Electricity Distribution nationalgrid

Independent Advisory Group (IAG) on Future Electricity Grid for Wales: Request for information 1

132kV and 33kV Electricity Distribution Network Topology Archetypes

In the tables below, we provide information based on the most common type of infrastructure we would look to install across our network. Across the South Wales licence area, National Grid Electricity Distribution operate 132 kV, 66 kV and 33 kV networks. As a result we have added to the table to include 66 kV where appropriate.

Table 1: Archetype description

We have used the following assumptions when populating Table 1:

Maximum Continuous Distribution Capacity (MVA):

For any new build of circuits the conductor type will be specified relative to the load requirements of the circuit. The table is populated based on the typical (most populous and in use) conductor type on our South Wales licence area as follows:

- 132kV tower OHL: 300 mm^2 AAAC
- 132kV wood pole OHL: 200 mm^2 AAAC (single conductor)
- 132kV underground cable: 1000 mm^2 3-core XLPE
- 66 kV wood pole OHL: 200 mm^2 AAAC (single conductor)
- 66 kV underground cable: 630 mm^2 single-core EPR
- 33kV wood pole OHL: 200 mm^2 AAAC (single conductor)
- 33kV underground cable: 400 or 630 mm^2 single-core XLPE

Maximum Technically Feasible Route Length (km):

We considered circuits based on the most typical conductor type, fully loaded and without reactive compensation. Underground cable route length is usually limited by capacitive charging current and voltage rise.

Life-span (years):

This is based on the Normal Expected Life from the Ofgem approved Common Network Asset Indices Methodology (CNAIM) v2.1. The Normal Expected Life is defined below:

> *"The time (in years) in an asset's life when it would be expected to first observe significant deterioration (Health Score 5.5), taking into consideration location or duty, in addition to the asset type."*

As a result, the figures provided indicate the point at which different asset types are expected to start to deteriorate but this may not correlate to the point at which they are replaced on the network where maintenance and inspections may result in a longer average life span. There is additional information that could be provided for the average asset life which is derived from the population of assets across South Wales and submitted to Ofgem in the annual regulatory reporting pack. Note that 132kV pole is not covered in CNAIM v2.1. The value for 33kV pole has been used. Similarly, pole OHL is not covered in CNAIM v2.1 so the value corresponding to tower OHL has been used.

Infrastructure Operational Footprint:

For tower and pole OHL, we have provided a range of typical support structure (i.e. tower or pole) dimensions, as well as OHL corridor length and clearance requirements.

For UG cable, we have provided cable trench range, joint bay dimension and depth of cover.

Note that building beneath OHL, building and excavations within UG cable swathe are permanently discouraged, though many agricultural/rural land uses can resume. Period vegetation management will be required.

Future Scalability for Long-Term Planning:

The operating temperature of the conductor is specified as part of the construction of the circuit, which is chosen in order to provide a suitably high rating for the circuit without risking infringing on the conductor clearances set out in the Electricity Safety Quality & Continuity regulations (2002).

In certain cases, an overhead line can be 'reprofiled' to a higher maximum operating temperature in order to increase the rating. To undertake this work, the line must be surveyed to ascertain if there are any infringements due to conductor sagging that may arise, and these issues solved by using taller poles/towers or diverting the circuits. Uprating can, in some instances, be easier for OHL subject to line construction and conductor sizes. Although not covered in the table, diversions are usually more difficult for OHL, and tend to be more challenging at higher voltages.

Table 1: Network archetype description

Characteristic	132kV			66 kV		33kV	
	Tower OHL	Pole OHL	UG Cable	Pole OHL	UG Cable	Pole OHL	UG Cable
Maximum Continuous Distribution Capacity	159 MVA	122 MVA	210 MVA	61 MVA	95 MVA	30 MVA	39 MVA (400 mm^2) 49 MVA (630 mm^2)
Maximum Technically Feasible Route Length	30 - 50 km	30 - 50 km	25 - 30 km	15 – 35 km	15 – 25 km	10 - 15 km	10 - 15 km
Life-Span	Tower: 80 years OHL: 60 years Fittings: 40 years	Pole: 55 years OHL: 60 years	100 years	Pole: 55 years OHL: 60 years	100 years	Pole: 55 years OHL: 60 years	100 years
Infrastructure Operational Footprint	Tower base: 4.0 - 4.8 m^2 Tower height: 26 m - 30m OHL corridor: 8.4 - 8.7 m Clearance to ground and roads: 6.7 - 14.6 m Normal and passing clearance: 1.4 - 3.6 m	Pole diameter: 0.23 - 0.35 m Pole length: 10 - 17 m OHL corridor: 4 - 5 m Clearance to ground and roads: 6.7 - 14.6 m Normal and passing clearance: 1.4 - 3.6 m	Cable trench: 0.6 - 1.2 m Joint bay: 16 x 2 m Depth of cover: 0.8 - 1.4 m	Pole diameter: 0.23 - 0.35 m Pole length: 10 - 17 m OHL corridor: 4 - 5 m Clearance to ground and roads: 6.3 - 14.6 m Normal and passing clearance: 1.4 - 3.6 m	Cable trench: 0.4 - 0.9m Joint bay minimum: 5 x 3 m Depth of cover: 0.9m	Pole diameter: 0.29 - 0.30 m Pole length: 9 - 16 m OHL corridor: 2.4 - 4.0 m Clearance to ground and roads: 6.0 - 14.0 m Normal and passing clearance: 0.8 - 3.0 m	Cable trench: 0.4 - 0.9m Joint bay minimum: 4 x 1.5 m Depth of cover: 0.8 - 0.9 m

Future Scalability for Long-Term Planning	In some cases, OHLs may be reconductored (depending on existing conductor sizes and OHL construction).	New underground cables would need to be installed to provide additional capacity.	The same as 132kV Pole OHL.	The same as 132kV UG Cable.	The same as 132kV Pole OHL.	The same as 132kV UG Cable.

Table 2: Deliverability and operability

We have used the following assumptions when populating Table 2:

Planning and Consents:

We have omitted substations. Nevertheless, for information, a 132kV substation typically covers 1 hectare of land when accounting for Biodiversity Net Gain. As for a 33kV substation, this is from 0.1 hectare of land upwards depending on the requirements for Biodiversity Net Gain and additional screening. Consents are usually acquired through negotiation however with an increase in objections there is an expectation that in future statutory powers may be used more often.

Reliability, Availability and Maintainability:

This is based on Probability of Failure (PoF) from the industry and Ofgem approved CNAIM v2.1. As detailed in the methodology, the PoF is derived based on three failure modes, which are incipient, degraded and catastrophic failures.

Note that 132kV pole is not covered in CNAIM v2.1. The value for 33kV pole will be used. Similarly, pole OHL is not covered in CNAIM v2.1 so the value corresponding to tower OHL will be used.

Also worth noting that physical damage normally repaired within hours or days (except when excessive damage is found, which could take weeks).

Flexible Circuit Rating:

We propose to provide a range, based on the typical conductor type used to populate the Maximum Continuous Distribution Capacity in Table 1.

The range will be dependent on material, size and temperature rating of the conductor for 132kV tower OHL, 132kV pole OHL and 132kV UG cable.

As for 33kV pole OHL, the range will be governed by material, size and single/multi circuit consideration.

Finally for 33kV UG cable, the range is influenced by material, size, core number, presence of armour, laid direct or ducted, with the assumption of continuous operation.

Provision of Restoration Services:

OHL and cable are passive network components that transfer power. Nevertheless, with the availability of generation, OHL and cable circuits can be switched to transfer power where it is needed. It is known that due to the significant charging currents that are required for cables, switching of cable circuits for system restoration can be more complex and challenging.

Table 2: Deliverability and operability considerations

Characteristic	132kV			66 kV		33kV	
	Tower OHL	Pole OHL	UG Cable	Pole OHL	UG Cable	Pole OHL	UG Cable
Planning and Consents	Min 2 km associated with generating station will require Infrastructure Consent. As for <2 km associated with generating station, Infrastructure Consent is needed if so directed by Welsh Ministers. Also dependent on when the Infrastructure Wales Act 2024 will be in force in its entirety.		Permitted development for licenced statutory operators unless Environmental Impact Assessment (EIA) is required, which then requires planning permission under Town and Country Planning Act (TCPA) regime.	Electricity Act Consent unless associated with generating station, Infrastructure Consent is needed if so directed by Welsh Ministers	The same as 132kV UG Cable.	Electricity Act Consent unless associated with generating station, Infrastructure Consent is needed if so directed by Welsh Ministers	The same as 132kV UG Cable.
Reliability, Availability and Maintainability	Tower PoF: 1.6 - 4.1 % Conductor PoF: 0.2 - 0.6 % Fittings PoF: 0.3 - 0.7 %	Pole PoF: 0.8 - 2.1 % Conductor PoF: 0.2 - 0.6 %	Solid Cable PoF: 1.9 - 4.9 %	Pole PoF: 0.8 - 2.1 % Conductor PoF: 0.2 - 0.6 %	Solid Cable PoF: 1.9 - 4.9 %	Pole PoF: 0.8 - 2.1 % Conductor PoF: 0.2 - 0.6 %	Solid Cable PoF: 1.9 - 4.9 %
Flexible Circuit Rating	159 – 194 MVA	122 - 147 MVA	188 – 210 MVA	61 – 74 MVA	85 – 95 MVA	30 – 37 MVA	36 – 39 MVA (400 mm^2) 45 – 49 MVA (630 mm^2)
Provision of Restoration Services	Switching is a proven technique for restoration.		More complex due to significant charging currents that are required.	The same as 132kV Pole OHL.	The same as 132kV UG Cable.	The same as 132kV Pole OHL.	The same as 132kV UG Cable.

Table 3 & 4: Environmental and Community Impacts

For Table 3 and Table 4, which cover environmental and community impacts respectively, we have broadly distinguished between permanent and temporary impacts where applicable. With the nature of work undertaken every scheme is different and considered accordingly, and there are policies owned by our Environment team.

Table 3: Environmental impacts

Characteristic	**132kV, 66 kV and 33 kV**		
	Tower OHL	**Pole OHL**	**UG Cable**
Construction	Permanent nature: Loss of ground cover, trees, hedgerows and habitats in ground preparation. Potential impact on biodiversity, and greenhouse gas emissions. Temporary nature: Loss of ground cover for tower/wood pole working area and construction corridor, all subsequently reinstated. Other impacts such as construction traffic on local roads, dust, noise and air quality.		Permanent nature: Soil disturbance. Although working corridor can be reinstated, we will not be able to plant trees or shrubs on top. Potential impact on biodiversity, and greenhouse gas emissions. Temporary nature: Construction traffic on local roads, dust, noise and air quality.
Operational	Impacts on landscape and visual amenity. Other impacts include acoustic noise and bird collision risk.	Similar to tower OHL, but lower environmental impacts.	Reinstatement avoids permanent environmental impacts. Cable access points will require vegetation clearance.

Table 4: Community impacts

Characteristic	132kV, 66 kV and 33 kV		
	Tower OHL	**Pole OHL**	**UG Cable**
Construction	Permanent nature: Similar to the environmental impacts above. There will be land use disruptions, with higher impacts on urban areas than rural. Temporary nature: Construction areas and construction traffic but can be managed by appropriate management mitigation measures. Storage of equipment and plant can be visually intrusive.		
Operational	Impacts are minimal, but can consist of: building on route denied, potential visual impact, potential EMF exposure, noise propagation, potential to depress property values.		Impacts are minimal, but can consist of: building on route denied, potential EMF exposure.

Table 5: Cost magnitude comparison factors

Table 5 shows the cost magnitude comparison factors, with 132kV tower OHL as the reference for both the lifetime archetype and losses costs.

In terms of the lifetime archetype costs, where appropriate, we have used Ofgem's RIIO-ED2 Final Determination asset replacement unit costs for the asset categories that are involved. We have also considered that the full lifecycle cost for an underground cable option is a factor of 2.2 to 2.8 times more expensive than an overhead line option. We have expressed losses as % of energy distributed as losses are sensitive to conductor length and loading.

Table 5: Cost magnitude comparison factors

Characteristic	132kV			66 kV		33kV	
	Tower OHL	**Pole OHL**	**UG Cable**	**Pole OHL**	**UG Cable**	**Pole OHL**	**UG Cable**
Lifetime archetype costs	x 1	x 0.2 – x 0.3	x 2.2 – x 2.8	X 0.2	X 1.5	x 0.1 – x 0.2	x 0.7 – x 0.9
Lifetime losses costs	4 – 6 %						