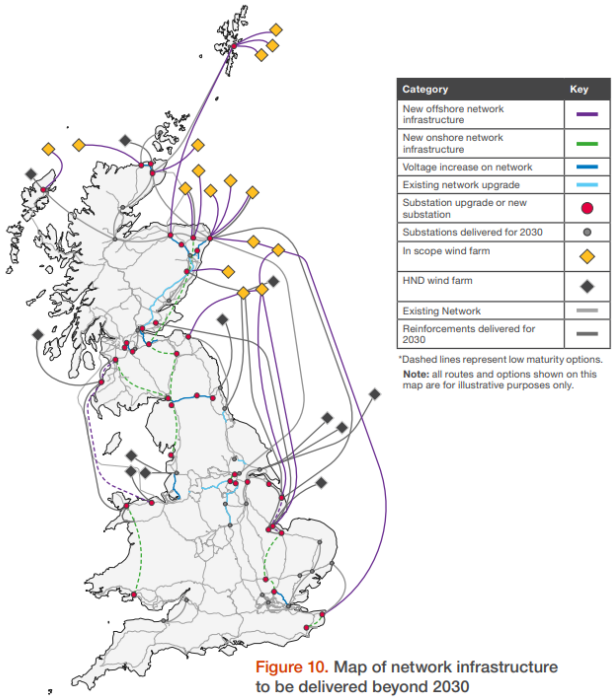


Figure 10. Map of network infrastructure to be delivered beyond 2030

1.3 Way Forward

1.3.1 The Beyond 2030 report builds on the 2022 Holistic Network Design (HND) and is a key step towards the effort to upgrade Great Britain's electricity transmission infrastructure. Both publications support the ambition of connecting a total of 86 GW of offshore wind as well as an array of other low-carbon technologies, potentially adding up to £15 billion to the economy. The plan also aims to produce significant supply chain benefits, create jobs, and facilitate greater energy security.

1.3.2 Central to achieving these goals is the UK Government's Transmission Acceleration Action Plan (TAAP) from November 2023, which outlines a series of activities to reduce network delivery times and gain societal consent for the transformational infrastructure changes.

1.3.3 The Beyond 2030 report also sets out the key role of strategic demand - utilising efficient placement of generation to potentially reduce future infrastructure needs. The Transmission Owners (TOs) will commence the Detailed Network Design (DND) phase to optimise the Beyond 2030 report's proposed designs. Continued coordination among project developers is crucial to minimise environmental and community impacts. Continued alignment with broader industry and policy changes to facilitate the decarbonisation of Great Britain's electricity system is crucial and will facilitate the necessary transition to whole energy system planning to meet rising energy needs.

1.3.4 The Beyond 2030 report has set out information on key policies and proposals, listed below, that are either under consideration or will be taken forward. These policies and proposals should not be viewed in isolation but as holistic changes to the design and operation of the energy system:

- Energy Act and creation of the National Energy System Operator (NESO) – NESO is built upon the principles and structure of the ESO and will cover Great Britain, spanning electricity and gas, giving an independent view of the whole energy system.
- Strategic Spatial Energy Plan (SSEP) – The SSEP will see UK Government targets across the whole energy system mapped spatially across Great Britain over a period of several years and define the optimal mix and location of clean generation and storage to meet forecast demand, net-zero targets and security of supply for all consumers.
- Centralised Strategic Network Plan (CSNP) – NESO will take on the role of central whole-system planner for the energy system, at both national and regional levels, and be responsible for a new CSNP.
- Regional Energy Strategic Planners (RESP) - As part of the new approach to energy planning, RESPs will support net-zero ambitions through the creation of strategic energy plans at a regional and national level, providing critical planning assumptions to inform system and network needs.
- Connections Reform – NESO will lead the development of several tactical and strategic reforms that have the potential to result in radical changes to both the size of the connections queue and how long it takes for projects which are 'ready to connect' to connect to the network.
- Network Competition - In November 2023, the TAAP outlined the Government's commitment to introduce competition for onshore transmission projects as soon as reasonably possible.
- Net Zero Market Reform - The objective of the NZMR programme is to outline holistic market design and complementary investment policy for net zero, and contribute to the Review of Electricity Market (REMA) debate from the perspective of Great Britain's electricity system operator.

Appendix G Onshore Alternative Option

1.1 Option Overview

1.1.1 As set out in Section 5, this appendix will provide an overview of the key factors NGET considered with regards to appraising a land-based option as part of the strategic options process and the reasons why this option was not progressed to a full appraisal as a potential strategic option.

1.1.2 An onshore reinforcement option was identified as a counterfactual solution, which proposes the development of a new onshore transmission circuit from the South of Scotland connecting to the existing Legacy substation in Northeast Wales. A geographical depiction of this option is seen below through Figure G.1.

1.1.3 This option would necessitate the construction of a new 450 km AC 400 kV 6,380 MW circuit or a new onshore HVDC 2,000 MW connection between T-Point (Central/South Ayrshire) and Legacy.

1.1.4 In accordance with the methodology set out in Section 5, the circuit distance considered for this option was derived by taking the most direct route between the South of Scotland and Legacy and adding 20% to accommodate potential route deviations that might be required if the route proceeds to more detailed routing and siting. This 20% addition is needed to accommodate situations when a clear obstacle exists, such as an estuary, watercourse, or geographical feature.

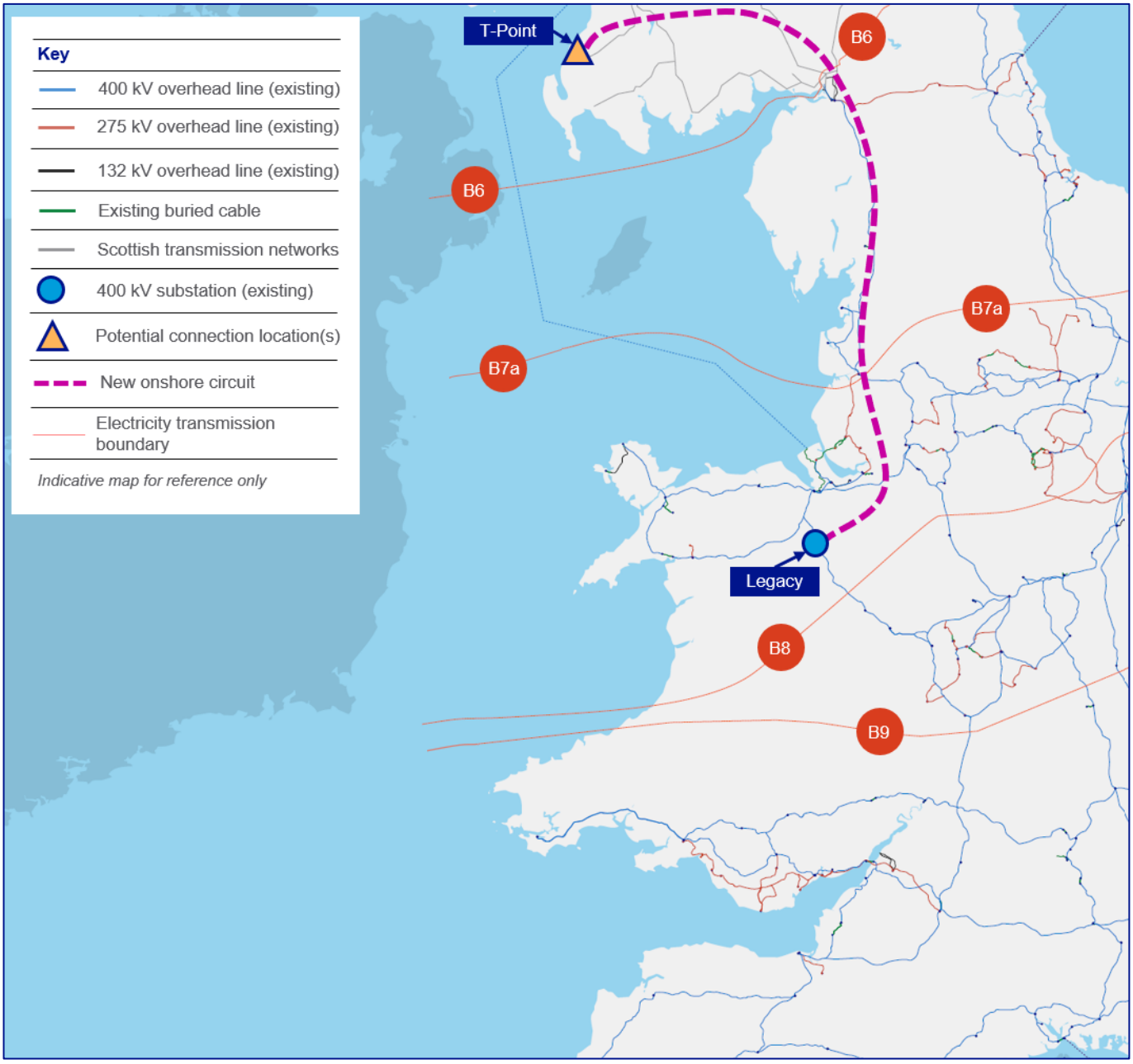
1.1.5 For the appraisal of onshore options of significant distance, an OHL would normally be expected to offer the most economic, efficient and coordinated development over alternative onshore technologies and therefore would meet NGET's obligations under section 9 of the Electricity Act. Therefore, our initial appraisal of this option has sought to establish the impacts of the proposal based upon an assumed use of OHL technology because this is usually the quickest technology to implement and usually is the lowest cost alternative.

1.1.6 The initial appraisal that was undertaken for this option followed the same process that is set out in Section 5 of this document. A "benefits filter" was applied to the option, which allows us to focus on options that best meet our obligations to the environment and consumers. It also ensures that any option NGET presents has a comparable benefit over an alternative. The criteria for any potential strategic option to be considered further are the following:

- An environmental benefit;
- A technical system benefit;
- A capital and lifetime cost benefit, which includes the consideration of initial capital costs and long-term maintenance and operating costs; and
- A socio-economic benefit.

1.1.7 Where the benefits of multiple options are very similar to each other, all options are captured and included for appraisal. This ensures that all possible solutions are assessed, regardless of having similar capability.

Figure G.1 – Onshore Alternative Option map



1.2 Environmental and socio-economic assessment

1.2.1 From an environmental and socio-economic perspective, a new OHL route from the South of Scotland (T-Point) connecting to Legacy would encounter and potentially impact on a number of environmental and socio-economic constraints. This would also likely include a range of statutory designated landscapes, National Parks and statutory ecological and historic environment designations, as well as being routed close to or through urbanised areas impacting on settlements.

1.2.2 Some of the receptors identified along the route include: Nine SACs, eleven SSSIs, two SPAs, two Ramsar sites, seven Conservation Areas, two AONBs, seven Scheduled

Monuments, five Landfill Sites, 22 Areas of Wildlife Interest (AWI), 23 Peatlands, 35 Agricultural Land Classification (ALC) Grade areas, two Woodland Dedications, 210 Carbon Peatland Class areas, 21 National Cycle Network routes, four Coast Paths and 60 Main Rivers. Based on the vast number of receptors present along the route, this onshore option would impact the greatest number of receptors compared to any offshore solution.

1.2.3 While many environmental and socio-economic impacts could be mitigated through careful route selection and appropriate mitigation including undergrounding sections of the route, this option would result in greater environmental and socio-economic impacts compared to alternative subsea HVDC options. The potential impacts of this option affect its deliverability, in particular whether such an OHL could be consented (and then constructed) in a reasonable timescale, when compared to the offshore solutions.

1.3 Cost and technical assessment

1.3.1 NGET undertook a cost appraisal of the following two technologies considering a distance of 450 km:

- Land based 400 kV AC connection
  - AC connections circuit options use medium capacity double circuits (two 400 kV AC circuits) with a total capacity of up to 6,380 Mega Volt Amperes (MVA); or
- Land based 525 kV HVDC cable and converter stations
  - HVDC connection options use 525 kV voltage source links of 2 GW, which requires a new converter station at each end of each circuit, similar in size to a large warehouse. In this case a 2 GW connection requires two converter stations in total, with one of the converters located at Legacy.
  - Connections between the new converter station and Legacy are also required.

1.3.2 Either of these options entail the following works:

- NGET Substation Works
  - Two bays extension at the existing Legacy substation.

1.3.3 NGET undertook a cost evaluation of the following four technologies for onshore options evaluation:

- 400 kV AC OHL
- 400 kV AC underground cable
- 400 kV AC GIL
- 525 kV HVDC underground cable

1.3.4 Table G.1 below sets out the capital costs for the onshore alternative option.

Table G.1 – Onshore Alternative Option – T-Point to Legacy: Capital Cost for each technology option

Item	Capital Cost			
Substation and Wider Works	**£20.5m**			
New Circuits	**AC OHL**	**AC Cable**	**AC GIL**	**HVDC**
New Circuit (450 km)	£2,223.0m	£19,207.2m	£22,428.0m	£4,768.8m
Total Capital Cost	**£2,243.5m**	**£19,227.7m**	**£22,448.5m**	**£4,789.3m**

1.3.5 Table G.2 below sets out the lifetime cost for the new circuit technology options, the lifetime costs are different for each circuit technology and are included as a differentiator between technologies. These costs are calculated using the methodology described in "Strategic options technical appendix 2025/2026 price base", found in Appendix D.

Table G.2 – Onshore Alternative Option – T-Point to Legacy: Lifetime cost for each technology option

Subsea Based Option	AC OHL	AC Cable	AC GIL	HVDC
Capital Cost of New Circuits	£2,223.0m	£19,207.2m	£22,428.0m	£4,768.8m
NPV of Cost of Losses over 40 years	£1,406.2m	£894.0m	£657.2m	£157.1m
NPV of Operation & Maintenance costs over 40 years	£33.6m	£103.4m	£34.0m	£74.9m
Lifetime Cost of New Circuits	**£3663m**	**£20,205m**	**£23,119m**	**£5,001m**

1.3.6 Based on the findings from the evaluation of this onshore option, a 6,380 MVA AC connection between Scotland and Wales with a connection location for the new circuit at Legacy, was identified as the preferred land-based option. In light of this analysis our starting presumption for further development of this option should it progressed, would be for a majority OHL connection.

1.3.7 Comparing the estimated capital cost of £2,243.5m for the Onshore Alternative Option with the preferred HVDC option (AC6-1), which has an estimated capital cost of £2,582.4m, the onshore option has a lower initial capital cost by approximately £339m at this stage. However, this comparison does not fully account for the likelihood that an onshore AC overhead line (OHL) of this length would require mitigation in sensitive areas, such as sections of underground cabling, which could materially increase its

capital cost. For example, if just 5% (22.5 km) of the 450 km route required undergrounding, this could increase the capital cost by approximately £1,300m, potentially offsetting the initial cost advantage.

1.3.8 Comparing the estimated lifetime cost of £3,663m for the Onshore Alternative Option to our preferred HVDC option (AC6-1), which presents an estimated lifetime cost of £2,732m, the preferred HVDC option carries a more favourable cost profile.

1.3.9 Our technical analysis of this option also noted that:

- A land-based circuit constructed for this option would cover a significant length across Scotland, England and Wales. An AC option is likely to see a lower load limit than the given circuit rating due to the high impedance of AC circuits greater than 400 km in length. This solution would be approximately 450 km in length.
- It is likely that an AC OHL option of such length would require some sections of mitigation, such as the use of underground cables, to limit impact on designations or due to natural features and this is likely to increase the cost of this option. This mitigation would increase the capital cost of the land-based option.

1.4 Summary of our initial assessment

1.4.1 This option does not offer any notable technical or cost benefits over the subsea strategic options presented in this SOR and it is characterised by significant environmental and socio-economic challenges.

1.4.2 An additional concern with the implementation of this counterfactual onshore option is its impact on the project delivery programme. In our strategic options appraisal process, NGET assess all options based on information relevant to their current stage of development, with the assumption that they can be delivered within a reasonable timescale. However, NGET recognises that the delivery of 450 km of OHL would not only extend the construction timeframe significantly but also involve additional complexities related to obtaining the necessary consents and agreements, making it less feasible compared to the construction of the same length of subsea HVDC cables.

1.4.3 This would be both in terms of the construction itself, as well as the potential consents and agreements that would need to be obtained to enable the works to proceed.

1.4.4 Based on these factors, NGET do not believe that this onshore option would be deliverable in a reasonable timeframe, especially when compared with the offshore solutions considered within this document.

1.4.5 In summary, this onshore option:

- Does not provide any notable technical or cost benefits when compared with other proposed options
- Would lead to significant environmental and socio-economic challenges
- Would not be deliverable in a reasonable timescale

1.4.6 Therefore, based on the information available to us at this stage, NGET will not progress this onshore alternative option (from T-Point to Legacy) for further development.

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