

The Lime Down Scheme: Infrastructure and Sustainability Considerations Distribution Network and Grid Connection

Scottish and Southern Networks (SSEN) serves as the Distribution Network Operator for the area where the Lime Down scheme is proposed. SSEN has published a pamphlet entitled "The challenges with undergrounding at 400 kV", which addresses issues related to a double 400 kV circuit. This publication provides insight into the complexities associated with high-voltage underground connections.

Grid Connection Length and Infrastructure

One notable concern is the length of the grid connection, of 22 kilometers. This extended connection, along with the additional cabling and infrastructure required to link five separate panel array sites, poses significant logistical challenges and major disruption. The necessity for a 400 kV connection appears to be driven by the need to minimize transmission losses over such a long distance.

Material Use and Sustainability

As the energy sector shifts away from fossil fuels toward renewable generation, it is crucial to consider the volume and sourcing of materials used and their sustainability. This includes evaluating finite resource availability and the potential for recycling. Often overlooked are the carbon emissions associated with the extraction, processing, and manufacture of these materials, particularly when these activities occur offshore. There is no analysis of the carbon benefit of the scheme and consideration of the replacement of key components over the life of the scheme. The need for maintaining frequency and load balancing on the grid to cater for the intermittency of the solar scheme should be included in the carbon analysis. The capacity factor of solar in the UK is only about 10%, and the need for alternative generators or storage to back up supply is evident. The BESS installation of 1,000MWh can produce up to 500MW for two hours, and should provide some of the load balancing resulting from the solar generator, but clearly not for prolonged periods of low output from solar.

Equipment Lifespan and Recycling

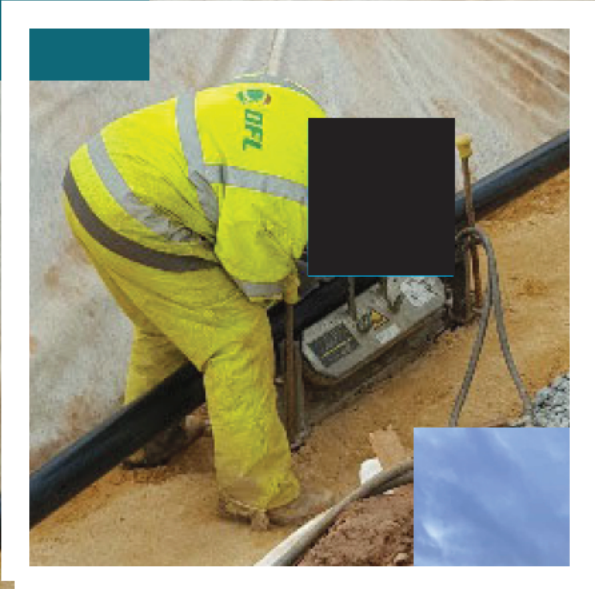
There has been insufficient information provided regarding the expected lifespan of key components, including solar panels, inverters, batteries, and other equipment. Most of this equipment will require replacement within 30 years, and currently, there is limited capacity for recycling these materials. Even the 400 kV cabling may need replacement after 40 years.

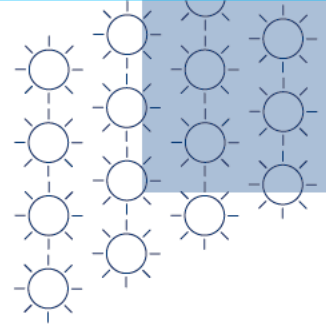
Site Selection and Project Layout

While there are several reasons to oppose the Lime Down scheme, the primary concern here is the suboptimal siting of the solar farm, which is exacerbated by its split locations and the lengthy grid connection. It is worth considering whether alternative sites could offer a more integrated layout and a shorter grid connection, thereby improving the overall efficiency and sustainability of the project. The current siting will cause major disruption to local communities over the construction period, and the road access to the construction sites is inadequate.



The challenges with undergrounding at 400kV





Introduction

SSEN Transmission's projects form part of a major upgrade of the electricity transmission system across Great Britain (GB) that is required to help deliver UK and Scottish Government energy security and clean power targets. This paper explores some of the technical, engineering, operational, environmental and economic challenges associated with underground cabling which need to be carefully considered in the development, delivery and ongoing operation of electricity transmission infrastructure, alongside wider network development and operational considerations.

All references to 400kV throughout this paper assume a double 400kV circuit and the challenges presented are specific to the undergrounding of this technology and capacity.



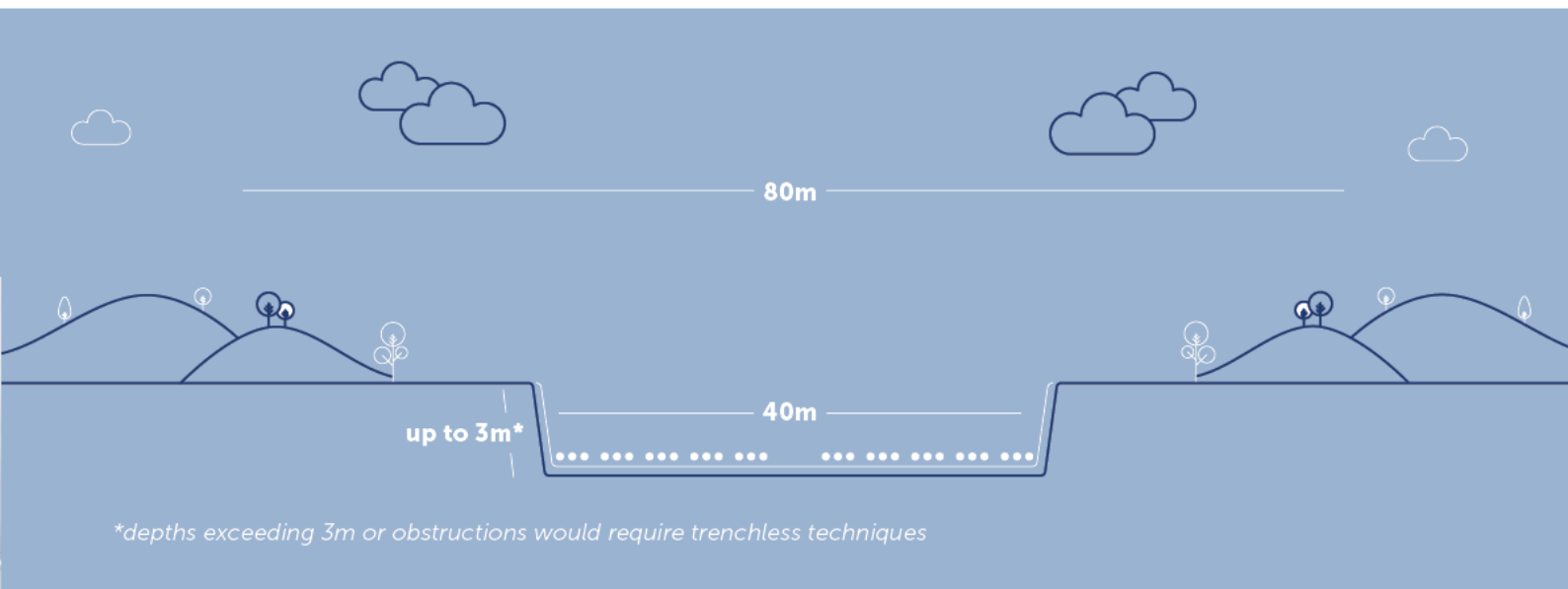
Engineering considerations

Underground cable engineering requirements

Underground transmission cables at 400kV for SSEN Transmission's projects require up to five cables. To deliver the necessary capacity, three sets of double circuit 400kV cables are required, which means that up to 30 parallel cables would need to be installed. For thermal reasons, these cables need to be suitably spaced out.

To achieve the required spacing, a group of trenches at a combined width of over 40m wide would need to be excavated, typically between 1m and 3m deep. During the construction period, a working corridor of over 70m wide is required for cable installation. This can result in significant land use constraints during the construction phase, typically more so than overhead line construction activities, particularly for farming operations.

These cable trenches can also leave a residual visual impact on the landscape with a potential to result in significant environmental impacts and future land constraints.



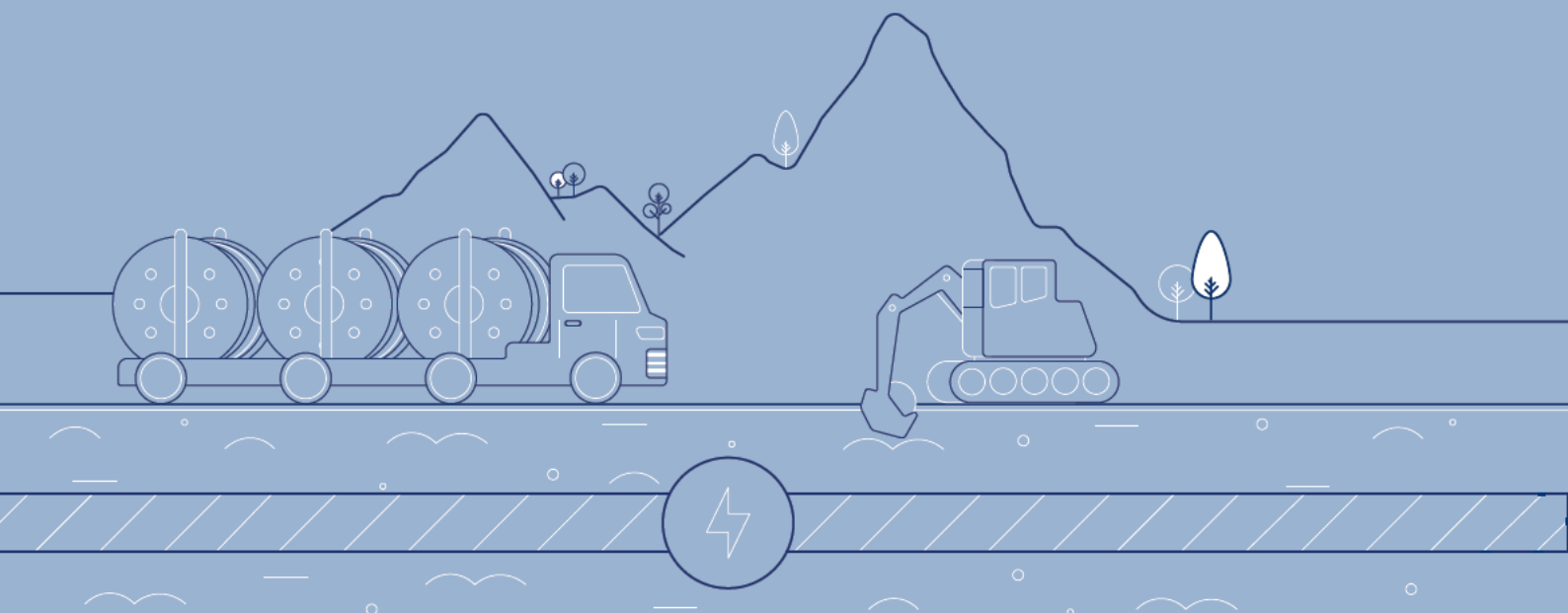
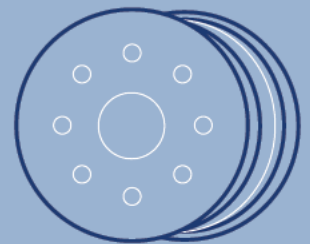
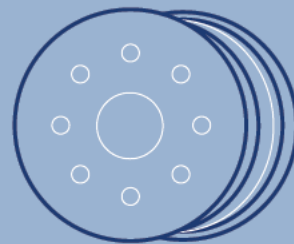
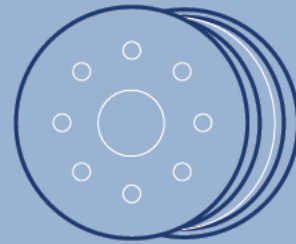
Additional infrastructure requirements

Cable joint bays

The lengths of cable that can be safely spooled and transported on a cable drum for installation, along with the maximum tensions that the cables can withstand during cable pulling operations during installation, are restricted due to their weight and dimensions. For electrical reasons, the maximum lengths for each section of 400kV cable with a high rating need to be further limited to approximately 400m. At each point where these sections of cable are jointed or connected together, there is a requirement for intermediate joint bays.

The footprint of these joint bays would exceed that of the width of the operational trench for the associated underground cable circuits, with the width of these joint bay locations likely to be around **45m wide**.

These cable joint bays would also result in some permanent above ground infrastructure in the form of manholes and link pillars installed in a free-standing arrangement to allow for ongoing maintenance access. For protection of the assets at these locations, the manholes and pillars would be contained within small, fenced compounds, with a footprint of approximately 5m x 5m and with one compound for each circuit.



Cable sealing ends

At each point an underground cable transitions to an overhead line there is a requirement for a Cable Sealing End compound. This would consist of a stoned hard standing platform with a security fence around its perimeter where the underground cabling would transition and connect to an overhead steel tower.

The footprint of these compounds is estimated to be around 70m x 70m.

Reactive compensation

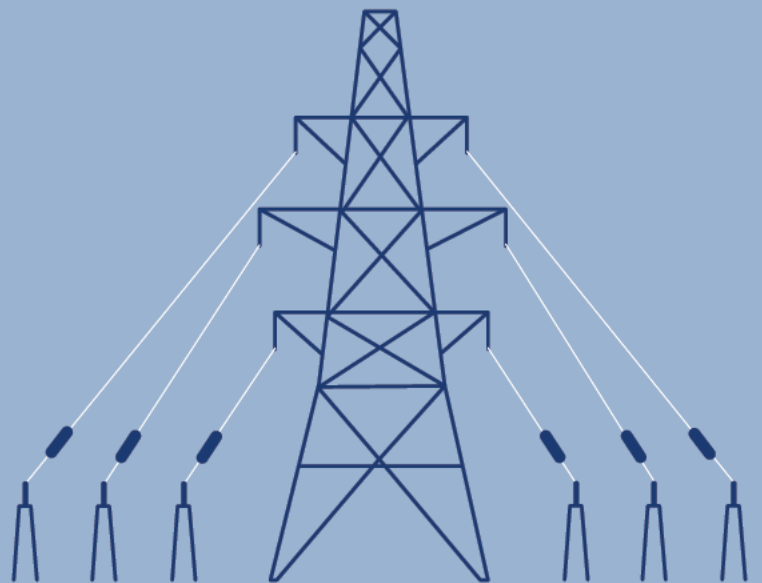
As underground cables operate less efficiently than overhead lines, particularly at high capacity and high voltage, the transmission of power becomes constrained. This leads to the requirement for reactive compensation equipment to be installed at substations connected to the overhead line to maximise the power flows.

This additional equipment would result in a significant increase in the overall size of substation footprints at each end of transmission circuits and could increase landscape and visual impacts of these substation sites.

At present, this specialist equipment would only be needed for a very short section of underground cable - typically around 1–2 kilometres in length - where a high-voltage cable is required to operate at full capacity.

In some parts of the network, where substations are located only a few kilometres apart, it may be possible to design the system in a more flexible way. By using additional cable circuits and sharing the electrical load between them, underground cables could be used more efficiently, with much less supporting equipment required.

The requirement to use reactive compensation equipment can make operation of the network significantly more difficult. In some situations, it can present considerable risks to security of supply and network reliability.





Operational considerations

Maintenance and operation

The ongoing maintenance and inspection of underground cabling is significantly more challenging than that of overhead transmission infrastructure.

Cable insulation and bonding systems require periodic inspection and maintenance to avoid early deterioration of the cable system. The route must be surveyed periodically to ensure that the cable system is protected from external factors such as infrastructure development, ground movement and the risk of vandalism.

Restoring power in the event of a fault

Cable faults on electricity transmission infrastructure can result in major disruption to power supplies. Restoring power in the event of an underground cable fault can take significantly longer than for an overhead line. Faults on overhead electricity lines typically take anything from a few hours to a few days to repair and are generally easy to locate.

Underground cable faults often require extensive works, specialist resource, tools and equipment to locate the fault, followed by significant civils work to expose the damage, replace the damaged section and then up to an additional month to carry out necessary cable jointing and testing of new sections. The mobilisation of specialist equipment to undertake fault repairs on underground cabling results in significant local impacts, particularly for landowners and public highways. This presents significant risks to security of supply and network reliability.

Land use constraints

The cable corridor width required for undergrounding at 400kV presents significant land use constraints, particularly during the construction phase but also during the operational lifetime of underground cable assets.

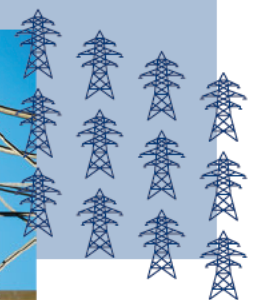
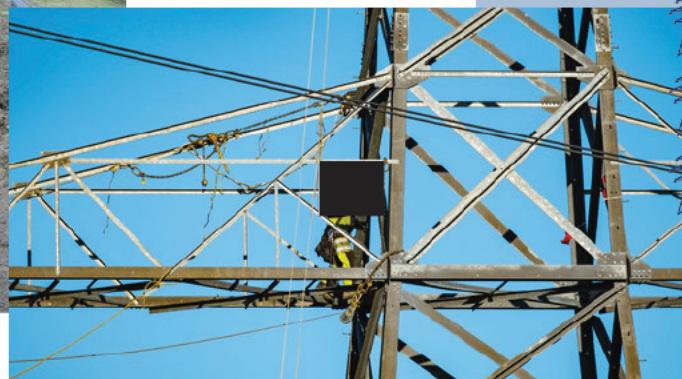
For overhead lines, the micro-siting of towers presents opportunities to greatly minimise impacts on future land use and we work very closely with affected landowners to locate this infrastructure in the most sensitive way.

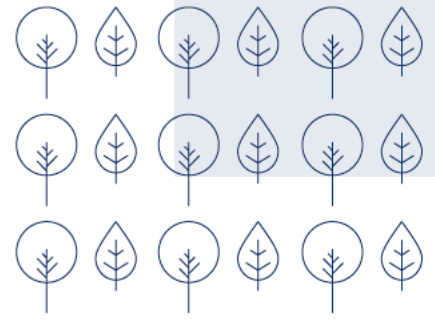
Due to ongoing operational requirements and in particular, the need to be able to access cables to undertake inspections, maintenance and in the event of a fault, carry out repairs, undergrounding can constrain future land use such as some farming operations.

Routine inspections and maintenance are required over the lifetime of underground cable infrastructure. Ground-based visual inspections can be as frequent as every year with more intrusive maintenance at all joint bay locations and cable sealing end compounds necessary every four years. In contrast, overhead line inspections can generally be undertaken from the air, using specialist equipment or drone survey flights or drone surveys.

An underground cable would be expected to have an operational life of around **40 years**, similar to an overhead transmission line conductor. However, steel lattice towers would typically be expected to have a lifetime of around **50–70 years** and when an overhead line conductor reaches the end of its design life, it can simply be replaced with limited impact to landowners.

The replacement of an underground cable would be significantly more intrusive, impactful and disruptive to both landowners, the wider local community and the environment.





Environmental considerations

Peat

Peat and carbon-rich soils present a significant challenge to underground cabling. The Scottish Government's National Planning Framework 4 (NPF4) clearly sets out that development proposals should seek to avoid or minimise peatland, carbon-rich soils and priority peatland habitat.

Where the development of essential infrastructure will affect peatland, the NPF4 clearly sets out that it would only be considered where there is a specific locational need and where it can be clearly demonstrated that no other alternative options are available to avoid excavating peat.

As overhead lines traverse over peatland, tower locations can be micro-sited to minimise impacts on peat, the footprint of development and subsequent excavation of peat can be significantly minimised using overhead line infrastructure rather than underground cabling.

Installing cables in peatland presents significant risks of movement as watercourses and ground conditions change over time, which can cause cable damage and faults. To mitigate against this, cables need to be installed within suitable and well-supported containment, like ducts and trenches, which can result in additional environmental impacts.



Woodland

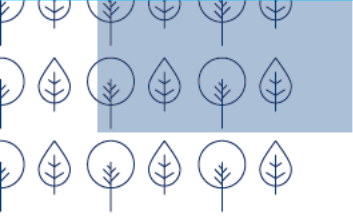
Whilst every effort will be made to avoid the felling of trees for new transmission infrastructure, woodland removal may be required to install transmission lines within a corridor that has been cleared of trees and other vegetation for installation and operational purposes—this being required for both overhead lines and underground cabling.

However, during construction of an overhead line, measures can be taken to reduce the width of the corridor and reduce the number and extent of tree felling required. This is particularly important when considering ancient woodland, veteran trees and native woodland habitats.

During construction of an overhead line, we can raise tower heights, increase or shorten span lengths, microsite tower and access track positions and consider different approaches to wiring that can all result in reductions in tree felling. In addition, once operational, low growing scrub habitats can be established under overhead lines which can help to maintain a connection with woodland on either side of the overhead line, supporting biodiversity.

Underground cable operational corridors need to maintain a set width and be clear of trees, to ensure root growth does not damage cables and equally that the construction does not damage tree roots, limiting opportunities for tree retention in design, construction, and operation. There is limited scope for flexibility.





Ground conditions

Underground cabling is highly sensitive to ground conditions, with much of the north of Scotland's mountainous, peaty and rocky terrain, making it extremely difficult to install and maintain.

Excavation in mountainous terrain to create cable trenches and working areas can require significant rock breaking activities. This can permanently alter the landscape, removing the natural appearance and creating hard edges, where a cable trench is positioned.

Re-establishing vegetation following ground disturbance in peatland and mountainous areas can take a long time due to the shorter growing season and adverse weather conditions, leaving a notable cable corridor visible at a landscape scale in open peatland and mountainous terrain.

Hydrology

Excavations involved with 400kV underground cable trenches have a higher likelihood to disrupt shallow groundwater systems which can result in the lowering of groundwater levels in the immediate vicinity of the excavations. In contrast, overhead lines are unlikely to alter groundwater flows.

Permanent access tracks for overhead lines have drainage designed to adapt to local conditions and tower bases have a small land footprint (approx. 15m x 15m). The land is restored under and around the tower bases resulting in natural conditions of groundwater being maintained. Cable trenches can also modify water drainage pathways to groundwater flows, with potential impacts on environmentally sensitive wetland habitats such as marshes, flushes; and heightened risk to groundwater fed Private Water Supplies (PWS).

Other environmental considerations

These range from impacts on local biodiversity, particularly ground nesting birds and mammals, to the risk of flood related pollution during both the installation phase and when undertaking repairs that require cable trenches to be reopened. For example, silt or peat pollutants, as well as the material used to stabilise cables, could be released into the local environment and watercourses following heavy rain or a flood event. Whilst steps will always be taken to mitigate and minimise such risks, these need to be carefully considered and balanced against a range of other factors when considering the technology

Economic considerations

The cost of investing in the electricity transmission network is ultimately paid for by GB electricity consumers and under Section 9 (2) of the Electricity Act 1989, we have a duty to develop and maintain an efficient, coordinated and economical system of electricity transmission.

It is acknowledged that underground cables are considerably more expensive than overhead lines. An independent report undertaken by the Institution for Engineering and Technology found that underground cable projects are around **4.5x more expensive** - a cost that is ultimately borne by GB electricity consumers.



Conclusion

In summary, whilst we are committed to exploring the possibility of undergrounding at sensitive locations where there is clear evidence to justify it, the technology presents significant challenges due to technical, operational, environmental and economic factors. In particular, it may not represent the best solution for landowners due to the greater footprint and associated impact on agricultural land, as well as the requirement for additional onshore infrastructure to manage system requirements.