Lifetime Costs Report

Brechfa Forest Connection Project

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CYSWLLT COEDWIG Brechfa FOREST CONNECTION

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Contents

1. Introduction

1.1. The Strategic Optioneering Report (SOR), June 2013, sets out the preferred option to provide an electrical connection to the three proposed wind farms in the Brechfa Forest area. The 132,000 volt (132kV) connection will be constructed using an overhead line carried on wood poles.

1.2. The length of the new connection is not yet known but depending on the final route it is likely to be in the order of 30-40 km.

1.3. The use of a 132kV underground cable for the whole connection route has been considered and ruled out as part of the strategic optioneering process as detailed in the SOR. Following Stage 2 Consultation, Western Power Distribution (WPD) will however consider whether there is justification for any sections of the proposed overhead line route to be laid underground.

1.4. It has already been established that the capital costs for the installation of underground cables is significantly higher than overhead lines. However, in comparing the relative costs of the overhead and underground options, consideration has now been given to the lifetime costs of each of the options. The lifetime costs include the on-going cost of each option over the lifetime of the project allowing a more complete comparison of the relative costs of each technology. The remainder of this report therefore sets out the methodology used, and costs derived for the lifetime costs of installing overhead lines and underground cables.

2. Overhead lines

2.1. 132kV wood pole lines are constructed to Electricity Network Association Technical Specification (ENATS) 43-50 issue 2. This construction type is nominally known as a “Trident” line due to the appearance of the poles once constructed. To achieve the rating for the total output of the three proposed Brechfa Forest wind farms, a non-standard heavier construction utilising Sycamore" 250 mm^2 AAAC and ‘H’ pole construction is needed.

2.2. At times, circuits may need to be taken out of service for repair and maintenance. However, rapid restoration times are achievable on overhead line circuits where they are needed to maintain a secure supply of electricity. Overhead circuits are more susceptible to transient faults (such as momentary tree contact, bird contact or lightning) than underground cables, however the repairs are generally quick to achieve and of low cost.

2.3. In addition, emergency structures can be erected in relatively short timescales to bypass damage and restore supplies. Overhead line maintenance and repair therefore provides a good degree of operational flexibility which helps reduce security of supply risks to end consumers.

2.4. Overhead lines have a design life of 40 years but can last longer. Components such as the insulators are normally replaced after 30-40 years, (depending upon their condition) and conductors are normally replaced after 40-50 years.

3. Underground cables

3.1. Underground cable circuits require significant civil works associated with installation. These make the construction times for cable circuits longer than for overhead lines. The construction working width required for a single AC circuit comprised of one cable per phase would be approximately 16m. 132kV underground cables can be laid in either a triangular or flat formation. It is normal to lay the underground cable at a depth of 1.5m and as far apart as possible to minimise mutual heating effects. The depth of the cable and the spacing between cables can have a significant impact on the ability of the cable to conduct electricity.

3.2. Identifying faults in underground cable circuits will often require multiple excavations to locate the fault and some repairs will require extraction and installation of new cables which can take a number of weeks to complete. While underground cables are less susceptible to transient faults, permanent faults are challenging to locate. The costs of fault location and consequent repairs are high.

3.3. Underground cables have a design life of up to 40 years but can last longer. Components such as the joints and cable sealing ends are normally replaced after 40 years.

4. Valuation of lifetime costs

4.1. For both overhead lines and underground cables, lifetime costs comprise:

a) the capital cost of procuring, installing and commissioning;

b) the on-going costs of the electrical energy lost in overcoming the electrical resistance in the conductors and

c) the on-going 'other costs' of operations and maintenance.

4.2. Decommissioning and reinstatement costs are not included in the lifetime costs. This is because the distribution network associated with the Brechfa Forest wind farms will be decommissioned and removed only if the wind farms it serves are removed and not replaced and if there is no requirement to use the network to connect other customers. WPD's experience however, is that the costs of decommissioning cables is higher than the costs of decommissioning overhead lines.

4.3. The lifetime assumed for both infrastructure types is 40 years. This is the figure adopted by WPD when calculating net present value even if an asset is replaced or removed in a shorter timeframe.

4.4. The following formula was used to assess the total lifetime cost of each technology option to provide the basis for comparison of the construction options for the proposed new circuit route from Llandyfaeolog.

CTot = CDC + CL + COM

Where:

CTot	Total Lifetime Cost.
CDC	Capital Cost of the equipment, installed and commissioned.
CL	Net Present Value of the Cost of Losses over the lifetime (40 years) of the assets

COM The Net Present Value (NPV) of the typical Cost of Operation and Maintenance over the lifetime (40 years) of the assets.

4.5. In the absence of detailed routes and tenders the following costs were used in estimating the capital costs of the installation of circuits:

- 132kV overhead line £150k per km;
- 132kV underground cables £986k per km.

4.6. From figures published by the Department for Energy and Climate Change, the average load factor for onshore wind farms in the UK is between 25 and 30%. This figure varies between regions and on an annual basis (in Wales 2012 for example, the load factor was 25.1%[1]). A mid-point value of 27.5% has been used in the calculation. From this load factor, the average loading of the circuit and the consequent losses per annum for each is evaluated.

4.7. This figure has been used to determine the average losses for the new connection based on the proposed capacity of the wind farms in the Brechfa Forest area.

4.8. The historical on-going maintenance and repair cost for 132kV overhead lines and underground cables for WPD in South Wales and the South West were used to calculate lifetime costs. This was achieved by using the total annual costs for inspection and maintenance, faults, tree cutting over a two year period, setting the results against the total length of circuit in service to calculate the average cost per kilometre per year.

4.9. Table 1 below shows the basis of the calculation of typical cost of operation and maintenance.

1 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/244732/1_regional_renewables_2012.pdf

Table 1.1– Cost of operation and maintenance

		132kV overhead lines	132kV underground cables
Inspection and maintenance	£m	1.9	0.0
Faults	£m	0.0	0.1
Tree cutting	£m	0.3	0.0
Total	£m	2.2	0.1
Length in commission	km	2612	100
Cost per km per year (approx)	£	800	1000

4.10. The resultant average cost of operation and maintenance of approximately £800 per km per year for overhead lines and £1,000 per km per year for underground cables are used in the calculation of lifetime costs.

5. Calculation of costs – overhead line

Capital Cost of Equipment (CDC)

CDC = circuit (km) x cost per km (£k)/1000

$$\mathbf{CDC} = \frac{40 \times 150}{1000} = \mathbf{£6\ million}$$

Cost of Losses (CL)

5.1. The cost of distribution losses are calculated as follows:

Step 1 – Calculate the Average Loading

Average loading (MW) = Peak circuit capacity (MW) (based upon combined capacity of the three wind farms) x Average circuit utilisation (load factor) (27.5%)

$$\text{Average Loading (MW)} = \frac{175 \times 27.5}{100} = \mathbf{48.125\ MW}$$

Step 2 – Calculate the Average Current

Average Current (A) = Average loading (kW)/ $\text{Operating Voltage (in kV)} \times \sqrt{3}$

$$\text{Average Current (A)} \frac{48.125 \times 1000}{132 \times \sqrt{3}} = \mathbf{210.492\ Amps}$$

Step 3 – Calculate the Resistance of the Circuit

Resistance of circuit = resistance per km x circuit length (km)

$$\text{Resistance of 40 km OH Line} = \mathbf{4.879\Omega}$$

Step 4 – Calculate the Three Phase Lost Power

OH Line losses (kW) = 3 x (Average Current)^2 x OH line resistance/1000 (convert to kW)

$$\text{OH Line Losses (kW)} = \frac{3\times(210.492)^2\times 4.879}{1000} = \mathbf{648.52kW\ (0.648MW)}$$

Step 5 – Calculate Annual Cost of Losses

Annual Cost of losses OH Line (£ per year) = Lost Power (MW) x 24hr x 365 days x Cost per MWh (a cost of £48 is used).

$$\text{Annual Cost of Losses OH Line(£ per year)} = \frac{648.52 \times 24 \times 365 \times 48}{1000} = \mathbf{£272,670}$$

Step 6 – Calculate Net Present Value of the Cost of Losses (CL)

5.2. Net Present Value is calculated over a 40 year period at a discount rate of 7% (excluding tax relief allowance) as per Western Power Distribution's Financial and Accounting Policies.

$$\mathbf{CL = £3.446\ million}$$

Cost of Operation and Maintenance (COM)

Operation and maintenance costs = Period (years) x Average Costs per year

$$\text{Operation and Maintenance costs per year} = 40 \times 800 = \mathbf{£32,000}$$

5.3. The Net Present Value (NPV) of the typical Cost of Operation and Maintenance (COM) over the lifetime (40 years) of the assets is calculated using a discount rate of 7% (excluding tax relief allowance) as per Western Power Distribution's Financial and Accounting Policies.

$$\mathbf{COM = £404,000}$$

5.4. Therefore taking account of the above calculations the Lifetime Cost for the Overhead option is as shown below:

CTot = CDC + CL + COM

$$\textbf{For OH Line Option CTot} = 6 + 3.446 + 0.404 = £9.85 \textbf{ million}$$

6. Calculation of costs - underground cable

Capital Cost of Equipment (CDC)

CDC = circuit (km) x cost per km (£k)/1000

$$\text{CDC} = \frac{40 \times 986}{1000} = \mathbf{£39.44}\ \text{million}$$

Cost of Losses (CL)

6.1. The cost of distribution losses are calculated as follows:

Step 1 – Calculate the Average Loading

Average loading (MW) = Peak circuit capacity (MW) x Average circuit utilisation (27.5%)

$$\textbf{Average Loading (MW)} = \frac{\mathbf{175 \times 27.5}}{\mathbf{100}} = \mathbf{48.125\ MW}$$

Step 2 – Calculate the Average Current

Average Current (A) = Average loading (kW)/ Operating Voltage (in kV) $\times \sqrt{3}$

$$\text{Average current (A)} = \frac{48.125 \times 1000}{132 \times \sqrt{3}} = \mathbf{210.492\ Amps}$$

Step 3 – Calculate the Resistance of the Circuit

Resistance of circuit = resistance per km x circuit length (km)

$$\text{Resistance of 40 km UG cable } = \mathbf{1.26}\ \Omega$$

Step 4 – Calculate the Three Phase Lost Power

OH Line losses (kW) = 3 x (Average Current)^2 x OH line resistance/1000(convert to kW)

$$\text{UG Line Losses (kW)} = \frac{3\times(210.492)^2\times 1.26}{1000} = \mathbf{167.48\ kW\ (0.167MW)}$$

Step 5 – Calculate Annual Cost of Losses

Annual Cost of losses OH Line (£ per year) = Lost Power (MW) x 24hr x 365 days x Cost per MWh

$$\text{Annual Cost of Losses UG Line(£ per year)} = \frac{167.48 \times 24 \times 365 \times 48}{1000} = \mathbf{£70,422}$$

Step 6 – Calculate Net Present Value of the Cost of Losses (CL)

6.2. Net Present Value is calculated over a 40 year period at a discount rate of 7% (excluding tax relief allowance) as per Western Power Distribution's Financial and Accounting Policies.

$$\mathbf{CL} = \mathbf{£890,000}$$

Cost of Operation and Maintenance (COM)

Operation and Maintenance costs = Period (years) x Average Costs per year

$$\text{Operation and Maintenance costs per year} = 40 \times 1000 = £40{,}000$$

6.3. The Net Present Value (NPV) of the typical Cost of Operation and Maintenance (COM) over the lifetime (40 years) of the assets is calculated using a discount rate of 7% (excluding tax relief allowance) as per WPD's Financial and Accounting Policies.

$$\mathbf{COM} = £\mathbf{505{,}000}$$

6.4. Therefore taking account of the above calculations the lifetime cost for the overhead option is as shown below:

$$\mathbf{CTot = CDC + CL + COM}$$

$$\mathbf{For\ UG\ Cable\ Option\ CTot} = \mathbf{39.44 + 0.89 + 0.505} = £\mathbf{40.84\ million}$$

7. Conclusion

7.1. The calculations above show that the inclusion of lifetime costs increases the overall cost of each option over and above the initial capital costs.

7.2. In summary the total life costs for an assumed 40km connection are:

- Total lifetime cost for overhead option = £9.86 million.
- Total lifetime cost for underground option = £40.84 million.