WEBSITE NOTE
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POWER CABLES – UNDERGROUND OR OVERGROUND?

Confronted with the scale of the infrastructure work required for transmitting the increased power needed from the locations of new renewable and no-fossil fuel electricity generation, the recent report to the Government by the Electricity Networks Commissioner (see webnote) noted both:

- the greater cost of putting transmission cables underground
- their environmental damage.

As this question of the merits carrying power cables overhead on pylons against laying them underground frequently features in public discussion of proposals, this note gives an initial consideration of some of the issues in the choice. Further information on the issues for high voltage transmission lines is in this National Grid paper.

Some of the comparison lies in the difference between the effects of the work in installing the cable and the effects thereafter over time.

Capacity

Overhead power lines have a superior current capacity to underground power lines, able to carry a voltage up to 400 kV. High voltage lines can carry more energy on the same sized conductors, allowing fewer cables but on higher and more intrusive pylons. National Grid uses 275 kV and 400 kV. It is easier for underground lines to carry much lower capacities. In either case, spacing cables further apart reduces the loss of power along a line (and so its heating) but underground cables have to be spaced much further apart, increasing the land take.

It is understood that all low-voltage and medium-voltage power lines in Holland are underground while Germany has a significant fraction of medium-voltage power lines and close to 90 per cent of low-voltage power lines underground.

However, high-voltage power lines are still overwhelmingly overhead across the world because of the limited current capacity of the underground power lines.

A different approach to reducing the loss of power along a line is to use High Voltage Direct Current (HVDC) which can carry a higher current for a given thickness of the conducting cable

as the lesser loss of power means they do not get as hot. The associated towers then do not need to be as strong and so can be less intrusive. However, the requirement to supply alternating current means that HVDC lines need a converter station at each end and so the economics might only be relevant for the longest power lines. The proposed 2GW undersea line from Peterhead to Drax (Scotland England Green Link 2) would use HVDC, converted back once onshore (though in England beside National Grid's substation at Drax, having come underground across the East Riding).

Construction Cost

Laying power cables underground is typically assessed as having a cost ten times that of carrying them overhead. It was that assessment that enabled the report's recommendation of payments to affected households and communities.

Reasons for increased costs include:

- the greater work in laying them
- any interactions with other services
- the need for the underground cable to have superior insulation that is resistant to soil, weather and chemicals while air is anyway a worse conductor than earth.

Overhead lines are effectively insulated by the air around them being only insulated at the pylon while underground lines need to be fully insulated for their full length – earth being a better conductor than air. High voltage lines also produce heat that is more easily dissipated in the air but need some form of cooling if underground. This and other issues of protection lead to very particular specifications for underground cables posing supply chain challenges.

While that cost might be not be seen as insuperable for some lengths of line in some sensitive areas, its cost across the tens of thousands of miles of cables likely to be required would be a major factor with consequences for electricity bills.

The report notes that undersea power cables are even more expensive in comparison. It could though be noted that they have fewer land acquisition issues (save where coming onshore) and, once an undersea cable is laid, it may well be easier to increase the capacity along a route that is already settled.

Installation

Underground Cables - As a linear piece of civil engineering work, laying underground cables can have considerable and disruptive consequences. It is essentially a long construction site with access needed for heavy machinery for trenching and installation. National Grid estimates that the volume of spoil excavated for an underground cable, where two cables per phase are installed, is some 14 times more than for an equivalent overhead line route.

This may influence the route chosen with the physical and environmental issues of avoiding wetlands (sometimes with the risk of possible long term ecological damage), sensitive water flows and archaeological features.

Directly buried cables need each cable to be at a distance from others for good heat dissipation. To match overhead line thermal performance for a 400kV double circuit, as many as 12 separate cables in four separate trenches may be needed, resulting in a work area up to 65m wide.

Animals (such as beetles, amphibians, reptiles and bats) and plants (such as ferns and seed plants) can be affected by the construction works.

Soil compaction can be an issue for both agriculture and biodiversity.

Overhead Lines – Typically the work of construction has less effect than laying underground cables. They are easier to install and for later extra connections to be added.

Continuing Use

Overhead Lines - By contrast to underground lines, overhead lines typically have greater environmental effects once they are in operation than during construction.

Most comment will be about the visual and landscape effects, the cables needing to be clear of any likely contact with normal activity. In the countryside, that sees particular concern about trees.

The ecological effects appear mainly related to birds colliding with the lines.

While overhead lines are more vulnerable to storms, accidents and failure and so have a greater risk of power "outages", they are also easier to repair.

Underground Lines – Once laid, these may typically have little effect on existing land uses. Farming is generally possible over the line of the cable but deep-rooting plants (such as vines) risk causing damage to cable.

That leads to limitations on future changes of use, whether to woodland (even hedges) or to development.

Once laid, underground lines are harder to replace and upgrade (some even to find where damage might be) though they are less often damaged while in use, being less vulnerable to storms with blowing debris or other accidents and so have less risks of causing power "outages".

Electro-Magnetic Field (EMF) Effects

These are often discussed popularly as a cause of concern (typically regarding health and pregnancies) and form part of the reasons for the regulatory framework for such infrastructure.

Both overhead lines and underground cables have these fields. As underground cables have magnetic fields right above them, their intensity falls swiftly with distance from the cable. If

required, they can be shielded to reduce the effect at the surface. Overhead cables have wider but less intense fields and are already at distance overhead.

More information on these fields can be seen on the pages of this website.

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