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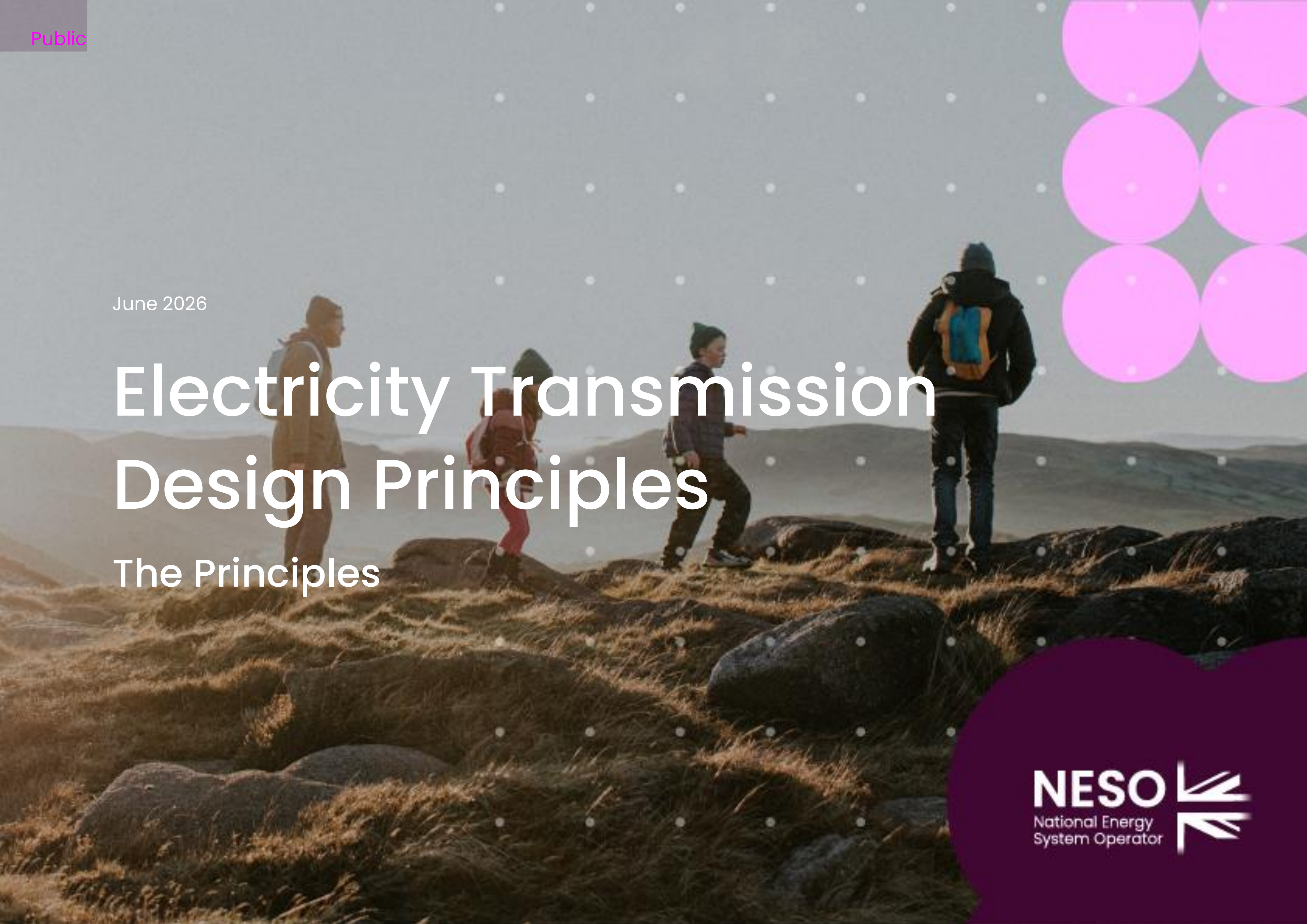

June 2026

Electricity Transmission Design Principles

The Principles

NESO
National Energy System Operator

Contents

Foreword

Foreword

The National Energy System Operator (NESO) is working with the government and the Office of Gas and Electricity Markets (Ofgem) to deliver a coordinated strategy and plan for Great Britain's electricity transmission network. NESO and the three Transmission Owners (TOs)[1] have a statutory obligation to develop plans that consider network efficiency and consumer value for money whilst balancing the impact on the environment and local communities.

Planning, consenting, and building new transmission infrastructure projects can take a significant amount of time. Accordingly, it is widely recognised within the UK government and the electricity transmission industry of Great Britain that, to achieve the UK's commitment to reach net zero by 2050 and enable the government's economic growth targets, the delivery of electricity transmission infrastructure needs to be significantly accelerated.

In 2023 the Electricity Networks Commissioner proposed recommendations to accelerate the deployment of strategic electricity transmission infrastructure. The government adopted these recommendations which now form the basis of the Transmission Acceleration Action Plan (TAAP)[2]. The TAAP sets out 43 recommendations, which collectively seek to reduce build time of electricity transmission network infrastructure from 14 to 7 years.

Part of the acceleration strategy declared by the TAAP is to clearly communicate to potential transmission development stakeholders the types of transmission infrastructure they can expect to be installed in different environments.

Recommendation "RD1" of the TAAP sets out that 'Electricity Transmission Design Principles' be created. NESO has been tasked by the Department for Energy Security and Net Zero (DESNZ) to lead on convening a working group to develop, own and manage these Electricity Transmission Design Principles ('ETDP', or 'the Principles'). The Principles will be held as a publicly available document, reviewed from time to time in a process of continuous improvement as described in Section 66, Governance.

No single document can cover every eventuality for every infrastructure project, so these Principles aim to provide clear, non-project specific transmission design guidance. It is expected that designers will provide justification for significant deviations from this guidance, including those resulting from community engagement.

The Principles aim to help streamline the transmission planning and consenting processes by reviewing and endorsing some of the general principles associated with transmission design up

[1] The Great Britain Transmission Owners are National Grid Electricity Transmission, Scottish Hydro Electric Transmission Ltd, and SP Energy Networks.

[2] Transmission Acceleration Action Plan, Department for Energy Security and Net Zero, November 2023

front, before specific projects come into development. This will allow consenting discussions to focus on the unique aspects of a project's development and reduce the need for repeated discussions on other design aspects.

These Principles sit within the context of government planning reforms to speed up and streamline the delivery of new critical infrastructure whilst protecting communities and the environment. The National Policy Statement for Electricity Networks Infrastructure, NPS EN-5 for England and Wales, sets out that developers of electricity transmission infrastructure should have regard to these Electricity Transmission Design Principles.

In Scotland, NPF4 does not currently refer to these Principles, but will still be a relevant consideration for designers of Scottish transmission infrastructure.

Background and approach

Recommendation 'RD1' of the UK Government's Transmission Acceleration Action Plan (TAAP) states that:

"Electricity Transmission Design Principles should be created to provide greater clarity on the type of asset to be used in different environments."

To achieve RD1, the Principles draw together design considerations from key government policy, industry guidance and professional experience, referencing, clarifying and updating these to ensure they are fit for purpose. In particular, this first publication has been strongly guided by:

- The legislative framework for transmission developers, in particular their Transmission Licence conditions and NPS EN-5, as well as the National Planning Framework 4 in Scotland.
- The Holford and Horlock Rules, that form part of current NPS EN-5 Policy.
- Environmental policies and frameworks including statutory requirements such as Biodiversity Net Gain, Environmental Impact Assessment (EIA) regulations, routeing and visual impact guidance, the application of the mitigation hierarchy, as well as other obligations covering habitats protection and climate resilience.
- Practical professional experience of transmission design provided by NESO and the three TOs.
- Respondents to the October 2025 consultation – transmission developers, national and local government, regulatory representatives, statutory nature and conservation bodies, campaign groups and individual members of the public amongst them.

To support the development of the Principles, NESO convened a Working Group to ensure alignment between project developers and policy makers. NESO have been working with the TOs, DESNZ, Ofgem, the Welsh and Scottish governments as well as the Planning Inspectorate, since June 2024 to scope and develop the Principles.

A key element of developing the Principles was our public consultation on draft Principles in October 2025. We engaged with societal interest and campaign groups, hosted webinars that were open to all interested parties as well as a formal consultation, with feedback informing the development of these final Principles. During the development process, NESO also sought input from other stakeholders including the Landscape Institute, the National Infrastructure and Service Transformation Authority (NISTA, formerly the National Infrastructure Commission), Renewable UK, the Energy Systems Catapult, and the Electricity Networks Commissioner. By engaging in this way, NESO have endeavoured to ensure that, while the Principles address the design points in question, they also reflect a broad range of perspectives from across the energy sector, affected communities and environmental interests.

To explore how the Principles would operate in practice, the TOs undertook a testing exercise. This involved applying the Principles to transmission projects recently granted consent and considering how they might have influenced outcomes had they been applied from project inception. Through this process, NESO gathered valuable insights that informed further refinement of the Principles, particularly where terminology or descriptions had, unintentionally, constrained the breadth of their intended application.

Relationship to Ofgem's Pre-approval of Solutions by Engineering (PASE)

Ofgem's Pre-approval of Solutions by Engineering (PASE)[3] is a regulatory process that allows for speedier regulatory approvals at the various stages of project development. It doesn't presuppose an outcome or planning decision, and there are processes by which the networks can justify alternative solutions to those which are PASE compliant.

It is worth noting the distinction between the ETDP and PASE. The ETDP sets overarching, strategic and project development principles for transmission infrastructure across Great Britain, guiding decisions on technology choices, routeing, siting, and overall design standards, aiming to help smooth regulatory approvals and planning consenting. PASE translates some of the Principles into a set of practical, pre-approved engineering solutions, enabling developers to secure funding more quickly and smoothly by adopting those solutions without requiring lengthy justification.

The use of PASE gives licensees a more expedited route to funding, with projects that are PASE compliant having more certainty of funding through the Ofgem review process. Where there are non-material changes to PASE compliant solutions, funding will reflect the efficient costs for those works, this is likely to include updates derived from local stakeholder feedback.

[3] The PASE Framework is included in the Load Re-opener Guidance and Submission Requirements Document 16 December 2025, which itself is included in the RIIO3 associated documents Zip file published as part of the Modifications to the RIIO-3 licences and associated documents.

1. Introduction

Introduction

This section introduces the ETDP, including the projects it applies to and how the Principles should be read. The content is provided for context only.

1.1 Origin and purpose of the Principles

The design of Britain's electricity transmission networks is rooted in the pioneering development and construction of the supergrid in the 1950s. To guide its development, the Holford Rules were introduced in 1959, setting out principles to preserve amenity and minimise environmental impact of new transmission proposals. The Horlock Rules followed in 2003 to inform the siting and design of new substations. Although both sets of Rules were originally developed to support the practices of National Grid at the time, they have since been more broadly adopted across the sector.

Today, the Holford and Horlock Rules are routinely applied in environmental assessments, and specifically landscape and visual impact assessments. The National Policy Statements (England and Wales) and National Planning Framework 4 (Scotland), which are not limited to electricity transmission development, also address similar landscape and amenity principles.

However, whilst these Rules continue to form the cornerstone of proposals for new transmission infrastructure, they can often be open to interpretation by different parties. This ambiguity can leave stakeholders uncertain about which elements of a proposed design can be changed and what impact mitigations can be included to support meaningful community engagement. Accordingly, public inquiries frequently revisit questions about the necessity of specific transmission technologies for particular routes or sites, with consequent project delays.

Quite separately, challenges during regulatory approval of designs, such as contested measures to preserve amenity, can require time-consuming route redesign, reapplication for planning approval, or additional funding approvals.

To counter these potential sources of project delay, the Electricity Networks Commissioner recommended the creation of electricity transmission design principles that would provide clear guidance on technology choices and design approaches for transmission proposals across England (for all transmission projects), and Wales (for projects that qualify as Nationally Significant Infrastructure), and Scotland (Electricity transmission planning decisions are devolved to Scottish Ministers. However, the provisions listed in NPS EN-5 [4], including those relating to the ETDP[5], may be 'a relevant consideration' in transmission planning decisions.)

[4] National Policy Statement for electricity networks infrastructure (EN-5), 2025, Clause 1.4.3

[55] National Policy Statement for electricity networks infrastructure (EN-5), 2025, Clauses 2.9.20, 2.10.5 and 2.11.2

The Commissioner, in Section 5.10 of his Report, includes recommendations NP1, NP2 and NP3, which relate to updates to the NPS and NPF policies to support the planning approval process. Accordingly, these Electricity Transmission Design Principles recognise the diversity of landscapes and legislation across, and between, each of the nations and regions of Great Britain.

The Principles are designed to be sensitive to, and strive to mitigate the impact of, transmission infrastructure on the environment, landscape, and communities. They encourage the exploration of routeing options and impact mitigations, and they encourage innovation, especially where it reduces transmission impacts effectively. Importantly, the Principles align with Great Britain's regulatory principles, such that these Principles promote economy and efficiency, and are compatible with the TO licence obligations (from the Electricity Act 1989) to develop and maintain an efficient, coordinated, and economical system of electricity transmission.

1.2 Projects and Technology in scope

The Principles apply to electricity transmission infrastructure in Great Britain. While the exact definition of "transmission" varies slightly between England, Wales and Scotland due to different planning laws and policies, it typically includes infrastructure operating at 400 kV and 275 kV (and, in Scotland, also 132 kV). These projects represent the "motorways" of the GB transmission network, transferring large amounts of power to industry and consumers. As such, they are usually vast in scale and represent large scale improvements to the transmission network. Further information on the differences between transmission and distribution infrastructure (size, technology etc.) is available on our website.

The Principles are forward-looking. Their purpose is to support a shared understanding of the considerations that are typically taken into account during the development of electricity transmission infrastructure. They are intended to support effective engagement and consultation, where relevant, and to form part of a broader set of measures aimed at streamlining and accelerating decision-making and delivery to support the energy transition. The Principles should be read as a whole and are designed to sit alongside, rather than replace, existing policy, guidance and regulatory frameworks.

Electricity transmission projects are complex engineering activities involving multiple interrelated components, design stages and constraints. As a result, projects can take many months or years to develop, even to the point where meaningful consultation can take place. At the time of publication, some projects will therefore already be well advanced or undergoing consultation, having entered development before the Principles were finalised. It is not intended that the Principles are applied retrospectively. Projects that have completed the strategic planning stage prior to publication would not be expected to have had regard to them, and the Principles are not intended to reopen established design decisions.

NESO does not have the direct authority to mandate the application (or disregard) of the Principles for specific projects.

However, decision-makers are encouraged to consider the intended purpose of the Principles (namely, to improve understanding of transmission infrastructure needs and to support timely delivery of the energy transition) when considering their relevance to projects that are already in progress at the time of publication. In doing so, due regard should be given to the maturity of individual projects and the forward-looking nature of the Principles. Over time, the application of the Principles is expected to become increasingly evident in emerging designs and future projects.

1.3 Structure of this Document

The Electricity Transmission Design Principles have been developed for a broad audience including policymakers, experienced energy industry professionals, planning authorities and decision-makers, and the public. They are designed to be clear and accessible and to promote constructive dialogue around new proposals for transmission infrastructure.

The Principles follow a tiered structure, where broad, governing **Overarching Principles (OP)** set the vision and detailed **Strategic Planning** and **Project Development Principles** translate the vision into practice.

Whilst the Strategic Planning and Project Development principles all follow from the Overarching Principles, no overall sequential order **is intended**; rather the aspects of each Principle are presented for consideration and guidance to the extent and level of detail that the application of each project warrants.

Note to reader

For the avoidance of doubt, the Principles are intended to provide, and be interpreted as, good design guidance rather than as a prescriptive checklist or an obligatory standard. Where a robust optioneering process identifies a preferred solution that departs in a material way from one or more Principles, it is expected that the process will clearly set out and record the justification for doing so for future reference.

Overarching Principles

The Overarching Principles set the vision for good transmission design, providing a clear guidance framework to promote network reliability, operability and flexibility whilst protecting the environment, communities and consumer cost.

Strategic Planning and Project Development Principles

The **Strategic Planning Principles** focus on matters relevant to the early stages of project design and guide the definition of high-level characteristics of future transmission infrastructure. Meanwhile, the **Project Development Principles** guide choices for the design of particular transmission assets and, where relevant, provide mitigation considerations.

The **Strategic Planning** and **Project Development Principles** are structured and indexed according to the type of technology, including **Substation (S)**, Route Assets: Overhead **Transmission (T), Underground (U)**, and **Offshore (O)**.

Each detailed Principle comprises:

1. The headline of the **Principle**, which provides an overarching statement capturing the core intent.
2. The **Rationale**, which provides the general reader with context and reasoning as to why the principle matters, and how it contributes to good transmission design.
3. The **Design Considerations**, which contain a selection of specific technical, operational, and site-related factors that designers might consider when applying the principle to a proposed transmission design. They may also identify circumstances that could justify deviation from the Principle.
4. Any relevant **references**.

2. Design Choices and Balance

Design Choices and Balance

This section outlines key considerations that typically shape the transmission design process, setting the scene for the Principles that follow. The content is provided for context only.

2.1 Design with communities in mind

The Principles prioritise choosing routes and technologies that avoid or lessen impact (e.g. skirting densely populated areas, avoiding green spaces which provide additional wellbeing benefits, or using lower-profile towers) which can significantly ease the later planning process.

Designers should consider the stages where communities can best influence decisions and seek engagement with communities at those times, ensuring community views are understood and considered in decision making. By considering the balance of project specific factors (e.g. technical need and tower heights) with community priorities (e.g. construction traffic and visual impact), discussions can be focused and streamlined early in the design process, supporting more efficient progression through the planning process.

2.2 Community engagement and transparency

The Principles set out key design considerations that should guide the development of new proposals for electricity transmission infrastructure and bring transparency to the design process. This transparency enables the public and wider stakeholders to engage with developers during initial and statutory consultations, around decisions made in line with the Principles, with an expectation that designers will provide justification for significant deviations.

By embedding these considerations early, the Principles aim to support constructive dialogue and enable meaningful engagement with communities. This ensures communities have sufficient information to understand the design choices and where they can influence aspects of design, which will always be subject to project specifics. Consistent and transparent application of the Principles helps designers prepare well-considered proposals before engagement begins, enabling discussions to focus on specific aspects of a design, rather than revisiting scope or fundamentals. While the Principles provide clarity, early, effective, dialogue with communities, in line with the Gunning Principles, remains of the utmost importance. The Gunning Principles, four rules supported by common law, provide for early, “formative stage” consultation, clear explanation, adequate time to respond, and conscientious consideration. If followed, they are designed to make consultation a fair and worthwhile exercise

2.3 Environmental protection and deliverability

The Principles seek to balance environmental preservation with practical considerations such as cost, time, engineering constraints, supply chain limitations, and regulatory approvals. They are not intended to replace or substitute environmental assessments[6] or other statutory environmental requirements; rather they aim to pre-empt some of the challenges with environmental assessment and embed protections early in the design process to streamline the consenting process.

Balanced decision making at a project level ensures outcomes that are sustainable and achievable. Design considerations identify trade-offs where environmental safeguards could increase cost and complexity to an extent that an optimal proposal may no longer outperform alternative options. The Principles provide guidance on environmental priorities throughout project development.

2.4 Development flexibility

Network development flexibility is critical to be able to accommodate future network needs. For instance, a common requirement is substation expansion to accommodate new customer connections or further network reinforcement. However, to allow for this future need efficiently and with minimum disruption to communities and the environment requires choosing a site now with sufficient space for the future additional circuits.

Such strategic measures help futureproof the network but involve balancing the risk of redundant assets and higher upfront costs against potential disruption later. Maintaining this balance ensures that today's design choices do not constrain tomorrow's system development, supporting efficient delivery while minimising environmental and community impacts over the asset's lifecycle. For the first time, with NESO's Strategic Planning processes, communities and stakeholders will have a whole system view of potential future network requirements.

2.5 Options Appraisal

Transmission design typically starts with a comprehensive options appraisal. At the outset of a project, designers identify a long list of potential solution options. Each option is then appraised and compared (at an appropriate degree of detail) to form a shortlist, followed by further data gathering, analysis, and comparison to determine a preferred option. This structured approach ensures that design choices are robust, transparent, and evidence based.

Option appraisal practices utilised by the TOs adopt the same philosophy as those behind more recognised frameworks, such as the UK Treasury's Green Book, and other transmission designers are expected to follow the TOs' example. The Principles aim to

[6] Such as an Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA)

provide clarity on the key ingredients that should inform these appraisals that must, themselves, balance sometimes competing factors to achieve the best outcomes for consumer security of supply and public value for money whilst protecting communities and the environment.

3. Overarching Principles

OP1: Technical Needs

OP2: Environment, Community and Sustainability

OP3: Economics and Regulation

Overarching Principles

The Overarching Principles provide a clear and practical framework for good design, aligned with planning and regulatory requirements.

They provide strategic direction to key stakeholders and translate high-level ambitions into strong design guidance that is accessible to both professionals and the wider public.

OP1: Technical Needs

Good transmission design seeks to ensure that proposals for new infrastructure meet the current technical requirements and anticipate future technical need and developments, as identified by Great Britain's transmission system strategic planning processes:

- Deliver required connections or additional capacity cognisant of future needs, to minimise the requirement for recurring network updates within recognised planning horizons, as identified by strategic planning processes such as the NESO's Strategic Spatial Energy Plan (SSEP) and Central Strategic Network Plan (CSNP).
- Meet network reliability expectations, and security and quality of supply standards.
- Protect the network's operability by ensuring its maintainability, flexibility, and resilience, to minimise the impact of current and future physical, cyber and climate related security risks.
- Use innovative technology and techniques to unlock further design value where technology readiness levels (TRL), solution availability and cost make these approaches safe and practicable.

OP2: Environment, Community and Sustainability

Good transmission design understands and assesses environmental and social outcomes and considers sustainability at every stage:

- Avoid or seek to protect environments, including landscapes and amenities of cultural and community importance; adhere always to the mitigation hierarchy of avoiding, reducing, mitigating and compensating.
- Actively reflect the views of communities and stakeholders in the preferred design where reasonably practicable.
- At the strategic planning and programme planning stages for new transmission infrastructure make early assessments (e.g. a Strategic Environmental Assessment) of landscapes and other environmental characteristics. Whilst studying, particularly, the cumulative impacts of energy infrastructure (transmission towers, underground cables, substations, and other related infrastructure) within transmission development areas. Reassess and seek to minimise these cumulative impacts at each project stage.
- Comply with current biodiversity legislation.
- Use innovative technology and techniques to help avoid or minimise environmental and social impacts, and to help offset residual effects where these add benefits beyond existing techniques.

OP3: Economics and regulation

Good transmission design delivers value for existing and future consumers by supporting regulatory objectives:

- Ensure that the capabilities of the existing network are optimised, economically and securely, before building new reinforcements.
- Where new equipment is needed, promote efficient, co-ordinated and economic infrastructure designs and technologies, and support effective and transparent option appraisal and project delivery, improving lifetime efficiencies wherever feasible.
- Use innovative technology and approaches to further efficiency and co-ordination, and to support the achievement of the government's objectives where technology readiness levels (TRL), solution availability and cost make these approaches safe and practicable.

4. Strategic Planning Principles

The Strategic Planning Principles serve as design guidance to be applied at the relevant stage of a project's lifecycle.

This section contains:

- Route Assets: Principles T1 and T2
- Substations: Principles S1 to S3
- Offshore: Principle O1

T1	Consider the technical feasibility, economic, environmental, community, deliverability, and operability characteristics of all appropriate onshore and offshore options to deliver the required transmission capacity and address future development need.
Rationale Section 9(2) of the UK Electricity Act 1989 places upon any electricity transmission licence holder the duty to "develop and maintain an efficient, co-ordinated and economical system of electricity transmission" – a duty reflected in transmission licences. Schedule 9 of the same Act places a duty on licence holders: 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" … "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." The Environment Act 2021, NPS EN-5, and the National Spatial Strategy for Scotland 2045, Part 1 of NPF4, amongst others, are all also strongly supportive of biodiversity. Impact to protected species and habitats requires substantial justification, and acceptance, by local planning authorities. Within the planning process, high-quality early, meaningful and constructive engagement is expected to take place. Acting alongside these duties are the common law Gunning Principles that provide for early, "formative stage" consultation, clear explanation, adequate time to respond, and conscientious consideration, and Holford Rule No1. Meeting this diverse set of requirements whilst achieving the required new transmission capacity is a significant challenge for any transmission asset designer since the design of a new transmission asset such as an overhead line or underground cable involves balancing many conflicting factors. To identify the most appropriate solution, designers will identify the full range of feasible options, both onshore and offshore, against the full range of requirements. These feasible options should explicitly include consideration of potential future development needs. Designing for the future may involve moderately higher upfront costs but can deliver long-term savings by avoiding the need for repeated interventions. It also enables faster deployment of future infrastructure and reduces disruption to communities and the environment over time. The level of detail that goes into considering each option should be proportionate to its potential to meet the project's objectives and support a comprehensive and balanced evaluation to ensure the selection of the preferred option(s) is (are) robust and justifiable.	**Design considerations** • Transmission capacity need (the need for additional power transfer capability that justifies the new development in the first place). • Technical (such as the reliability and robustness of the proposed solution, ensuring compatibility with existing and future infrastructure and technology). • Operability (such as ease of operation and maintenance, flexibility and scalability for future upgrades, and resilience to adverse conditions e.g. wind, snow, pollution). • Deliverability (such as the feasibility of the site for construction, availability of materials and equipment, technology readiness level of the solution, outage impacts of any system access required and timeliness to meet the need). • Environment (important environmental and cultural heritage assets such as national, regional and local landscape, ecological and heritage designations, hydrology and natural carbon stores, and the need to consider these early in the development). • Protected environmental sites, including irreplaceable habitats (such as ancient woodland) - any impacts to these first require significant designer justification. • Biodiversity net gain opportunities, England's NPPF's mitigation hierarchy, and the Environment Act 2021's biodiversity net gain action hierarchy, or the Wesh or Scottish equivalents (see references, below). • Community (such as visual impact, amenity, current land uses, settlement dispersion, and the Gunning Principles). • Economy (such as capital costs, operational costs, whole life costs, and performance). • Future development needs (including considering the space needed to accommodate additional circuits, such as those identified through strategic planning processes). Opportunities to install higher voltage equipment and operating at a lower standard voltage in the interim. • Robust, transparent and evidence-based options appraisal (See Section 2.5 of this document).
References • assets.publishing.service.gov.uk/media/64252f852fa848000cec0f53/NPS_EN-5.pdfNational Policy Statement for Electricity Networks Infrastructure (EN-5) DESNZ, December 2025, Paragraph 1.1.7, Sections 2.7, 2.8 • National Planning Framework 4 NPF4, Scottish Government, February 2023 • UK Environment Act 2021, Schedule 15 • UK Planning Act 2008, Gov.uk, Sections 47 to 49 • UK Electricity Act 1989, Gov.uk, Section 9(2) and Schedule 9 • Electricity Transmission Standard Licence Conditions, Ofgem, Condition B.7, June 2025 • Gunning Principles: Four rules supported by common law which, if followed, are designed to make consultation a fair and worthwhile exercise	

T2	**The design of onshore transmission circuits starts from the presumption that they will be continuous AC overhead lines.**
Rationale Section 2.9.21 of NPS EN-5 indicates that the strong starting presumption for electricity networks developments is that they be overhead line. Overhead line is the preferred electricity transmission technology because, despite their potential landscape and visual effects, compared to equivalent underground transmission cables they are usually: (i) quicker to construct, (ii) easier and quicker to access for maintenance and repair, (iii) less environmentally impactful along similar routes, (iv) more cost effective with a 4 to 5 times lower lifetime power transfer cost, (v) more future-proof, and (vi) easier to connect into existing or future circuits[7]. Great Britain's onshore supergrid employs predominantly double circuit alternating current (AC[8]) overhead lines. This approach is typically the most cost-effective solution as it maximises the infrastructure's power transfer capacity and minimises materials consumption. At the same time, it enhances security of supply and minimises disruption to communities and the environment during construction and operation. Despite all the above good reasons for proposing overhead line, this starting presumption for overhead line may be overturned in favour of underground cable in some very specific and localised conditions. For example, in England and Wales, the starting presumption for overhead lines is, reversed in favour of underground cable when proposed developments cross part of a nationally designated landscape (i.e. National Parks, The Broads, Areas of Outstanding Natural Beauty – now known as National Landscapes). Such a proposal would only be made after the designer has exhausted all reasonable options to avoid encroaching upon the area in the first place and would not apply where the geology precludes the use of underground cable, where long sections of undergrounding would be considered to unreasonably raise the cost burden for consumers, or where the proposal would result in unreasonable environmental impact.	**Design considerations** • Differences in the national planning policies of the country in which the transmission circuits are proposed in situations where planning is a devolved matter and therefore subject to the national frameworks of England, Wales or Scotland (see section 1.1). • Landscapes that would affect the transmission route starting presumptions. • In England and Wales, the starting presumption of overhead lines is reversed for the sections of the proposed development that crosses part of a designated National Landscape (i.e. National Parks, The Broads, Areas of Outstanding Natural Beauty). • In Scotland, there is no equivalent starting presumption in national planning policies. • Specific localised conditions that might, after appropriate assessment, overturn the presumption for overhead line, such as sections of the transmission route that cross known bird migration routes, localised exceptional visual amenities or widely cherished cultural areas.

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- National Planning Framework 4 NPF4, Scottish Government, February 2023
- Approach to Routeing and Environmental Impact Assessment, SPEN, February 2020, Foreword from CEO
- Comparison of Electricity Transmission Technologies: Costs and Characteristics, IET, April 2025
- HVDC Links in System Operations, ENTSO-E, Dec 2019.
- Approach to Consenting, NGET, April 2022
- Planning Policy Wales Edition 12, Welsh Government, February 2024

[7] In this context, a "continuous" overhead line refers foremost to a design with no underground sections.
[8] Whilst AC is the more flexible technology for power transmission networks, high voltage direct current (HVDC) is an alternative transmission that, while more efficient over very long distances, particularly subsea, is more complex to integrate with the interconnected, flexible, and distributed nature of the onshore transmission system of Great Britain.

S1	Proposals for new substations, substation extensions and converter stations should meet the technical needs in a cost-effective way whilst considering environmental and community effects alongside deliverability and operability.
Rationale Section 9(2) of the UK Electricity Act 1989 places upon any electricity transmission licence holder the duty to "develop and maintain an efficient, co-ordinated and economical system of electricity transmission" - a duty reflected in transmission licences. Schedule 9 of the same Act places a duty on licence holders 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" … "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." The Environment Act 2021 and NPS EN-5, amongst others, are also strongly supportive of biodiversity. Impact to protected species and habitats requires substantial justification, and acceptance, by local planning authorities. Within the planning process, high-quality early, meaningful and constructive engagement is expected to take place. Acting alongside these duties are the common law Gunning Principles that provide for early, "formative stage" consultation, clear explanation, adequate time to respond, and conscientious consideration, and Horlock Rule N°1. To align with these policies and licence obligations, the substation design (or substation extension) process will thus evaluate, early on, environmental, community, and amenity effects and ensure designs demonstrate a commitment to economic, sustainable and socially responsible infrastructure development whilst, at the same time, meeting technical and deliverability requirements.	**Design considerations** • Electricity, environmental and planning legislation, and the Gunning Principles. • Efficiency (such as technical losses, system flexibility, and operational complexity). • Co-ordination (with other parts of the transmission network, with the requirements of any directly connected Critical National Infrastructure (CNI), and with other energy vectors). • Economy (such as capital costs, operational costs, whole life costs, performance – particularly network availability). • Environment (important environmental and cultural heritage assets such as national, regional and local landscape, ecological and heritage designations, hydrology and natural carbon stores). • Protected environmental sites, including irreplaceable habitats (such as ancient woodland) - impacts to these first require significant designer justification • Biodiversity net gain opportunities, England's NPPF's mitigation hierarchy, and the Environment Act 2021's biodiversity net gain action hierarchy, or the Wesh or Scottish equivalents (see references, below) • Community (such as visual impact, amenity, current land uses and settlement dispersion). • Deliverability (site feasibility, materials and equipment availability, technology readiness level, outage impacts of any system access required, timeliness to meet the need) • A preference for brownfield sites over greenfield, and a preference to avoid nationally important areas, such as Grade 1 agricultural land and sites of nationally scarce minerals. • Future planned requirements – allowance in current designs for future anticipated requirements, e.g. installing 400 kV-rated equipment that will initially be run at 275 kV. • Robust, transparent and evidence-based options appraisal (See Section 2.5 of this document) • Strategic anticipatory investment that would help to futureproof the site.

References

- assets.publishing.service.gov.uk/media/64252f3b60a35e00120cb158/NPS_EN-1.pdf UK Electricity Act, Gov.uk, 1989, Section 9(2) and Schedule 9
- UK Environment Act 2021, Schedule 15
- UK Planning Act 2008, Sections 47 to 49
- assets.publishing.service.gov.uk/media/65a78a5496a5ec000d731abb/nps-electricity-networks-infrastructure-en5.pdf National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025
- National Planning Framework 4 NPF4, Scottish Government, February 2023
- Electricity Transmission Standard Licence Conditions, Ofgem, June 2025, Condition B.7
- Country Planning (Scotland) Act 1997
- Gunning Principles: Four rules supported by common law which, if followed, are designed to make consultation a fair and worthwhile exercise.
- The Horlock Rules for the Siting and Design of Substations, National Grid Company, 2006 Rule No.1: In the development of system options including new substations, consideration must be given to environmental issues from the earliest stage to balance the technical benefits and capital cost requirements for new developments against the consequential environmental effects in order to keep adverse effects to a reasonably practicable minimum.

S2	Consider operational flexibility and network resilience in the electrical design, layout and siting of all new substations, substation extensions, and converter stations.
Rationale Network resilience is essential to customers' continuity of supply. Many substation design elements affect the operational flexibility of the network, and thus network resilience, but two elements in particular – the substation electrical topology and the bay spacing - are totally dependent upon the space available in the substation. Since space is not easily increased after a site has been chosen, these two need to be considered very early in a substation's design and in the choice of its site. [9] **Substation Topology** Every Main Interconnected Transmission System (MITS) substation has an impact on the transmission system's operational flexibility and resilience. One way a substation design can boost these two characteristics is by offering an alternative connecting point (busbar) to each of its transmission circuits so that, when any busbar needs to be maintained, network continuity can be sustained through another busbar. This is normally achieved by adopting a double busbar substation configuration[10] along with appropriate bus-section and coupler circuit breakers. However, for this to occur, the substation layout must include enough space, from the start, to accommodate the required double busbar, section and coupler topology. **Bay spacing** Another way for substation design to promote network operational flexibility, and thus resilience, is by ensuring that, when a substation's circuit connection points (bays) need to be maintained or repaired, this action can be safely achieved with a minimum (or no) need to also remove neighbouring bays from service. Again, for this to occur, Air Insulated Switchgear (AIS) substation layouts must include enough space and access around each bay, from the start, for them to be worked on safely with neighbouring bays live. For Gas Insulated Switchgear (GIS) substations, this same provision translates to incorporating sufficient space around the switchgear and Gas Insulated Busbar (GIB) equipment, in particular to facilitate lifting operations without impacting other circuits. It also translates to incorporating enough gas zones within the switchgear to allow interventions with single bay outages.	**Design considerations** • Busbar configurations as set out in the SQSS. • Size and layout of substation footprint, particularly for strategically important substations. • Operational flexibility to allow maintenance of both AIS and GIS substation bays with live neighbouring bays, reducing the need for circuit outages. • System access with different substation configurations.
References • National Electricity Transmission System (NETS) Security and Quality of Supply Standard (SQSS), NESO, April 2025	

[9] Operational flexibility of the network relates to the network's ability to reconfigure to maintain supplies in the event of an unplanned outage. This is important not only to minimise the risk that consumers are disconnected, but also to minimise the need for consumers to pay constraint costs to generators who can no longer supply their customers due to the transmission outage.

[10] In accordance with NESO's Security and Quality of Supply Standard (SQSS), Appendix A

S3 Consider current and anticipated future network needs in the location and layout of new substations including the availability of land to provide space for future connections.

Rationale

Although designs for MITS substations cater for transmission connections known and planned for at the time of the original design, later these same substations frequently need to accommodate further development triggered by new customer connection requests or wider system imperatives. However, these developments require additional physical space, which is acquired with much less time, cost, and disruption to neighbours and to the environment where the necessary land and planning provisions are negotiated at the time that the substation location is first established.

This future-proofing principle encourages designers to take a proactive review of the above triggers (potential customer connections and wider system imperatives) to anticipate and justify appropriate strategic investment in land, equipment or capacity to reduce both future connection delays and incremental local disruption. It advocates a holistic, do-it-once approach to substation design, with the starting presumption that the substation's ground footprint and planning consent will be sized for the connections anticipated by strategic planning processes (including the SSEP and the CSNP[11] as well as for potential new network connection customers), even if some equipment is installed later, as required.

The Principle described here is formulated for the long-term benefit of both local stakeholders and electricity consumers. In doing so, it accords particularly closely with Wales's Well-being of Future Generations Act 2015, since, in its aim to connect new renewable generation quickly, with minimum repeated disruption to local stakeholders, it promotes sustainability and long-term collaboration with, and responsibility for, the well-being of the local and wider community.

Design considerations

- Land availability for the potential future expansion of the substation.
- Strategic investment to acquire options on land or buildings that would help future-proof the substation's ability to satisfy demands on its accommodation.
- Coordination between network needs, customer needs, and future anticipated (not yet specifically identified) needs.
- The appropriate mix of fully equipped bays, skeleton bays (bays with minimal equipment) and future bay space provision (substation space that is initially undeveloped).
- Specification of switchgear capacity for futureproofing.
- Any restrictions on future connection types due to spare bay sizing.
- Space for anticipated (not yet specifically identified) transmission circuit entries, for circuit disposition between bus-sections, and for anticipated reactive compensation requirements.
- For DC multipurpose substations, whether they are designed multi-terminal ready[12].

References

- SSEN's Shetland multi-terminal link at 320 kV, Hitachi Energy, August 2020
- tennet.eu/2gw-program CIGRE paper on Modular Offshore HVDC transmission planning principles, Cigré, 2024
- National Electricity Transmission System (NETS) Security and Quality of Supply Standard (SQSS), NESO, April 2025, Appendix A
- Well-being of Future Generations (Wales) Act 2015

[11] The SSEP and the CSNP: NESO's Strategic Spatial Energy Plan, and NESO's Central Strategic Network Plan.
[12] Multi-terminal ready', as exampled by SSEN in Shetland, or TenneT for Germany and the Netherlands. Multi-terminal readiness considers the need to reserve offshore platform space for further bays and yet-to-be-refined HVDC circuit breakers as well as accommodating spare cable hang-offs and j-tubes in the platform design. Considerations are described by the referenced CIGRE paper on Modular Offshore HVDC transmission planning principles.

01	Strategic parameters for offshore cable designs, such as landfalls, routes, and technology, should balance technical considerations with marine spatial constraints, considering potential impacts on the environment, community, and amenity, as well as deliverability and economic efficiency.

Rationale

Offshore cable design and routeing at the strategic planning stage is primarily influenced by the need for transmission reinforcement or generation connection, the technical requirements of available offshore cable technologies, and marine and landfall spatial constraints. The technical design options identified at this stage will inform the total cost, delivery time, and spatial footprint of the project. The design options will also interact differently with both marine and landfall spatial constraints. These considerations must therefore be carefully balanced during the design process to account for potential impacts on communities and the environment whilst also delivering the required transmission capacity and economic efficiency.

Offshore coordination (spatial and electrical) should be considered during the strategic planning stage as a potential way of achieving further economic and deliverability-based efficiencies, alongside the potential to reduce impacts on the environment and communities (for example, by reducing the number of cable crossings and the extent of external cable protection). The route optioneering itself, during a specific project design, would then be informed by the higher-level strategic coordination considerations.

Design considerations

Technical

- Technical needs for the provision of new transmission capacity and supporting SQSS requirements.
- Technology options using High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC).
- Offshore cable and landfall installation methods.

Offshore cable:

- Marine constraints and sensitive areas including (but not limited to):
    - the marine ecology, marine physical environment, marine historic environment, seabed geology and topology, other marine infrastructure and sea users.
    - Offshore areas that have restricted navigation (for example, moorings and shallow waters).
    - Known wrecks and areas of archaeological/historical importance.
    - Hazardous seabed terrain (e.g. bedrock outcrop, boulder fields, excess slopes) and sediment processes (e.g. mobile sediments).
    - Third parties, including high intensity demersal and static gear fishing areas, local tourist trade, military practice zones and aggregate extraction areas/dredged channels.
    - Anchorage areas, traffic separation schemes and high-density shipping lanes.
    - Marine protected areas and sensitive nature conservation areas both on and offshore (e.g. benthic marine protected areas), and the feasibility and cost of finding a proportionate environmental compensation for potential impacts thereon where they cannot be avoided. Susceptibility to high-impact physical and climate-related events.

Landfall:

- Physical characteristics of the coastline and area in the direct vicinity of landfalls.
- Availability of onshore space at the landfall location to host the required AC substations or DC converter stations and other auxiliary equipment.
- Availability of onshore transmission capacity in the vicinity of landfall locations.
- Presence of communities and/or protected sites and sensitive areas in the vicinity of landfall locations that may experience cumulative impacts.
- Presence of other infrastructure that might heighten (or lessen) the impression of cumulative impacts.
- Susceptibility to high-impact physical and climate-related events.

Coordination:

- Opportunities and risks of shared cable corridors and landfalls being mindful of physical security risks, physical resilience implications and access requirements during construction and operation.
- Availability of marine and landfall space for multiple cable systems, while ensuring sufficient spacing in accordance with the SQSS requirements.
- Opportunities and risks of shared or nearby primary and auxiliary infrastructure onshore and offshore.

References

- HND Follow Up Exercise Methodology, NESO, November 2022
- Export transmission cables for offshore renewable installations, Principles of Cable Routeing and Spacing, Crown Estate, 2012

5. Project Development Principles

The Project Development Principles serve as design guidance to be applied at the relevant stage of a project's lifecycle.

This section contains:

- Overhead Lines: Principles T3 to T7
- Underground Cables: Principle U1
- Substations: Principles S4 to S10
- Offshore: Principles O2 and O3

T3 The starting presumption for support structures for double circuit overhead transmission lines is that they be of a steel lattice design.

Rationale

Where double-circuit overhead transmission lines are selected (see Principle T2 on the overhead line starting presumption for further details), steel lattice towers offer several benefits over other forms of support structures (e.g. monopole constructions such as T-pylons). They have lower levels of embodied carbon (less concrete and steel, whilst still retaining excellent structural integrity), they are easier to construct and maintain (in general they do not require permanent access roads and they can be serviced using smaller site vehicles), and they are more cost-effective. In addition, the lengths of steel angle-section used in lattice towers can be more easily transported to, and assembled in, hard-to-access areas than the prefabricated sections of monopole designs, causing less disruption to the environment and local ecology.

Alongside other benefits, the relatively open silhouette of lattice towers make them easier to see through, allowing them to be backdropped by local landscape features (especially in wooded or moorland areas).

Alternative tower designs, such as monopole and lower height steel lattice towers can reduce landscape disruption and lessen visual impacts in certain highly situation-dependent settings. However, these designs are often more difficult to construct and maintain. Additionally, their increased costs must be weighed against their effectiveness.

Overhead lines form the backbone of the electricity supply to the national economy, so must continue to operate reliably through the very harshest British weather conditions. For this reason, whatever factors contribute to the selection of a transmission support structure design for a given project, be they technical, visual or both, only thoroughly tested, durable designs should be considered.

Design considerations

- Where adverse effects of steel lattice towers on key receptors cannot be mitigated by careful routeing, consider whether alternative tower designs could be visually advantageous and economically justified.
- Differences in national planning policy frameworks between England, Wales, and Scotland.
- Locations of any transitions between different tower designs along a continuous route, considering technical requirements and visual impact.
- Altitude, wind-speeds, ice loading and ground conditions for the tower and foundation design.
- Wood poles as a proven alternative to single circuit steel lattice transmission designs (132 kV in Scotland only), where future double-circuit capacity is not envisaged.
- Opportunities to install structures capable of supporting higher voltages operation and operating at a lower standard voltage in the interim.

References

- UK Electricity Act 1989, Gov.uk, Section 9(2) and Schedule 9
- Approach to Consenting, NGET April 2022
- Approach to Routeing and Environmental Impact Assessment, SPEN, February 2020, p19
- The Holford Rules, Lord Holford, 1959, Version containing NGET notes p5 – “In additional [sic] to adopting appropriate routeing, evaluate where appropriate the use of alternative tower designs now available where these would be advantageous visually, and where the extra cost can be justified.”
- National Planning Framework 4 NPF4, Scottish Government, February 2023, Policy 11
- National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025
- Comparison of Electricity Transmission Technologies: Costs and Characteristics, IET, April 2025

T4 Route options for overhead lines should avoid or seek to minimise the impact on areas of amenity value which are afforded protection through national planning policies, acknowledging the hierarchy of protection designations.

Rationale

The most direct route between two substations is usually the most economic choice for new overhead lines, as it has the potential to minimise the length of infrastructure required and therefore reduces materials and construction costs.

However, in developing route options for new overhead lines, designers may encounter areas of particular sensitivity. These may include settlement areas, designated landscapes, protected habitats, and Heritage Coasts. National Policy Statements (NPS) for England and Wales, and National Planning Framework 4 (NPF4) for Scotland, assign varying levels of protection of amenity to these areas that should be considered and addressed by all proposals for new developments.

Design should endeavour to avoid or minimise, the impacts on the amenity value of sensitive areas. It is important to balance the benefits of following the hierarchy of designated protections in national planning policies against the technical feasibility and the costs of routeing an overhead line to avoid areas of amenity value.

Design considerations

- The type and extent of protection afforded to designated areas or buildings under relevant national planning policies[13].
- Differences in policy frameworks and protection levels between England, Wales, and Scotland.
- In England, certain designated landscapes have statutory purposes set out in legislation, and public bodies are required to seek to further those purposes when exercising their functions.
- Trade-offs associated with lengthening routes to avoid protected areas, including the additional number, location and impact of the larger angle towers which are required. to change the direction of the new overhead line.

References

- National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025
- National Planning Framework 4 NPF4, Scottish Government, February 2023
- UK Electricity Act 1989, Gov.uk, Section 9(2) and Schedule 9
- Guidance for relevant authorities on seeking to further the purposes of Protected Landscapes, DEFRA, December 2024
  - The Holford Rules, Lord Holford, 1959
  - Rule#1 'Avoid altogether, if possible, the major areas of highest amenity value, by so planning the general route of the line in the first place, even if the total mileage is somewhat increased in consequence.'
  - Rule#2 'Avoid smaller areas of high amenity value, or scientific interest by deviation; provided that this can be done without using too many angle towers, i.e. the more massive structures that are used when lines change direction.'
  - Rule#3: 'Other things being equal, choose the most direct line, with no sharp changes of direction and thus with few angle towers.'

[13] For example, the NPS EN-5 [2.9.12] states for England and Wales that "*in nationally designated landscapes (for instance, National Parks, The Broads and Areas of Outstanding Natural Beauty) even residual impacts may well make an overhead line proposal unacceptable in planning terms*".

T5	Route options for overhead lines should seek to balance the impacts on communities and the environment with technical and cost considerations.
Rationale Overhead line routes traverse areas of varying landform, topography, ecology, land use and population. The routeing of an overhead line should follow a landscape-led approach, seeking to balance competing factors to minimise the line's overall impact on communities and the environment while delivering the technical need. This could involve, for example, balancing the benefits of avoiding prominent skylines or ridgelines and using natural screening (e.g. trees or hills) to break up views of the infrastructure and reduce perceived height of supports, against the potential drawback of routeing in lower-lying areas which may bring infrastructure closer to settlements and properties. Re-routing part of the line is likely to affect adjacent sections of the line. Design decisions should, therefore, demonstrate how often competing considerations are balanced along the length of the overhead line route.	**Design considerations** • Proximity to settlements and land use categories, including residential, industrial, and mixed-use areas. • Topography and landform features that influence visibility and provide opportunities for screening, while ensuring appropriate buffers. • Cumulative visual impacts from existing electricity infrastructure and other developments. • Opportunities to maintain visual consistency in tower design, height, and alignment. • Ecology, including wildlife areas such as woodlands, wetlands or bird migratory routes. • Deliverability and accessibility of the route for construction and ongoing maintenance. • Cost of the different route options.

References

- The Holford Rules, Lord Holford, 1959
- Rule#4: 'Choose tree and hill backgrounds in preference to sky backgrounds wherever possible; and when the line has to cross a ridge, secure this opaque background as long as possible and cross obliquely when a dip in the ridge provides an opportunity. Where it does not, cross directly, preferably between belts of trees. '
- Rule#5: 'Prefer moderately open valleys with woods where the apparent height of towers will be reduced, and views of the line will be broken by trees.'
- Rule#7: 'Approach urban areas through industrial zones, where they exist; and when pleasant residential and recreational land intervenes between the approach line and the substation, go carefully into the comparative costs of the undergrounding, for lines other than those of the highest voltage.'

T6	Where a continuous overhead line route that avoids designated landscapes cannot be identified, consider forms of mitigation for environmental, community and technical impacts.
Rationale Where a proposed new continuous overhead line route[14] passes through one or more designated or protected areas and re-routeing is not feasible, a review of the likely adverse effects should be undertaken as part of any required environmental assessments[15] to determine whether there is an emerging case for considering other forms of mitigation. Planning for mitigation should be undertaken at the earliest opportunity, so costs are factored into decision making. Mitigation options come with their own set of challenges and must be thoroughly justified in balancing economic viability, technical feasibility and the extent of the predicted effects on a receptor or grouping of receptors. Where, following conversations with affected stakeholder(s), (1) the effects on a sensitive receptor or group of receptors, are assessed by the relevant professional as being over and above the thresholds of significance defined in relevant environmental assessment legislation and guidance, or (2) where the technical feasibility brings into question the continuity of an overhead line, and (3) where these effects cannot be otherwise mitigated, undergrounding sections of the line may be the only viable alternative. The assessment of potential underground solutions must carefully balance the advantages and disadvantages of undergrounding, considering environmental impact, costs and associated technical issues within the context of relevant obligations.	**Design considerations** • Where factors are identified that call into question the continuity of an overhead line route, carefully assess the advantages and disadvantages of undergrounding, including environmental and community considerations, while ensuring that costs remain proportionate to the benefits delivered and mindful of the technical and operational challenges associated with undergrounding. • As a guiding example, undergrounding a section of a line should be carefully considered where it crosses a National Park, Area of Outstanding Natural Beauty or a National Scenic Area, provided no suitable overhead line route can be identified. • Ground conditions preventing certain cable ratings, complex crossings with other infrastructure, other designations and limited access areas. • Availability of space for cable sealing end compounds and their impacts on the visual amenity. • Alternative tower designs (see Principle T3). • Compensatory planting where woodland is removed.
References • assets.publishing.service.gov.uk/media/64252f852fa848000cec0f53/NPS_EN-5.pdf National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025, Paragraphs 2.9.20, 2.9.23 to 2.9.25 • National Planning Framework 4 NPF4, Scottish Government, February 2023, Policy 11(e) • Comparison of Electricity Transmission Technologies: Costs and Characteristics, IET, April 2025 • Approach to Routeing and Environmental Impact Assessment, SPEN, February 2020, p9	

[14] In this context, a "continuous" overhead line refers to a design with no underground sections and consistent support structures used throughout the route.
[15] Environmental, Impact Assessments (EIA), Habitats Regulations Assessments (HRA) for European designated sites, and SSSI consent requirements.

T7	Consider overhead line transmission routes and designs that minimise susceptibility to high-impact physical and climate-related events.
Rationale The increasing frequency of extreme weather events due to climate change threatens the resilience of Great Britain's transmission networks. Whilst overhead lines are designed to be exposed to sustained periods of wind and rain, temperature fluctuations and ice loading, this infrastructure remains susceptible to more severe external influences, including very high temperatures, wildfires, intense flooding and airborne debris. These climate-related events, such as flooding and wildfires, can damage conductors and tower structures, leading to temporary disruptions (e.g. electrical flashovers) or more permanent failures that pose safety risks and can undermine the system's operational flexibility, heightening the risk to security of supply. In addition to environmental risks, transmission routes may also be exposed to malicious threats, such as sabotage or vandalism, which could result in significant outages and safety hazards. Given that transmission infrastructure is rarely relocated once built and is designed for operational lifespans of up to 80 years, it is essential to embed resilience against both physical and security risks in routeing and design decisions from the outset.	**Design considerations** • Risk zones, including areas prone to natural hazards such as flooding, land slip, high winds, icing, and wildfires, can restrict access for maintenance or repair. Risks can be mitigated with strategies such as designing for flood resilient infrastructure, crossing at a risk zone's narrowest point, as directly as possible, spanning the lowest flood levels by choosing tower locations above normal flood levels or using strengthened tower designs. • Nature based solutions for mitigating certain impacts such as peatland restoration to stabilise soils and store carbon. • Malicious threats, such as sabotage or vandalism, ensuring that the materials and the way in which they're used maintain or improve current levels of physical security (e.g. enhanced anti-climb measures).

References

- ETR 138 Resilience to flooding of Grid and Primary substations, ENA, 2018
- CCAR4 ENA Fourth Round Climate Change Adaptation Report, ENA, December 2024
- Approach to Routeing and Environmental Impact Assessment, SPEN, February 2020, p12
- assets.publishing.service.gov.uk/media/64252f852fa848000cec0f53/NPS_EN-5.pdf National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025, Section 2.3 "…ensure that electricity networks infrastructure is resilient to the effects of climate change."
- Electricity Safety, Quality and Continuity Regulations, Gov.uk, 2002

U1 Where underground transmission cables are proposed, impacts on communities, the environment and visual amenity need to be balanced with the costs and inevitable technical constraints of underground cable technology, including ground conditions, land use and access.

Rationale

Underground transmission cable routeing differs fundamentally from the landscape-led approach used for overhead lines. While overhead line design prioritises minimising visual and landscape impacts, underground cable routeing is primarily engineering-led, since routes are determined largely by technical feasibility, constructability, safety, and cost.

High-capacity AC underground circuits require wide construction swathes (typically 35–70 metres) to allow for heat dissipation, with trenches to bury cables around 1.2 metres deep. These physical requirements, combined with the need to avoid challenging ground conditions, flood zones, and sensitive and protected habitats, and the greater motivation for routes to be shorter due to the higher cost of underground cables, often result in routes that diverge significantly from those of an equivalent overhead line.

Although, with the exception of their sealing ends, cables are less visually intrusive post-construction, underground cable installation causes substantial ground disturbance and has the potential to increase environmental and landowner impacts significantly during installation, compared to that of an equivalent overhead line. The success of land reinstatement varies by land type, being quicker and least visible in agricultural land and most visible and long-lasting in uplands or semi-natural areas.

Unlike overhead lines, which can span certain obstacles such as protected waterways and habitats, underground cables typically avoid them altogether or, where practicable, use specialist methods, such as horizontal directional drilling (HDD) or tunnelling, to install the cables safely under the obstacle. This can significantly increase project costs and in some locations may not be technically feasible. As such, careful route selection, habitat protection and reinstatement, and long-term access planning are essential to minimise both temporary and permanent environmental effects.

Design considerations

- Cable technical constraints including bending radii, above-ground accommodation of sealing ends, heat dissipation, access for maintenance, and additional AC reactive power compensation equipment, where relevant and DC converter stations.
- Environmental disturbances during construction and repair (such as noise, visual, air quality, soil migration, contamination, stability, and drainage).
- Designated and undesignated archaeology including Scheduled Monuments. Opportunities and risks associated with routeing along existing and proposed disturbed corridors such as roads or existing infrastructure to reduce overall impacts, being mindful of physical security risks, physical resilience implications and access requirements during construction and operation.
- Longer construction and repair times than overhead lines. Note The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 provisions for construction as well as for operational conditions. Safety and land use requirements in areas directly above the buried cables.
- The cost and availability of underground cables for a given application, which may vary on a case-by-case basis.
- Susceptibility to high-impact physical and climate related events, including flooding or drought.
- Innovative high technology readiness level (TRL) techniques that improve transmission cable installation speeds or reduce impacts.

References

- Approach to Routeing and Environmental Impact Assessment, SPEN, February 2020
- Undergrounding high voltage electricity transmission lines - The Technical Issues, NGET, January 2015
- assets.publishing.service.gov.uk/media/64252f852fa848000cec0f53/NPS_EN-5.pdf National Policy Statement for Electricity Networks Infrastructure (EN-5), DESNZ, December 2025, Paragraphs 2.9.23 to 2.9.25
- The Infrastructure Planning (Environmental Impact Assessment) Regulations, 2017 (for England)

S4	Where appropriate, locate new substations or converter stations near to the infrastructure to which it will connect.
Rationale During the project development stage, substation siting choices should be optimised to reduce transmission infrastructure requirements and associated impacts. For new substations or converter stations, consideration should be given to locating them close to the transmission assets to which they will connect, or, at least, close to the preferred transmission route, as this typically reduces the extent of the new transmission connections required, thereby reducing both the associated impacts and the cost.	**Design considerations** • Distance to existing transmission infrastructure requiring connection or diversion. • Number and configuration of circuit entries and exits and the length and routeing complexity of new transmission connections required. • Land availability and ground conditions. • Access requirements for construction and maintenance. • Environmental, community and other planning constraints for the areas under consideration.
References • Informed by discussions with transmission project developers.	

S5	Siting of new substations and converter stations should seek to minimise susceptibility to high-impact physical and climate related events.
Rationale Extreme climate related events, such as floods, land slip, wildfires and heatwaves, present an enduring threat to the resilience of Great Britain's transmission networks. These events are increasing in frequency and intensity due to climate change, which poses new challenges for designers of transmission substations. Substations are also susceptible to malicious threats, such as sabotage and vandalism. Careful engineering consideration of not only the technical requirements but also the environmental factors (including visual amenity) and stakeholder views will allow siting to balance these risks with a view to reducing overall effects and improving infrastructure security. Once constructed and in operation, transmission infrastructure is rarely relocated due to its scale and its integral role in providing security of supply. Moreover, substations are generally designed to operate for 40 years, or longer, so it is important to consider physical and future climate related risks in the positioning and design of new transmission infrastructure.	**Design considerations** • Avoidance of areas prone to natural hazards such as flooding, land slip, subsidence, high winds, icing, and wildfires. • Electrical redundancy and diversity of substation auxiliary supply[16]. • Single points of failure for incoming and outgoing circuits of the Main Interconnected Transmission System (MITS)[17]. • Materials and equipment that operate efficiently under foreseeable environmental conditions. • Security enhancing measures, for example, flood prevention through nature-based solutions, water barriers or raising equipment within a substation or converter station; such design details would be subject to engineering judgement regarding its efficacy, and dependent upon any consequential landscape and visual impacts, but note that nature-based design features can help protect the development against climate related events whilst also restoring and managing ecosystems to benefit both people and the environment. • Ease of operational and maintenance access. • Measures to deter non-authorised entry to substations and mitigate the impact of other malicious actions on or relating to the substation.
References • Flood defence framework for National Grid substations in United Kingdom, Climate Adapt, 2019 • Enhancing Resilience in UK Energy Networks, DESNZ, April 2024 • Electricity Safety, Quality and Continuity Regulations, Gov.uk, 2002 • The Environment Agency's approach to groundwater protection, February 2018, Version 1.2	

[16] Back-up power supplies to ensure essential substation systems continue to operate if one supply fails.
[17] Points of failure that could interrupt power flows due to a lack of alternative connections.

S6 Substations may be designed for indoor or outdoor service, and may comprise air insulated or gas insulated switchgear, dependent upon many site-specific factors

Rationale (general)

A substation may be installed either outdoors or indoors, and it may comprise either air-insulted switchgear (AIS) or gas-insulated switchgear (GIS). Both enclosure choices and both insulation technologies have their advantages; outdoor AIS can often be the economic choice for new substation designs, however, the key benefit of GIS, namely that it normally requires a reduced ground footprint compared to that of AIS, means it can, in some cases, offer a more economic and efficient solution. Some further comparative details follow.

Rationale (indoor or outdoor?)

Transmission substations may be installed outdoors or enclosed in protective buildings. Whilst it is less costly to install substations outdoors, there are a few reasons why some substations are installed indoors, key amongst them being:

- For GIS: The UK climate tends to degrade the external parts of GIS, impacting its long-term reliability and, in particular, compromising its ability to effectively retain the insulating gas, so GIS equipment is normally, though not always, enclosed indoors, thus enhancing its expected lifetime.
- For AIS: Pollution (such as salt from blown sea spray, or industrial pollution) would, over time, degrade the performance of AIS substation steelwork, insulators and other components. Equally, in some locations, extreme weather (for example, heavy icing, severe snow, high winds) may jeopardise network operability and resilience. Such pollution or weather conditions may well lead to the judgement that an AIS substation in that area should be installed indoors to mitigate the associated risks. Again, this treatment improves the expected switchgear lifetime. Note, however, that the physical scale and associated costs of the required building become increasingly significant at higher transmission voltages.

Rationale (AIS or GIS technology?)

A substation's high voltage switchgear connections and busbars are insulated either by air (AIS) or by an insulating gas (GIS). Differences between the two technologies include:

- Environmentally: GIS typically needs a smaller ground footprint than AIS, though this only applies to the switchgear itself, not to the other substation components, such as transformers, reactive compensation, and overhead line entries. For this reason, for substations with a greater number of plant items and/or connecting circuits, the space-saving benefit of GIS is usually less significant. The size of the substation footprint will proportionally affect the volume of earthworks, the quantities of concrete and steel required and, in some cases, the extent of biodiversity and visual impacts. In which case these effects will tend to be greater for AIS construction than for the equivalent GIS. Conversely, GIS construction involves greater use of metal in its insulating enclosures compared to AIS and requires much more insulating and interrupting gas (IIG), both of which have a heavy carbon cost. Operationally, AIS substations almost invariably use much smaller amounts of IIG than the equivalent GIS substations[18]. Regarding visual impact, where AIS is installed outdoors, its relatively open silhouette, and its smaller ancillary buildings, differ from the 'block' effect of a GIS building that is inevitably taller, wider and longer than the equipment it contains. Except in built-up areas, screening by trees and earthworks can equally be applied to both substation technologies to reduce their visual impacts. A site-specific assessment should thus consider the balance of the following factors for any proposed substation.
- Technically: AIS substations are simpler to repair than GIS, though regular maintenance of healthy GIS equipment is simpler and less frequent than that for AIS. As described above, AIS can be installed indoors or outdoors, however, at least in the UK, GIS is predominantly installed indoors to preserve its operational reliability.
- Future extension: AIS substations are typically easier to extend and have lower reliance on the original equipment manufacturer than GIS. However, it is easier to design in space for future expansion to a GIS substation as it takes up less land initially and the equipment required for future extensions is much smaller than an AIS.
- Ageing substations: Individual asset replacement or refurbishment of AIS is normally straightforward; however, for GIS, individual asset replacement is highly dependent upon the original equipment manufacturer and continuing availability of compatible components. Furthermore, a full end-of-life replacement of an AIS substation whilst maintaining operations can be more challenging than that of a GIS equivalent, due to the larger simultaneous space requirement of both operational and new-build equipment.
- Cost-wise: the purchase cost for GIS equipment is normally higher than for the AIS equivalent, although the overall lifetime cost comparison for the full solution between the two technologies will depend upon many factors including the location, land-take and planning conditions, the cost of land, the need for a substation building, the extent of earthworks, lifetime carbon costing, biodiversity net gain costs and projected maintenance and repair costs.

See Principle S10 for further consideration of lifetime carbon impacts.

Design considerations

Substation design is complex and affected by many variables, including (but not limited to):

- Space available for each substation site option given the availability of unconstrained land areas.
- Visual impact from key viewpoints considering the smaller footprint of a GIS block building versus the larger footprint and openness of outdoor AIS.
- Expected pollution levels (salt spray, industrial or other airborne pollution).
- Cost of the different substation options including lifetime costs.
- Severity of anticipated weather conditions such as heavy icing or high winds.
- The global warming potential of the composition of gases that comprise the insulating medium[19].
- Ecological and resources effects such as disturbance of peat and mineral-rich soils, whose impacts are sensitive to the volume of construction earthworks.

References

- The Horlock Rules for the Siting and Design of Substations, National Grid Company, 2006,
- Rule#7 Note 8 'Where there are particular technical or environmental constraints, it may be appropriate to consider the use of GIS equipment which occupies less space and is usually enclosed within a building'
- Evaluation of Different Switchgear Technologies (AIS, MTS, GIS) For Rated Voltages of 52 kV and Above (390), Cigré, August 2009

[18] Historically, the IIG used in both AIS and GIS has been sulphur hexafluoride (SF_6), which has a very powerful global warming potential (GWP). From 2025 there will be a number of GIS and AIS alternative SF_6 free technologies available for use by transmission and distribution operators. Whilst a full route to phasing out SF_6 in electrical switchgear for GB networks is being explored by the UK Government, operators have begun to install SF_6-free alternatives.

[19] Whilst distinctly less potent than legacy SF_6, the SF_6-free F-gas alternatives are still powerful greenhouse gases.

S7 Optimise, with respect to its surroundings, the space to be occupied by any new substation or converter station, its line entries, and potential future extensions.

Rationale

Whilst Substation Principle S3 urges the designer to set aside enough space for current and future substation needs, this complementary Principle focuses upon using that space efficiently, balancing technical requirements with careful regard to the community and the uses of land into which it is placed, to minimise disruption to the lives, businesses and environment that its arrival effects.

Early consultation with stakeholders allows understanding of the local issues, as a first step to optimising the location and layout of the substation and its transmission line entries. Consideration should be given to mitigating any changes of access to roads, buildings, footpaths and fields and to the useability of land parcels that are left surrounding the station. Consideration should also be given to mitigating environmental impacts. In rural locations this could be through tree planting or earthworks, for which additional ground space would most likely be required whilst, in urban environments, suitable perimeter walls or buildings might offer the most appropriate impact mitigation of visual effects.

Design considerations

- Access and egress for abnormal indivisible loads.
- Access and accommodation for Construction.
- Access, egress, and control point facilities for emergency services (fire, police and ambulance).
- Utility diversions.
- Detour lengths and routes for established rights of way.
- Drainage considerations, minimising environmental impacts and maintaining established field boundaries.
- Environmental factors such as ecology and biodiversity, cultural heritage, archaeology visual and acoustic noise.

References

- The Horlock Rules for the Siting and Design of Substations, National Grid Company, 2006
- Rule#4: 'The siting of substations, extensions and associated proposals should take advantage of the screening provided by landform and existing features and the potential use of site layout and levels to keep intrusion into surrounding areas to a reasonably practicable minimum. '
- Rule#6 'The land use effects of the proposal should be considered when planning the siting of substations or extensions.'
- Rule#8: 'Space should be used effectively to limit the area required for development consistent with appropriate mitigation measures and to minimise the adverse effects on existing land use and rights of way, whilst also having regard to future extension of the substation.'

S8 Consider the implications of overhead line and underground cable connections in the siting and design of substations or converter stations, and any mitigation or enhancement required.

Rationale

Where overhead lines converge and enter a substation or converter station, the visual effect of the lines and their terminal towers, or 'wirescape' must be carefully considered. The design of these assets should endeavour to mitigate cumulative wirescape issues by siting line entries and using visual screening in this way helping to ensure that landscape and environmental factors are considered alongside technical requirements.

Design considerations

- Existing and planned overhead line entries, potential conglomerations of structures and wires, as seen from key viewpoints.
- Cumulative visual impacts at key viewpoints due to anticipated substation or converter station extensions or new line entries.
- Visual impact mitigation such using landscaping as screening.
- Designated landscape impacts and any mitigation or enhancement required.
- Planned customer connections to sites via either overhead line or underground cables.
- Environmental factors such as ecology and biodiversity, cultural heritage and archaeology.

References

- The Horlock Rules for the Siting and Design of Substations, National Grid Company, 2006
- Rule#7: 'In the design of new substations or line entries, early consideration should be given to the options available for terminal towers, equipment, buildings and ancillary development appropriate to individual locations, seeking to keep effects to a reasonably practicable minimum.'
- Rule #10: 'In open landscape especially, high voltage line entries should be kept, as far as possible, visually separate from low voltage lines and other overhead lines so as to avoid a confusing appearance.'
- The Holford Rules, Lord Holford, 1959
- Rule#6: 'In country which is flat and sparsely planted, keep the high voltage lines as far as possible independent of smaller lines, converging routes, distribution poles and other masts, wires and cables, to avoid a concatenation or 'wirescape.'

S9 The design of substations, converter stations, access roads and other ancillary developments should consider the local environment in the vicinity of the new infrastructure.

Rationale	Design considerations
A new substation or converter station, with its access road and other ancillary developments can have a considerable impact upon the ecology, hydrology and visual amenity of the locality. However, with careful consideration during the project development stage, most effects can at least be mitigated, if not avoided. Substation and converter station design should ensure that, whilst any new substation achieves its functional purpose, its impacts on its surroundings are studied through required environmental assessments to inform the design so that impacts can be avoided and where not, mitigated as necessary. For visual impact mitigation this could take the form of careful siting and layout of the infrastructure, consideration of the design, colour and form of buildings, or partial visual screening with vegetation or earthworks. For ecological impacts, substation design should avoid negative effects, but where this is not possible, minimise and mitigate such negative effects.	• Ecological effects on the surrounding area, including potential impacts on habitats and species. • Hydrological conditions, such as flood risk and water flow patterns, which influence both siting and design of infrastructure and access roads. • Visual impact from key viewpoints, with opportunities for mitigation through siting, layout, building form, colour, and screening measures. • The protection or avoidance of groundwater protection zones.

References

- The Horlock Rules for the Siting and Design of Substations, National Grid Company, 2006
- Rule#1: 'In the development of system options including new substations, consideration must be given to environmental issues from the earliest stage to balance the technical benefits and capital cost requirements for new developments against the consequential environmental effects in order to keep adverse effects to a reasonably practicable minimum.'
- Rule#3: 'Areas of local amenity value, important existing habitats and landscape features including ancient woodland, historic hedgerows, surface and ground water sources and nature conservation areas should be protected as far as reasonably practicable.'
- Rule#5: 'The proposals should keep the visual, noise and other environmental effects to a reasonably practicable minimum'
- Rule#9: 'The design of access roads, perimeter fencing, earth shaping, planting and ancillary development should form an integral part of the site layout and design to fit in with the surroundings.'
- Rule#11: 'The inter-relationship between towers and substation structures and background and foreground features should be studied to reduce the prominence of structures from main viewpoints. Where practicable the exposure of terminal towers on prominent ridges should be minimised by siting towers against a background of trees rather than open skylines.'
- The Environment Agency's approach to groundwater protection, February 2018, Version 1.2

S10 When designing substations, substation extensions, and converter stations, seek to minimise carbon impact in construction and operations

Rationale	Design considerations
As with all major infrastructure projects, the construction of substations and extensions depends on materials such as concrete and steel, which are often manufactured using relatively carbon-intensive processes. Designers should seek to minimise the lifetime carbon impact from these sources whilst also considering other sustainable construction and operational solutions that may arise from time to time. See Principle S6 for further considerations of the use of SF_6 and alternative interrupting and insulating gases (IIG) to reduce carbon-equivalent impacts on the environment.	• Extent of disturbance to natural carbon sequestration (e.g. trees, peat, wetlands, ponds and seagrass) • The degree to which the substation's layout follows land contours, to minimise energy-consuming earth-moving. • Type(s) of concrete used, and associated water consumption. • Potential for natural air and oil flow cooling systems to reduce operational emissions, supported by appropriate equipment and thermal designs, and noting the trade-off with this leading to larger equipment sizing. • Balance between lifetime operational emissions from technical losses and cooling, and the embodied carbon from equipment manufacture.

References

- Informed by discussions and engagement with transmission project developers.

O2 In the design of offshore cable routes, consider opportunities and risks arising from coordination with other existing and planned offshore infrastructure in the region

Rationale

Developers of offshore transmission infrastructure should consider opportunities to coordinate with other projects. This could include, at the earlier stages of a project's development, the consideration of the following aspects of other project(s) being developed in the region: delivery programmes, cable installation corridor alignments, identified landfall areas.

Coordination can bring several benefits:

- More efficient use of space by routeing multiple cables along parallel corridors and towards common landing points.
- Potential reduction in disruption/interaction with most sensitive environments and communities.
- Minimising interactions with existing infrastructure and avoiding overlapping routes, with additional cable crossings.
- Lower cost by sharing surveys, equipment, and construction efforts (e.g. installation vessels and trenching operations).

However, coordination also comes with risks:

- Possible delays or additional costs if projects are interdependent.
- Increased vulnerability to damage or failure resulting in security risks if assets are too close to each other.
- Challenges in accessing and repairing adjacent infrastructure.
- Potential risks due to interface management between multiple developers – delays, dependencies, commercial, regulatory and liability difficulties, etc – that would prevent the transmission developers from meeting their licence obligations.

Once a cable route corridor is chosen in the light of the other known projects, the developer would not be expected to change the cable route corridor later to accommodate new third-party plans.

Design considerations

- Marine and landfall spatial and temporal constraints which limit space for multiple cable systems or impose restrictions on subsea cable installation.
- Requirements for cable spacing for the projects under consideration and the availability of required seabed and landfall area.
- Relative timing and location of developments in the vicinity.
- Potential to minimise the number of cable crossings.
- Potential for coordinated impact mitigation measures, subject to each project's consents obligations.
- Potential security and safety risks due to physical proximity of coordinated assets – risks of common failure modes (internal failures and external damages).
- Available space and ease of access for repair and servicing.

References

- Proximity Study, The Crown Estate, 2012
- Cable Burial Risk Assessment Methodology, Carbon Trust, 2015

O3 Landfall area locations should meet the technical requirements of the overall project, while respecting both marine and terrestrial constraints, considering potential impacts on environment, community, as well as deliverability and economic efficiency.

Rationale

Offshore transmission infrastructure makes landfall at various locations along the coastline of Great Britain. For offshore transmission infrastructure, the location of landfall is primarily influenced by the technical need to provide transmission capacity in that geographical region. This is then refined and assessed by considering the detailed technical design requirements, environmental constraints, potential impacts on communities, economic efficiency, deliverability and security of supply, in order to determine a suitable landfall location.

Design considerations

- The primary technical need justifying the requirement for new offshore transmission infrastructure, and thus determining the wider geographical region for the location of the landfall
- Location of feasible landfall locations with reference to marine and terrestrial spatial constraints, including local communities and tourism; environmental designations and features of conversation importance, historic environment designated sites and features of interest; suitable geology and topography as well as other existing or planned infrastructure. Availability of access roads and other enabling infrastructure and facilities.
- Availability of sufficient onshore space at the landfall location to host the required High Voltage Alternating Current (HVAC) or High Voltage Direct Current (HVDC) cables and other auxiliary equipment.
- Location of point of connection with available capacity for feed-in
- Feasibility of offshore and onshore cable corridors to and from landfall locations, alongside consideration of their interactions with the environment and local communities.
- Potential for applying mitigation measures.
- Availability of landfall space for planned and future cable systems, while ensuring sufficient spacing in accordance with the SQSS requirements.

References

- Proximity Study, The Crown Estate, 2012

6. Governance

Ownership and Management of the Principles

NESO owns the ETDP publication and leads the management and maintenance of the Principles.

Endorsement in National Planning Policies

These Principles are referenced in DESNZ's National Policy Statement for Electricity Networks Infrastructure (EN-5), December 2025, which states that developers should have regard to the ETDP for nationally significant infrastructure in England and Wales. Whilst recognising that some planning law is devolved, NPS EN-5, and therefore the ETDP, may become increasingly relevant as cross-border transmission links are developed to meet future energy needs.

Review Cycles

The ETDP is designed to be enduring. Nevertheless, from time-to-time NESO may conduct a review of the ETDP to ensure that the Principles remain relevant, up-to-date and fit-for-purpose. Reviews are expected to occur at the following intervals and will incorporate feedback from the practical application of ETDP to new projects:

- Early Impact Review: 12 months after initial publication.
- Full Review: In step with any future update of the NPS or every 5 years as a backstop.

Change Process

NESO shall convene a Working Group of industry stakeholders, drawn from the organisations that developed the Principles, to consider major amendments to the ETDP, consulting more widely where appropriate to do so. Minor changes will be considered by NESO during routine review cycles.

7. Legal Notice

For the purposes of this document, the terms "NESO", "we", "our", "us" etc. are used to refer to National Energy System Operator Limited (company number 11014226).

This document has been prepared in good faith by NESO (the National Energy System Operator Limited, company number 11014226) pursuant to its statutory duties. It represents the output from the working group it convened pursuant to the Department of Energy Security and Net Zero's Transmission Acceleration Action Plan. NESO's role in respect of the Electricity Design Transmission Principles includes convening and leading the working group and co-developing and consulting on the Principles. NESO's role in respect of the Principles is not policymaking, endorsing into planning law (into the NPS or otherwise), and/or decision-making in respect of consenting specific projects.

The content of this document is not intended to constitute legal, financial, or other professional advice and nothing within this document alters or supersedes applicable policy and law. Readers and/or any party interpreting, considering and/or applying the Principles should not act, refrain from acting, and/or place any reliance upon the contents of this document, should make independent enquiries as to the legal and practical implications of applying the Principles in any specific context, and should seek their own independent professional advice tailored to their specific circumstances and applicable policy and law.

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8. Glossary

Acronym	Description
Air Insulated Switchgear (AIS)	Switchgear that uses air as an insulating medium to dissipate fault currents.
Alternating Current (AC)	A type of electricity transmission in which the voltage varies in a wave fashion, resulting in a current flow that periodically reverses direction. In Great Britain the direction is reversed 50 times each second, which is known as a frequency of 50 Hz. The majority of onshore electricity transmission is AC in Great Britain.
Busbar / Double Busbar	A busbar is a conductive bar or set of bars within a substation that collects and distributes electrical power to multiple circuits. A double busbar arrangement uses two busbars to provide additional operational flexibility and resilience, enabling circuits to be switched between busbars and maintained without full outages.
[Department for] Business, Energy and Industrial Strategy (BEIS)	A former UK government department responsible for business, industrial strategy, energy and climate policy. BEIS was replaced in 2023 when government responsibilities were reorganised, including the creation of the Department for Energy Security and Net Zero (DESNZ).
Cable Sealing Ends	Equipment used to terminate a high-voltage cable and connect it to other assets (e.g., overhead lines, GIS, transformers, or switchgear). Cable sealing ends provide electrical insulation and mechanical sealing, ensuring safe stress control at the cable termination.
Carbon Dioxide (CO_2)	A greenhouse gas produced naturally and through human activities (e.g., fossil fuel combustion). CO_2 is used as the reference gas for comparing the climate impact of other greenhouse gases for GWP.
Centralised Strategic Network Plan (CSNP)	A longer-term strategic assessment of transmission network needs, primarily for the transfer of energy across electricity transmission, gas transmission, and hydrogen, initially to 2050 but with a rolling 25-year time horizon. It will assess options for achieving the net zero target and select optimal projects for a shorter-term delivery, and a longer-term range of potential projects for future delivery.

Acronym	Description
Chief Executive Officer (CEO)	The most senior executive in an organisation, responsible for overall leadership, strategic direction and organisational performance.
Circuit / Single Circuit / Double Circuit	A circuit is an electrical path used to transmit power, typically comprising three phases at transmission voltage. A single circuit refers to one three-phase set of conductors on a given route. A double circuit refers to two independent three-phase circuits on the same route, often carried on the same towers, increasing capacity and operational resilience.
Conductor / Twin Conductor / Quad Conductor	A conductor is the wire/cable that carries electrical current. Twin conductor (twin bundle) refers to two conductors per phase, electrically connected and spaced apart. Quad conductor (quad bundle) refers to four conductors per phase. Bundled conductors reduce electrical losses, corona effects, and audible noise, and increase power transfer capability.
Conseil International des Grands Réseaux Électriques (CIGRE) *[English: International Council on Large Electrical Systems]*	An international non-profit organisation that publishes technical guidance and research on electricity transmission and distribution systems, including best practice, working group reports, and industry reference documents.
[HVDC] Converter Station	Electrical substation located that converts electrical power from AC to DC or vice versa in high-voltage direct current (HVDC) transmission systems
Critical National Infrastructure (CNI)	Assets, systems and networks that are essential to the functioning of a country, the loss or compromise of which could cause significant disruption to national security, the economy, public safety, or essential services (including the electricity system).
Department for Energy Security and Net Zero (DESNZ)	UK government department focused on the energy portfolio, formerly part of the Department for Business, Energy and Industrial Strategy (BEIS). DESNZ is responsible for delivering security of energy supply, ensuring properly functioning energy markets, encouraging greater energy efficiency and seizing the opportunities of net zero to lead the world in new green industries.

Acronym	Description
Department for Environment, Food and Rural Affairs (DEFRA)	A UK government department responsible for improving and protecting the environment. They aim to grow a green economy and sustain thriving rural communities supporting food, farming and fishing industries.
Direct Current (DC)	Electrical current that flows in one direction only.
Electricity Transmission Design Principles (ETDP)	The ETDP are a key recommendation outlined by the Electricity Network Commissioner Nick Winser and discharged by the Transmission Acceleration Action Plan. These principles seek to provide greater clarity on the type of asset to be considered in different environments and to set out the core rationale and design considerations that shape the development of the electricity transmission system.
Environmental Impact Assessment (EIA)	A process that evaluates the potential environmental consequences of a project or development before it is approved.
Fluorinated Gas (F-Gas)	A category of manufactured gases containing fluorine that have high GWP. In electricity transmission, F-gases have historically been used as insulating and arc-quenching media in gas-insulated equipment such as GIS.
Gas Insulated Busbar (GIB)	A high-voltage busbar enclosed within a sealed metal housing filled with insulating gas. GIB is used to connect substation bays or components in a compact layout, often where space is constrained.
Gas Insulated Switchgear (GIS)	Switchgear that uses gas (typically F-gas) as an insulating medium to dissipate fault currents. Can also be used for a Gas Insulated Busbar (GIB).
Global Warming Potential (GWP)	A measure of how much heat a greenhouse gas traps in the atmosphere over a specific time period, relative to carbon dioxide (CO_2).

Acronym	Description
Great Britain (GB)	Collective term used to describe UK nations of England, Scotland and Wales, excluding Northern Ireland
Habitats Regulations Assessment (HRA)	A process that evaluates the potential impacts of a project or development on habitats before it is approved.
High Voltage Alternating Current (HVAC)	Transmission voltages of 400 kV and 275 kV in England and Wales, and 400 kV, 275 kV and 132 kV in Scotland.
High Voltage Direct Current (HVDC)	Transmission voltage typically at ±320 kV or ±525 kV using direct current to transmit power over significant distances minimising transmission losses. An offshore High Voltage Direct Current (HVDC) transmission link comprises two onshore DC converter stations connected to separate nodes on the transmission network, along with two or three HVDC offshore cables connecting the two converters. Each of these converter stations is expected to occupy between 4- 5 Ha, which is approximately 8 times larger than a football pitch. It is important to note that not all offshore cables use HVDC technology; routes of a few tens of kilometers can use High-Voltage Alternating Current.
Horizontal Directional Drilling (HDD)	A method of undergrounding cable for short sections to mitigate against challenging topography or other infrastructure obstacles.
Main Interconnected Transmission System (MITS)	High-voltage electricity transmission network in Great Britain, specifically the 400 kV and 275 kV supergrid elements and, in Scotland, the 132 kV elements operated in parallel with the supergrid.
National Energy System Operator (NESO)	NESO is the independent energy system operator in Great Britain. Taking a whole system approach, NESO strategically plan the electricity and gas systems and operate the electricity system to deliver a secure, affordable and sustainable energy future.

Acronym	Description
National Grid Electricity Transmission (NGET)	Transmission owner that is responsible for (owns and maintains) the high-voltage electricity transmission network in England and Wales.
National Infrastructure and Service Transformation Authority (NISTA)	A UK government body responsible for supporting the delivery of major programmes and infrastructure, improving project execution, and strengthening capability across government for complex and high-impact delivery.
National Planning Framework (NPF)	NPF sets out spatial principles, priorities, developments and planning policy for Scotland.
National Policy Statements (NPS)	Statutory documents (particularly NPS EN-1 and NPS EN-5) published in accordance with the Planning Act 2008.
The Office of Gas and Electricity Markets (Ofgem)	Ofgem is the government regulator for the electricity and downstream natural gas markets in Great Britain. Their principal objective is to protect the interests of existing and future electricity and gas consumers.
Offshore Transmission	Offshore transmission projects including bootstraps, OFTO connections, and interconnectors are all within the scope of ETDP.
Offshore Transmission Owner (OFTO)	A company that is typically selected through a competitive tender process and are regulated by the UK's energy regulator, Ofgem that owns and operates the electrical transmission infrastructure that connects offshore wind farms to the onshore electricity grid.
Overhead Line (OHL)	A high voltage transmission circuit carried by steel lattice or folded steel plate towers (or wooden poles at 132 kV for Scotland).
Project Development Stage	The project development stage involves translating strategic intent into design, routeing, and consenting activities. It prepares the project for planning and regulatory approvals ahead of construction.

Acronym	Description
Receptor	A term used to describe people, communities, and environmental features that may be affected by a proposed transmission project.
Steel Lattice	A type of transmission tower structure formed using steel angle sections in a lattice arrangement. Steel lattice towers are commonly used to support overhead line conductors at transmission voltages across Great Britain.
Overarching Principle(s) (OP)	High-level Principles that guide technology selection, siting and design of transmission infrastructure. In ETDP, these principles provide consistent decision-making criteria across technical, environmental/community, and economic/regulatory considerations.
Scottish Power Energy Networks (SPEN)	ScottishPower's electricity networks business, comprising the regulated licence holders that own and operate ScottishPower's transmission and distribution networks, including SP Transmission plc (SPT), SP Distribution and SP Manweb.
Scottish Power Transmission (SPT)	Transmission owner responsible for (owns and maintains) the transmission of electricity in central and southern Scotland.
Scottish and Southern Electricity Networks (SSEN)	SSE's electricity networks business, comprising its regulated transmission and distribution businesses, including SSEN Transmission and SSEN Distribution.
Scottish and Southern Electricity Networks – Transmission (SSEN-T)	Transmission owner responsible for (owns and maintains) the electricity transmission network in the north of Scotland.
Security and Quality of Supply Standard (SQSS)	It sets out the criteria and methodology for planning and operating the National Electricity Transmission System onshore and offshore.
Strategic Spatial Energy Plan (SSEP)	The SSEP will spatially map the optimal mix and location of clean generation and storage to meet forecast demand, net zero targets, and security of supply for all consumers.

Acronym	Description
Strategic Planning Stage	The strategic planning stage is typically part of the Centralised Strategic Network Plan (CSNP), Connections, or Business Plan process and defines the high-level characteristics of future transmission infrastructure. It sets broad parameters such as technology type, connection points to the existing network, and capacity requirements.
Supergrid	The Supergrid refers to the high-voltage transmission network, primarily operating at or above 275 kV, that facilitates the long-distance bulk transfer of electricity across Great Britain.
Switchgear	The term used to describe components of a substation that can be used to carry out switching activities. This can include, but is not limited to busbars, isolators/disconnectors and circuit breakers, protection equipment, transformers.
T-Pylon	A type of overhead line support structure with a “T” shaped profile, designed as an alternative to traditional lattice towers. T-pylons are intended to reduce visual impact and land take while supporting high-voltage overhead line circuits.
Technology Readiness Level (TRL)	A scale used to assess the maturity of a technology, typically from TRL 1 (basic principles observed) to TRL 9 (technology proven in operational use).
Transformer	Electrical equipment used to change voltage levels (step-up or step-down) in AC systems. In transmission substations, transformers enable efficient long-distance power transfer and connection between different voltage levels.
Transmission Acceleration Action Plan (TAAP)	The government’s response to the Electricity Network Commissioner’s report on accelerating electricity transmission network build. The Action Plan seeks to halve the end-to-end build time of electricity transmission network infrastructure, from 14 to 7 years.
Transmission Owner(s) (TO)	A collective term used to describe the three transmission asset owners within Great Britain, namely National Grid Electricity Transmission (NGET), Scottish and Southern Electricity Networks – Transmission (SSEN-T) and SP Transmission Limited (SPT).

Acronym	Description
Underground Cable (UGC)	A high voltage transmission cable originating onshore, including those whose routes are partly offshore. UGCs make up approximately 5% of the existing transmission system in England and Wales. Most underground cables are installed in urban areas, where it is less practical to use OHLs.
United Kingdom of Great Britain and Northern Ireland (UK)	A country consisting of England, Scotland, Wales, and Northern Ireland.
Working Group/ETDP Working Group	The group convened by NESO to develop the Principles, consisting of subject matter experts from the TOs, UK government, Scottish Government, Welsh Government, and Ofgem. The Planning Inspectorate also joined the group during the development of the Principles.

Public

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