Explainer of **Electricity Transmission Networks**

NESO
National Energy
System Operator

Purpose of this explainer

This explainer describes the key elements that make up the electricity transmission network and outlines the decisions that shape its development.

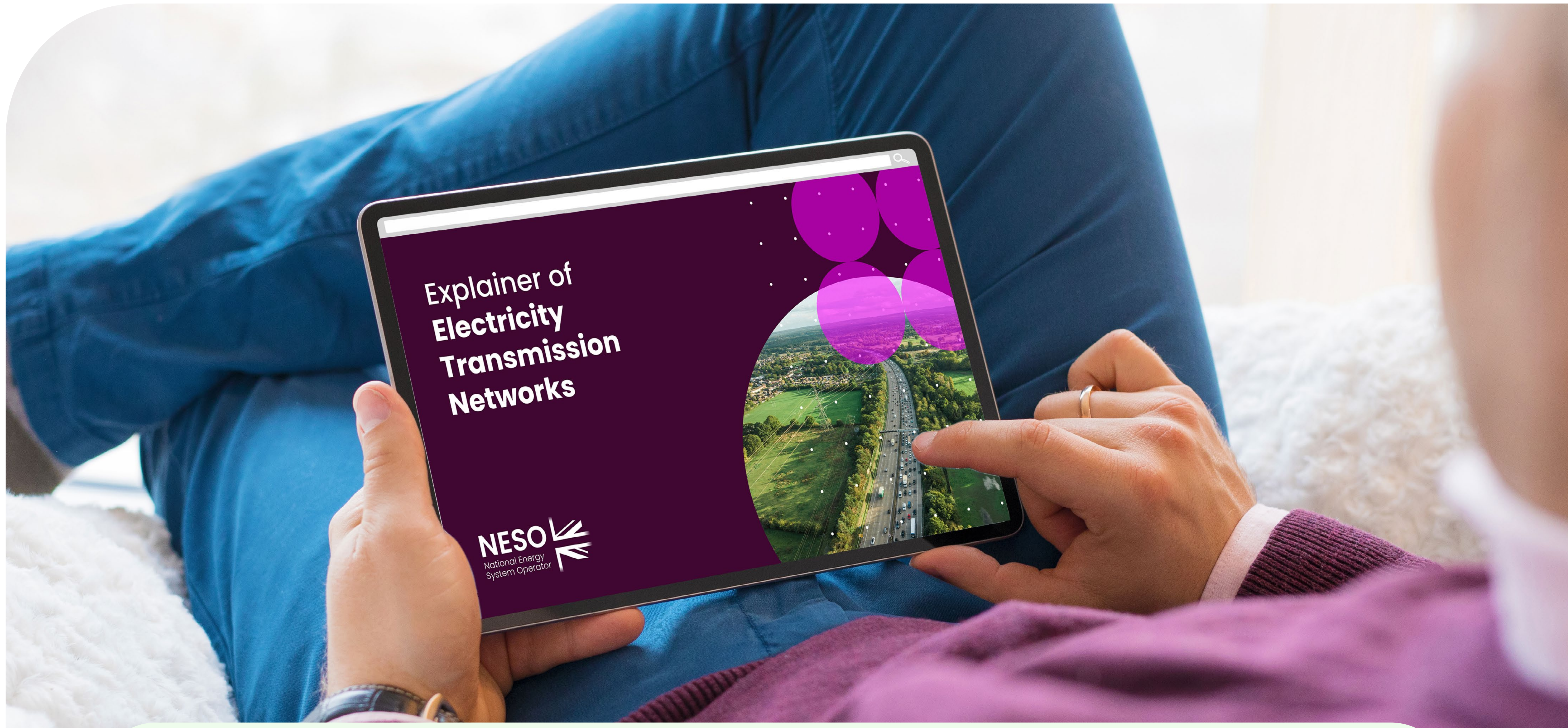
It explains high-voltage transmission and some of the most common terms you will come across when reading about the electricity transmission network. It also discusses the decisions and trade-offs involved in transmission network planning and the different technologies used to transmit power around Great Britain.

In interviews, people said they would like a jargon-free, accessible summary of the electricity transmission network.

"Busy people don't have time to read large documents. They just need ... quickfire ... this is what it means for you."

We hope this explainer answers the most important questions people ask when faced with new electricity network developments in their communities.

Some of the pages have footnotes. You can click on these to learn more about a specific subject.



An independent research company, BMG, conducted a survey of more than 2,000 people across Great Britain and carried out 20 in-depth interviews with local residents and stakeholders to find out their views on the electricity transmission network. You will see their findings popping up throughout this report.

Great Britain’s electricity transmission network is changing

Every home, business and industry in Great Britain depends on resilient, clean and affordable power. And as demand for electricity is expected to grow significantly by 2050, today’s electricity network will have to change.

Electricity is moved around Great Britain via a vast network of wires and cables. These networks are supported by substations, which connect different parts of the system and help manage how it operates. This electricity will be needed more and more as the years go by, so our electricity transmission network will have to expand.

Most of our electricity is now generated from renewable energy (such as wind turbines and solar farms), often in remote areas. New infrastructure is required to connect it to our homes and businesses.

There are limits to how much power can be transported securely across each part of the network. In some areas, network infrastructure has not kept pace with the volume of new generation and demand connecting to the system. To ensure the system transmits enough power to where it is needed, additional costs may be incurred.

Without investment, these pressures will continue to grow. So we must plan for the future – to create an electricity transmission network that meets Great Britain’s energy needs in a resilient, clean and affordable way.

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The role of NESO in guiding long-term network development

NESO plans Great Britain's future energy system and operates its electricity system. We take a long-term, strategic approach to planning, identifying whole-system needs so the energy system can meet future demand from homes and businesses around Great Britain.[1]

We aim to offer clear, objective guidance on network development and the reasoning behind network design choices. This includes explaining how different technologies compare and what trade-offs are made when delivering a resilient, clean and affordable energy system.

We want to shape a network that reflects what society values – one that benefits bill payers and minimises impacts on communities and the environment.

98% **of respondents think it is important to invest in the UK's electricity grid and infrastructure.**

1 Our strategic energy planning (SEP) publications explain more about this. To find out more, please visit neso.energy.

What are the key elements of electricity networks?

Different parts of the electricity transmission network – often referred to as ‘the grid’ – operate at different voltages, depending on whether they transmit or distribute electricity.

The **transmission network is like a motorway system, moving large volumes of electricity over long distances** from power stations to distribution substations and major industrial users.

It uses high voltages (400 kV, 275 kV and, in Scotland, 132 kV) to enable large quantities of electrical energy to flow efficiently around the network. Depending on its rating, a double transmission circuit route (for example a line of pylons) can supply, on average, 2m–6m homes. The subsea cable transmission network operates at even higher voltages of up to 600 kV.

Voltage represents the potential energy of the power being transmitted. The higher the voltage, the more power can be transmitted from where it is generated to where it is needed. **Transformers** then reduce this voltage (known as ‘stepping down’) to distribute power to homes and businesses.

Distribution networks are like local roads, delivering electricity directly to homes and businesses. These regional and local networks operate at lower voltages (England and Wales 132 kV, Scotland below 132 kV). This makes them better suited to (and more cost-effective for) delivering smaller amounts of electricity to millions of individual homes and businesses.

This explainer does not discuss things like domestic solar panels or the junction boxes you may see on your street corner. Instead, it focuses on Great Britain’s high-voltage transmission network.

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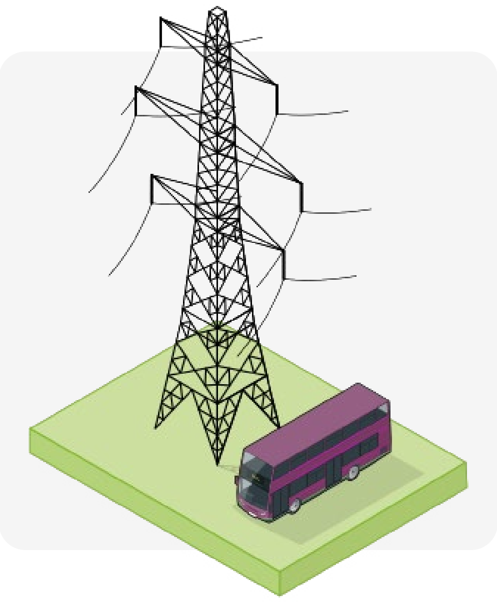
The physical assets of the transmission network

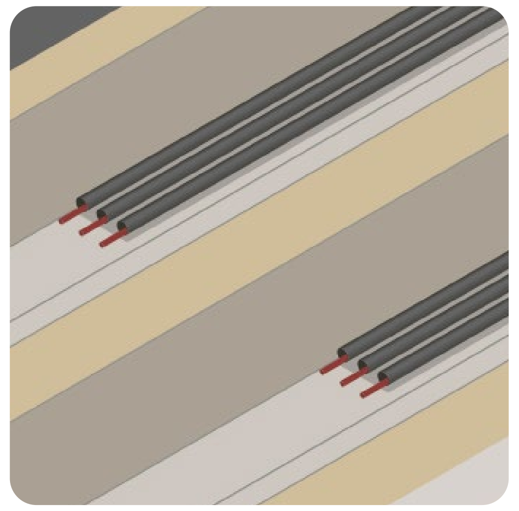


Transmission overhead lines (OHLs) are the most visible part of the transmission network.

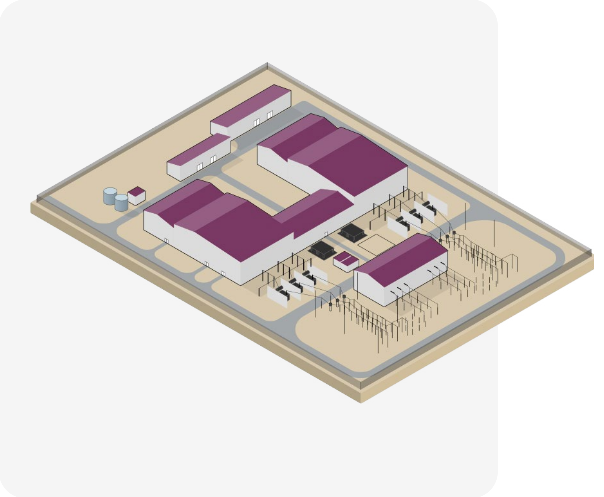
They are generally made up of steel towers (pylons) that suspend high-voltage conductors (wires) safely above ground.

In Scotland, large wood poles are sometimes used to support more remote, lower-capacity conductors.

77% say they live within a 15-minute walk of some form of transmission network infrastructure, and **61%** say they can see some sort of transmission infrastructure from their home.

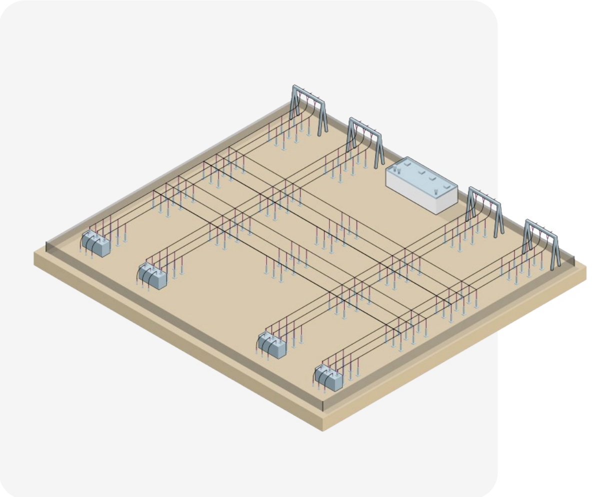


Underground cables (UGCs), protected by layers of insulation, transport electricity underground.



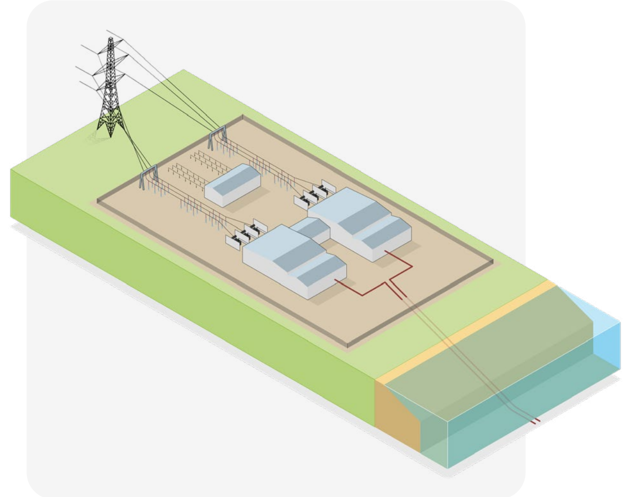
High-voltage direct current (HVDC) converter stations house equipment that converts the flow of electrical energy between alternating current (AC) and direct current (DC) electricity.

Substations connect them to the network.



Substations connect the OHLs and UGCs, and house the transformers that set the voltages for each part of the network.

They protect the network from being damaged should a fault develop.



Subsea cables are laid on or buried under the seabed.

Subsea HVDC cables can transport large amounts of power over long distances very efficiently.

The cables will always need to cross the land from the seabed to join the onshore network.

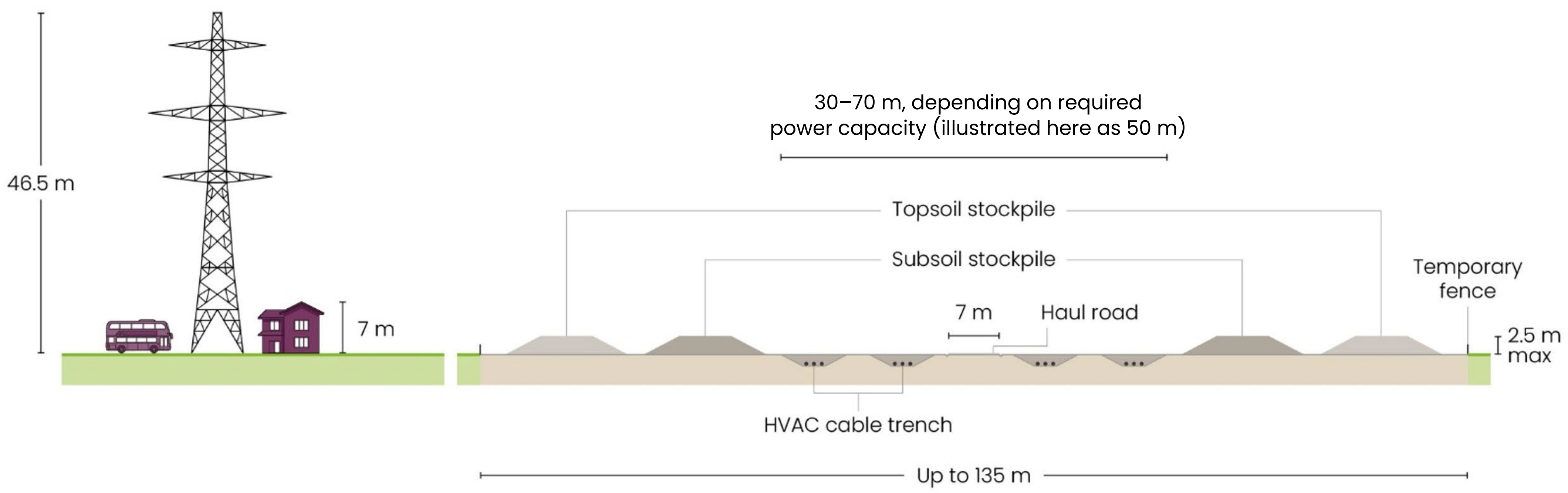
"One of the biggest things we need to get right is the infrastructure so that we can have the future that we want. So if we've got to have all this connected renewable energy, we have to have cables and pylons somewhere."

High-voltage alternating current (HVAC) transmits electricity across the network. It is called 'alternating current' because the current reverses direction (50 times a second). It can be transmitted over long distances and at high voltages, without losing much energy to heat. Transformers reduce this voltage so that the electricity can be safely distributed to homes and businesses.

HVAC

Overhead line
Example shown: 400 kV double circuit
Capacity: 7.6 GW

Underground cable
Example shown: 400 kV double circuit, two cables per phase
Capacity: 7 GW (over short distances)



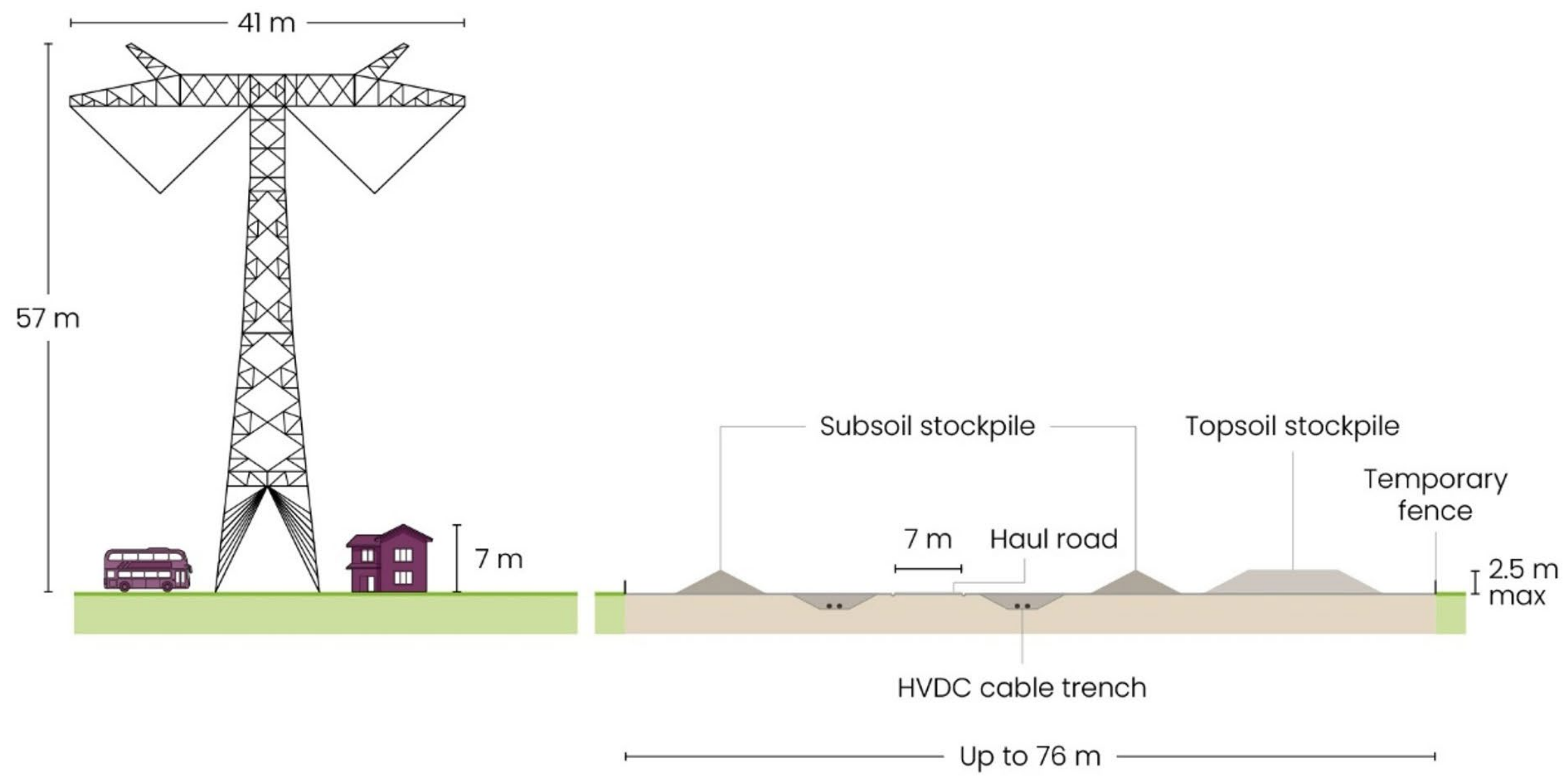
Typical construction swathe - four trenches (combined corridor)

High-voltage direct current (HVDC) is also used in electricity transmission. It is called 'direct current' because the current flows continuously in one direction. HVDC can move power over long distances even more efficiently than HVAC, and loses less energy, too. However, it needs to be converted to HVAC before it can be distributed to consumers. This can be complicated and costly.

HVDC

Overhead line
Example shown: 800 kV single circuit
Capacity: 6.4 GW

Underground cable
Example shown: 525 kV single circuit
Capacity: 2 GW



Typical construction swathe - two trenches (combined corridor)

Who benefits from, and who is responsible for, the delivery of new networks?

Ultimately, the people of Great Britain – every home, business and public service – benefit from having the right infrastructure. These networks bring resilient, clean and affordable electricity to our homes and businesses.

There are several organisations involved in building, running, regulating and delivering power from the network to homes and businesses across Great Britain – and some of them make a profit from doing so.

The main organisations

The **UK Government** sets overall energy policy, targets and the laws that govern the supply of electricity. The **Scottish and Welsh Governments** set policy in areas of devolved responsibility. **(Funded through taxes)**

Ofgem (the Office for Gas and Electricity Markets), the regulator, protects consumer interests. It sets financial limits on, and standards for, network companies where there is not enough competition to create those limits 'naturally'. **(Non-profit, funded through licence fees to energy companies)**

We, the **National Energy System Operator (NESO)**, are an independent public corporation at the heart of the energy system. We operate today's electricity transmission system and design tomorrow's energy system. We ensure that the electricity transmission network can move power securely, efficiently and cost-effectively to where it is needed across Great Britain. **(Non-profit, funded through energy bills)**

Privately owned **network companies** build, own and maintain the networks that supply electricity to homes and businesses. They include transmission owners (TOs) and distribution network operators, which operate under licences regulated by Ofgem. These licences limit how much companies can earn and are designed to ensure they are run efficiently.

Network companies can propose new infrastructure, but it is Ofgem that decides whether there is a clear need for it before approving any funding. These proposals can sometimes require support or direction from NESO. **(For-profit, funded through energy bills and private investment)**

Other organisations

Generator and storage companies generate electricity or store energy. They sell the electricity to suppliers or directly to large demand sources, such as data centres. They sometimes build infrastructure to connect their equipment to the network.
(For-profit, funded through energy bills and private investment)

Suppliers are the companies you pay your electricity bill to. They buy electricity in bulk from generator companies and then sell it to homes and businesses.
(For-profit, funded through energy bills and private investment)

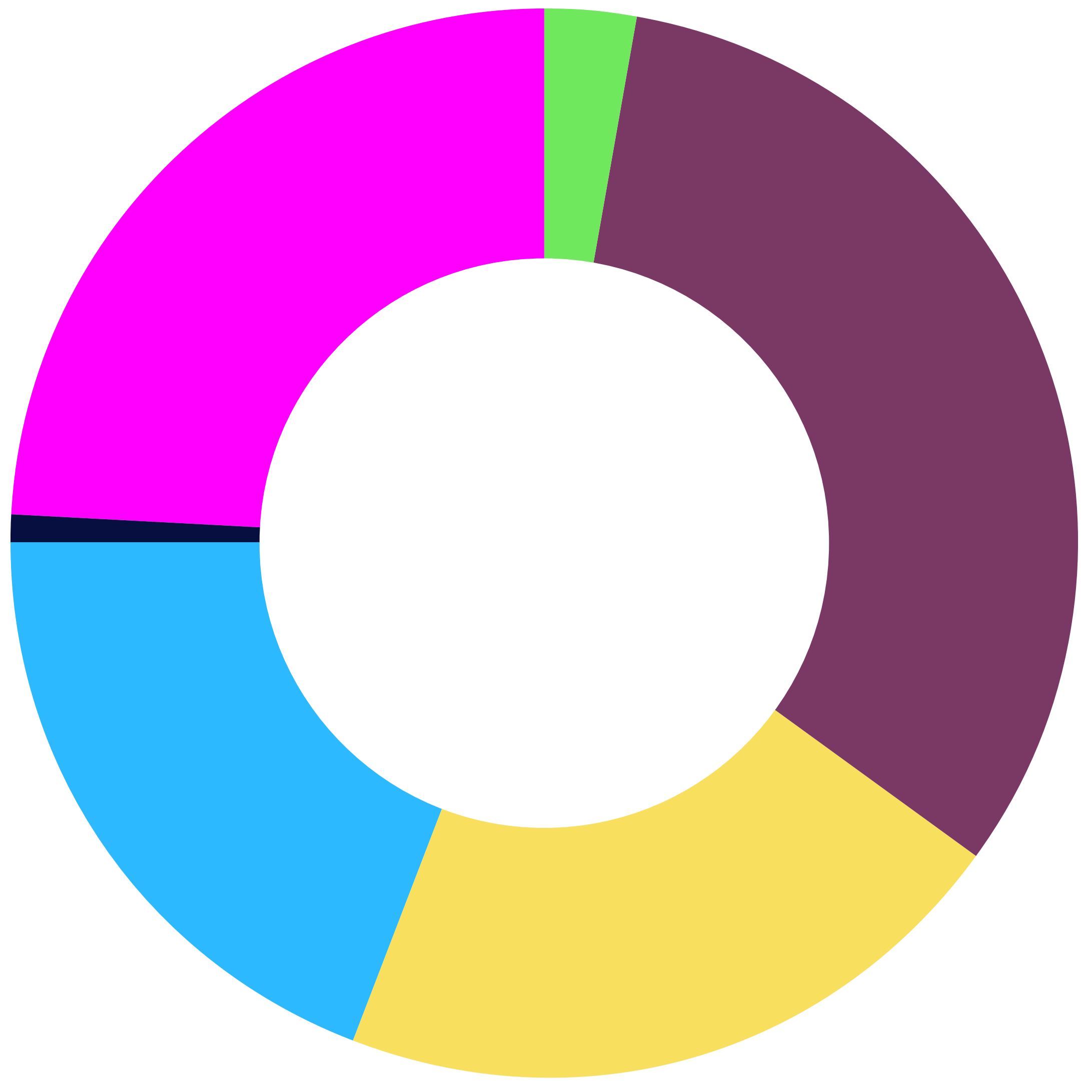


Figure 1: Breakdown of an annual electricity bill, 2025

- Capacity market **3%**
- Wholesale costs **32%**
- Network costs **21%**
- Policy costs **19%**
- Smart metering **1%**
- Other **24%**

Figure 1 shows the breakdown of an annual electricity bill.

- Wholesale costs cover the energy that supplies your home or business.
- Network costs are associated with building and operating the electricity network.
- Policy costs are associated with government energy policies.
- Capacity market costs ensure that sufficient, reliable electricity capacity is available to meet demand at peak times.
- Smart metering costs cover the running of the smart metering network.
- Other costs include the day-to-day running costs of the energy supply company, financial buffers to cover unexpected price fluctuations in the wholesale energy market and the cost of administering customers' bills.

neso.energy

How do we get the most from existing infrastructure?

When transmission equipment no longer has the capacity to carry all of the electricity needed to power homes and businesses, it is known as a 'constraint'. This requires action to ensure the safe flow of power around the network.

Before having to build new or upgrade existing infrastructure (known as 'network reinforcement'), NESO and transmission owners (TOs) have several ways of dealing with a constraint. For a start, we can work with generators or adjust output at times of increased network pressure, but this can result in higher bills for consumers.

Options that minimise costs to bill payers – and reduce impacts on communities and the environment – are always considered first before proposing new infrastructure. For example, we consider 'consumer flexibility'.

"An investment ... yields financial gains and employment opportunities, benefiting landowners and local communities."

This involves encouraging homes and businesses to use less electricity at peak times. But it has its limits.

As a result, network reinforcement is generally the best long-term solution to meet consumer needs.

TOs can install equipment that changes how, or how much, electricity flows through the network, making it easier to manage by redirecting power away from overloaded lines. They can also upgrade existing infrastructure to increase a line's capacity. Upgrades can be delivered faster, at a lower cost and with less impact than building new assets.

Sometimes, however, building new transmission assets is the most effective way of maintaining a resilient and affordable system.

Additional demand means that new assets are often the only way the system can cope. Without them, the chances of new constraints increases – and that usually means more costly interventions in the long term.

Respondents' top three reasons to invest in the UK's electricity grid and infrastructure were to reduce electricity bills **(46%)**, reduce reliance on imported energy **(44%)** and meet the increased need for electricity **(44%)**.

Why do we need new electricity infrastructure?

Great Britain's electricity network is constantly evolving to meet changing needs and enable new connections.

New infrastructure is required to keep the system safe, reliable and affordable – long into the future. Decisions on network investment and planning are based on technical, economic and environmental analysis.

"I think a strategic approach, informed by understanding of environmental constraints and opportunities, is really a good approach."

Ensuring the system remains affordable

Many people use electricity generated far from their homes and businesses. But when the network lacks the capacity to transport this power (known as a 'constraint'), they must use local power, which can increase costs.

Without investment in the electricity network to deal with these constraints, costs will continue to rise for bill payers.

To increase capacity, TOs must either introduce new technologies, upgrade or build new infrastructure. Delaying this leads to higher system costs over time.

Supporting economic growth, increased demand and connections

New data centres, housing growth and the electrification of industry, heating and transport are increasing electricity demand.

This electricity is increasingly generated from renewable sources, often located far from where it is used. This is very different from the system the network was originally designed for.

So the electricity network must adapt. It needs to accommodate renewable generation, electricity storage, interconnectors with other countries and major new electricity users.

Maintaining a resilient network

Strict standards ensure the transmission network operates safely and reliably.

The Security and Quality of Supply Standard (SQSS) sets the requirements for planning and operating the National Electricity Transmission System.

Much of the network has been in service for decades. This means there is an ongoing need to maintain, upgrade and replace assets so Great Britain can continue to benefit from a reliable electricity supply.

Without investment in the electricity network ... costs will continue to rise for bill payers.

How are new network solutions chosen?

Once a need for new or upgraded infrastructure has been identified, we must decide on the best way to meet that need.

- **NESO's** role is to identify where upgraded or new infrastructure is required.
- **Transmission owners (TOs)** then develop detailed designs and proposals to meet these needs. They consider planning consent, environmental impacts, engineering feasibility, cost, supply chain constraints and regulatory requirements.

It makes sense for TOs to develop the proposals, as these involve their assets – which they are most familiar with. The options include location and choice of technology, tested across multiple scenarios.

We then assess the TO's proposals and identify the solution that best meets Great Britain's future energy needs. Our assessment considers cost, operability, deliverability, and community and environmental impact.[2]

All options must adhere to the Security and Quality of Supply Standard (SQSS). As all proposed investments are subject to regulatory funding approval to ensure they deliver best value for consumers, the regulator, Ofgem, then decides whether to fund the project.

Great Britain has three onshore TOs, each managing different parts of the transmission network:

- National Grid Electricity Transmission (NGET)
- SP Transmission (SPT)
- Scottish and Southern Electricity Networks Transmission (SSEN-T)

2 At the heart of our approach to this is our Centralised Strategic Network Plan (CSNP). This outlines the assessment criteria we use. Please visit neso.energy to find out more.

What are the key design considerations and costs?

When planning changes to the network, two key decisions are: whether to install infrastructure onshore or offshore, and whether to use overhead or underground conductors.

Onshore or offshore infrastructure?

Great Britain benefits from some of the world's best onshore and offshore wind energy resources, especially in Scotland and the North Sea.[3] However, electricity demand tends to be concentrated in the south of the country. This means much of the renewable power generated must be transported over long distances to reach its greatest points of demand.

Originally, when asked their general impression of their preferred way to transport electricity, respondents held similarly positive views about onshore **(51%)** and offshore **(54%)** transmission and similarly negative views **(7% for both)**.

There are two options to deliver this power to where it is needed, routeing it:

- onshore, mostly with overhead lines
- offshore, using subsea cables

The Electricity Transmission Design Principles (ETDP) sets out the design principles that transmission owners (TOs) consider when identifying alternative options (Table 1).[4]

3 wwindea.org
4 You can find out more about our ETDP by visiting: neso.energy.

Table 1: Onshore or offshore?

	Onshore (HVAC overhead lines)	Subsea (HVDC cables)
Advantages	Lower cost per kilometre Can carry up to 2.5× more power Can connect multiple power stations and communities Easier access for maintenance and repairs	HVDC transmission is more efficient over longer distances Often avoid populated areas Can connect directly to offshore windfarms Greater protection from weather conditions
Disadvantages	Closer to communities Concerns over visual impact Planning permissions can be lengthy and contested Limited space, particularly in urban areas	Higher construction costs, particularly for converter stations Carry less power than onshore overhead lines Repairs can take months and require specialist ships Limited ability to serve intermediate locations Require some onshore infrastructure
Costs	Variable, depending on application Typically £3m–£9m per kilometre, including lifetime operating losses	Variable, depending on application Typically £7m–£10m per kilometre, including lifetime operating losses

The cost estimates presented in this report have been informed by the findings of the IET Electricity Transmission Technologies report (2025). We have also reviewed evidence from a DESNZ-commissioned study examining innovative approaches to undergrounding transmission cables. The comparable cost ranges identified in the DESNZ study are consistent with the values presented in this document, indicating broad alignment across the available evidence base. The DESNZ study examines additional emerging cable installation technologies that were not considered when determining the costs presented in this report.

Once respondents had learnt more about onshore transmission, **49%** were more positive about it, but only **34%** were more positive about offshore transmission – with **21%** becoming more negative.

Overhead lines or underground cables?

Both methods of transmission have advantages and disadvantages, as Table 2 outlines.

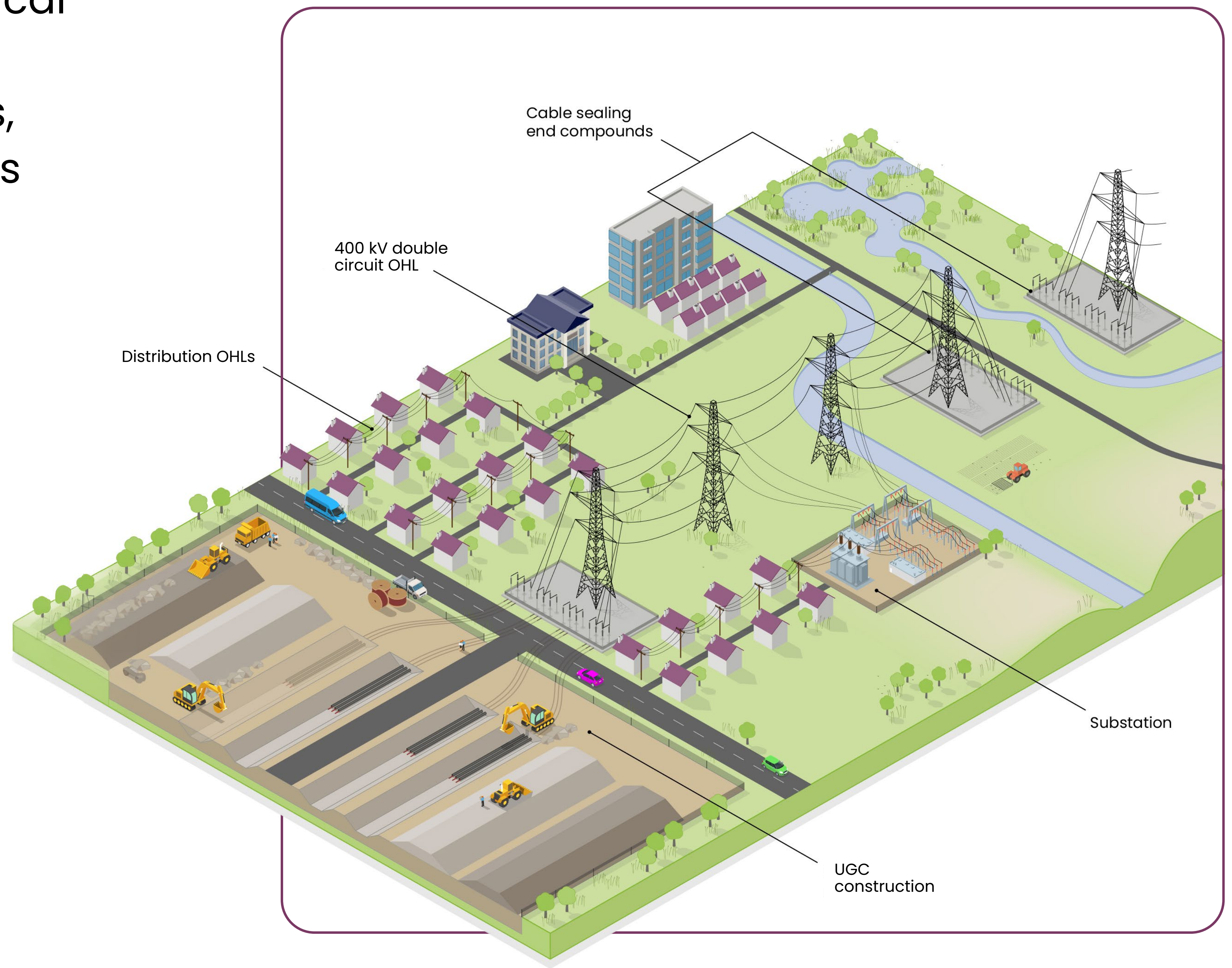
Overhead transmission lines (OHLs) are the main technology used to transmit high-voltage electricity safely and reliably over long distances – from where it is generated to where it is needed. There are two types: high-voltage alternating current (HVAC) and high-voltage direct current (HVDC) OHLs.

- HVAC is the preferred type of OHL for onshore power transmission.
- HVAC networks are flexible, simple to interconnect and relatively easy to expand.
- HVDC networks, on the other hand, require more complex and expensive equipment to distribute power to multiple destinations.

Many people worry about the visual and physical effects of OHLs. So transmission owners (TOs) work closely with environmental organisations, communities, landowners and local authorities to reduce potential impacts.

Underground cables (UGCs) are sometimes a workable alternative to OHLs, for example in densely populated areas or when crossing nationally designated landscapes. The problem is that UGCs are much more expensive than OHLs to build and maintain.

They are also more intrusive to communities and the environment during construction.



"I'm aware of a project where the joints for some underground cables from an offshore wind farm failed … And you think, yeah, that was a lot of hassle. If it had been up in the air, it probably would have been easier to have dealt with."

Table 2: Overhead or underground?

	Overhead HVAC lines	Underground HVAC cables
When should they be used?	National Policy Statement EN-5 (clause 2.9.21) declares that overhead lines should be the starting presumption for electricity networks.	National Policy Statement EN-5 (clause 2.9.21) declares that underground cable should be the starting presumption for parts of an electricity network that will cross part of a nationally designated landscape.
How big are they?	For the highest transmission voltages, usually 3–4 pylons are used per kilometre of the route. They are, on average, 46.5 m high (about half the height of Big Ben). The pylons support between 13 and 25 wires (also known as 'conductors'). Each pylon has four legs. A leg's base is 7–10 square metres (roughly the size of a small garden shed).	UGCs are 10–15 cm in diameter. They are typically buried in a series of trenches between 1 m and 1.5 m deep. They are normally laid in 500 m lengths and then spliced together on site.
Do they affect the land around them?	The land around them can still be used by farmers. The only things not allowed near or under the wires are bonfires, buildings and tall trees.	The land above the cables can be used for agricultural and recreational purposes, but not for planting trees or construction. Construction or excavation work is not permitted within, typically, 30–75 m of the route.
How visible are they?	Pylons are painted and positioned, wherever possible, to reduce their visual impact. They are still highly visible up close.	While largely invisible once installed, UGCs still require some overground infrastructure. This can include large voltage control equipment and cable sealing ends where the cable connects to substations, and small earthing kiosks placed above ground along the route of the cable. Earthing kiosks, painted to blend into their surroundings, can be up to 1.5 m high and 1.3 m wide (about the size of a tall chest of drawers) and typically appear every kilometre along the route.

Before they learnt more about transmission, **75%** of respondents were positive about UGCs, while only **41%** were positive about OHLs – and **21%** had a negative view.

Is construction disruptive?	Pylons require substantial foundations. During their construction, temporary roads are built to minimise the impact construction vehicles have on the land around the pylon.	During construction, a construction 'corridor', often more than 100 m wide, is temporarily dug to house the cables and carry out work on them. Once the cables are laid, the corridor is filled in and the land around it reinstated.
Are they easy to maintain and repair?	Once pulled into position, OHLs require very little maintenance. Conductors and fittings are easy to replace, and most faults can normally be fixed within hours (and serious faults within days).	The cables require little routine maintenance beyond periodic inspections. Repair times can be lengthy and disruptive.
Can they be expanded in the future?	Future expansion requires little more than monitoring the wire temperatures or replacing them with thicker wires.	Future expansion is much more difficult. It is usually more cost-effective to install a new cable than to excavate and replace an existing one.
Can they be built anywhere?	The siting of pylons is flexible, meaning temporary tracks and construction roads can be sited where they have the least impact on communities and the environment.	The siting of cables is less flexible.
What effect do they have on the environment around them?	OHLs have the potential for a range of impacts on landscape, communities and habitats. Bird collisions are the greatest environmental risk, and so TOs work hard to avoid sensitive bird habitats and use flight diverters to reduce this risk further.	Laying cables is more disruptive to habitats, species, hedgerows and archaeological sites. TOs take steps to mitigate this disruption and can often reinstate affected areas after construction.
How much do they cost?	They cost £2m–£3m per kilometre to build. Or £3m–£9m per kilometre to build and run.	They cost £12m–£34m per kilometre to build. Or £14m–£39m per kilometre to build and run. This makes their build cost between 5.7 and 9.7 times more expensive than OHLs. And 4.5 times more expensive to run.

The cost estimates presented in this report have been informed by the findings of the IET Electricity Transmission Technologies report (2025). We have also reviewed evidence from a DESNZ_commissioned study examining innovative approaches to undergrounding transmission cables. The comparable cost ranges identified in the DESNZ study are consistent with the values presented in this document, indicating broad alignment across the available evidence base. The DESNZ study examines additional emerging cable installation technologies that were not considered when determining the costs presented in this report.

When respondents were given more information about UHLS vs UGCs, **53%** became more positive about OHLs, but **40%** became more positive about UGCs (and **21%** became more negative).

Interestingly, the more people learnt about network infrastructure, the more positive they became about it: over a quarter **(28%)** of respondents became more positive about both OHLs and UGCs.

Summary

This explainer has outlined how Great Britian's electricity network is changing to meet our growing energy needs in a resilient, clean and affordable way.

It described what makes up the network and the organisations involved in planning, building, running, regulating and delivering it. It also explained how NESO considers options to reinforce the network that minimise bill-payer costs and reduce community and environmental impacts.

It then highlighted some of the reasons why new infrastructure is needed, and how decisions are made on the best way to meet this need. The rest of the explainer looked at the route and technology issues – and the trade-offs between them – that NESO considers when planning building or upgrading infrastructure.

We hope it answered the most important questions people ask when faced with new electricity network developments in their communities.

If you want more details on a specific topic, have a read of our Detailed Appraisal of Electricity Transmission Networks. For our latest recommendations for the electricity transmission network, read Beyond 2030 – Update.[5]

5 You can access this by visiting: neso.energy.

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