Disclaimer

Appendix 2 – Review of ICF and EC reports

ICF Report - Overview of the Potential for Undergrounding in the Electricity Networks in Europe – ICF Consulting Ltd, February 2003. [ref 3]

In reviewing reports of this nature it is usual to consider first the objectives behind the work and the conclusions reached. From the outset, the objective assessment of the ICF Report is made somewhat difficult because:

a) the purpose of the report is vague (it is simply stated as being prepared in order "to assist the European Commission in assessing the potential for undergrounding the Electricity Network in Europe"); and,

b) there are no definitive conclusions set out in the document.

The report is thus more of a review of the issues surrounding the OHL/UGC debate, together with information about some recent EHV transmission schemes involving UGC solutions. There seems to be a wider objective in mind to provide information to enable an assessment to be made as to whether the application of UGCs might assist in bringing forward further European transmission network interconnector schemes as a means of promoting further competition in the European electricity market.

It is judged that the report has been prepared for a non-technical audience and it is noted that the report contains a number of technical inaccuracies which serve to undermine its wider value as a source of reference. There are also a number of instances throughout the document where statements are made for which neither supporting evidence, nor sources of reference are quoted.

The report's Executive Summary (pp 3 -8) advances five reasons why undergrounding of electricity lines is more expensive than overhead lines. It may thus be helpful to offer comment on each of these stated reasons as a means of illustrating some of the shortcomings in the document.

"Additional insulation is required because cables are often laid only one metre below ground".

This statement is incorrect. As has been described in section 1.2, OHLs use the air as the insulating medium whereas cables are themselves insulated.

Cables are normally buried to provide them with both physical restraint and protection and for rather more practical reasons as cable runs above ground would need to be fixed to some form of support structure which would be both costly and obtrusive. Greater depth of burial would provide greater physical protection but at increased installation cost and with less-effective transfer of heat away from the cable during operation. Thus, depth of burial is usually a compromise with higher voltage cable being installed at greater depth. The maximum installation depth (used for 132kV and above) does not generally exceed 1.2m however.

"Extra land is needed for the sealing end where the cables need to be connected to overhead lines"

Whilst true, the SEC land *costs* are not normally a major factor in the cost comparison between UGC and OHL. Because a cabled section of a transmission circuit requires a SEC at either end, the shorter the cabled section of the route, the higher the fraction of the total cable route cost which the SECs will represent and the higher the overall "per kilometre" cost rate will be.

What is often important in the design of transmission connections, however, is the area taken up by SECs (see figure 6), which is determined by the electrical clearances to earth required for the OHL conductors. Typical dimensions for a SEC at 400kV are given in section 1.2.

"Access to the cables is essential for repairs and maintenance purpose[s], therefore the land above the cables cannot be used for farming or industrial purposes".

Essentially, this statement is not completely true as the land above EHV cables may be used for agriculture. Equally, however, the need for subsequent access is not a major factor in determining the *cost* of a UGC (or, for that matter, an OHL). Land beneath OHL can be used for a variety of purposes and there are many examples where residential properties are directly beneath the conductors of the OHL (although UK transmission companies would not normally seek to build new lines above existing properties because of the access problems inherent in this approach).

For cabled circuits, disruption caused during installation is more significant than for OHL (which itself contributes to the higher cost of UGC) and there are significant restrictions on what can be allowed to be grown over the route of an UGC. As will be seen later in this report, there are examples of reinstatement of UGC circuits where, a few years after installation, it is difficult to identify where the cables are buried. Any vegetation growth above the cable circuits must, however, have a relatively shallow root system, hence it is not possible for trees to be planted above UGC circuits.

"With Alternating Current, it is necessary to provide for reactive power at 400kV, this requires compensation/substations every 15 to 20km".

Whilst true, it should be noted that the majority of UGC circuits are much shorter, hence reactive compensation is rarely necessary in order to accommodate those cables (and, hence, rarely of relevance to the cost comparison issue).

"Within an existing network of overhead lines, it is difficult to integrate underground cables due to the differences in impedances. To solve this, it is necessary to split up meshes networks and operate them as partial networks, which requires additional investments to increase transformation power to these partial networks".

Whilst theoretically true, Jacobs Babtie is not aware of any cases where this has been an issue. If this were to be a problem for the proposed Beauly - Denny line, this would, of course, have the impact of *increasing* the relative cost of the cabled option.

Some of the other arguments advanced in the ICF Report which merit further observation and comment are:

1. On P3 (final paragraph), it is suggested that one reason for a reducing price differential between UGC and OHL is an "over capacity in the European Market for transmission cables".

   Research undertaken in the preparation of this report has revealed no such over-capacity. Indeed, the manufacture of EHV cables and accessories is such a specialist activity that it is felt unlikely that manufacturers would have invested speculatively in such manufacturing capacity.

   It should also be pointed out that the high capital values of EHV transmission schemes (cable or OHL) are such that competitive tendering is invariably employed, thereby ensuring that capital costs are market tested. SHETL have indicated that they would be seeking competitive tenders for the Beauly - Denny line.

2. Much is made in the UGC report of a recent Danish transmission project in which the cost ratio between the UGC and OHL portions of a new 400kV circuit are said to be as low as 3 or 4 : 1. This particular reference case is considered in more detail in section 2.

3. On P4 (para 4) of the ICF Report, it is suggested that UGC "are far less likely to cause death or injury due to accidental contact with the lines/cables".

   It is felt more realistic to acknowledge that both UGC and OHL are potentially hazardous but that the nature of the hazard differs. UGCs pose a risk to those excavating in their vicinity, the mitigation for which is use of techniques to identify the location of those cables including the keeping of good installation records. OHLs pose a risk to the wider public from inadvertent contact with live conductors but only under particular circumstances (e.g. contact with fishing lines, boat masts, kites and similar).

   In the UK, accidents and fatalities arising from the inadvertent contact with network operators' live conductors mainly occurs at distribution rather than transmission voltages (i.e., at 132kV and below). Figures from the DTI's Engineering Inspectorate [ref 7] show that, in 2002-3, of the 15 UK deaths from incidents associated with the assets of the electricity utility companies, only two involved voltages of 132kV or above. The same report also shows that 99% of the 274 injury accidents in that year involved voltages below 132kV.

In any event, inadvertent contact with 400kV circuits (OHL or UGC) is considered much less likely than with lower voltage circuits as in the case of UGCs, the precise location of the cables is always well-documented, the cables themselves being physically protected by cable tiles and cement bound sand. For OHLs, the hazard is more readily identified (that is to say, visible) than with, for example, 11kV wood pole circuits, and has a far greater clearance to earth.

4. Reference is also made in paragraph 4 on P4 to the fact that UGCs are not susceptible to storm damage whereas OHLs are. Whilst this is true and whilst it is also recognised that parts of the proposed Beauly - Denny route are on high, exposed area, the following should also be borne in mind:-

   a) at higher voltages, OHLs are specifically designed to withstand wind and ice loadings likely to be encountered, (for example, by reducing tower spacings). SHETL have indicated that the proposed Beauly - Denny OHL would be "designed for the climate and altitude"; and,

   b) most cabled routes form part of larger, composite OHL/UGC lines, hence, any benefit in storm resistance gained from cabled parts of the line may not have a significant impact in the overall availability of the circuit as a whole.

   In addition, the ICF Report makes the point that circuit restoration times following faults in cable circuits are significantly longer due to the time required to locate, excavate and repair the faulted portion of the cable. These times would be correspondingly increased for cable fault occurring in remote and/or inaccessible sections of a circuit.

   Attempts have been made to financially model the impact of these factors in section 2 of the main body of the report.

EC Background Paper - Commission of the European Communities Background Paper on "Undergrounding of Electricity Lines in Europe", December 2003. [ref 6]

It is noted that the EC Background Paper has been based, in part, on information given in the ICF Report (recognising that the latter was prepared to inform DG TREN and the European Commission). It therefore repeats much of the information given in the ICF Report.

The EC Report also sets out to assess the potential for the application of UGCs to improve cross-border transmission network interconnectivity, recognising that many of Europe's planned interconnection schemes appear to be stalled due to planning difficulties associated with the proposed OHL routes.

In its Introduction, the EC Report sets out a brief background to the history of cable system development and provides figures for European Networks to show the extent of cable network at various system voltages. In Section 2, the document provides a country-by-country overview of the approach to the OHL vs. UGC issue across Europe, outlining some recent and proposed projects. Much of this section is extracted from the earlier ICF report. Section 3 provides some statements about the perceived benefits of UGCs (some of which are discussed below) whilst sections 4 and 5 assess the prospects and viability for the application of UGCs to a number of European interconnector projects. (These sections are thus of limited relevance to the proposed Beauly - Denny line.) Finally, section 6 draws conclusions on the above whilst the Appendices provide more information on the alternative technologies available and of some recent UGC projects worldwide.

As with the ICF Report, it is noted that the report contains a number of technical inaccuracies and that the conclusions it reaches are often not supported by the data presented. Again, this is best shown by example.

On the basis of the information presented in section 2 of the EC Report, it would, in the opinion of Jacobs Babtie, be reasonable to summarise the position in Europe as follows:

"At EHV, application of UGCs to transmission networks is extremely limited (<0.5% by circuit length) and this reflects transmission network operators' reluctance to use UGCs due to their significantly higher cost when compared with OHLs. Estimates on the cost ratios between OHLs and UGCs vary widely between countries (between around 4:1 and 25:1) but there is little data available to be able to assess the basis on which these ratios have been calculated and hence, direct comparison is difficult. It is acknowledged that the cost ratio will be heavily influenced by the terrain under consideration and the system voltage. The ratio will also be influenced by what cost elements are included in the comparisons.

"The information presented also suggests a view that, because many network operators across Europe are unwilling to meet the additional expense involved in undergrounding, a number of key transmission interconnector projects have stalled."

In contrast to this analysis, the main conclusion of the report (relating to EHV systems) is as follows:

"*that coordinated action should be taken 'at a European level [to] underground at least those sections [of the transmission network] which are prone to adverse weather conditions, so that better levels of security of electricity supply can be expected'*".

This conclusion appears to be extrapolated from a single case study from France where, in December 1999, significant disruption to electricity supplies was experienced due to adverse weather conditions. This example alone is used to support the argument that OHLs are less reliable than UGCs and **is in contrast to the national UK fault statistics provided by the Electricity Association (now the Energy Networks Association) which show the reverse to be true**. (This data is reproduced in section 2.5 of the main body of this report.)

In paragraph 5 of page 2, the report also suggests that the December 1999 experiences led the French government to follow a new policy of undergrounding significant parts of their electricity system in order to secure supply availability yet, at EHV, this does not appear to be borne out in practice as, in paragraph 3 of page 10 of the EC Report, it is noted that, **in France "there has been almost no undergrounding of 380kV [400kV] lines in recent years"**. Paragraph 6 of page 2 of the EC Report also sets out the new French policy referred to in the Introduction which states that, for 400kV lines, "undergrounding should only happen in exceptional cases". It is therefore felt that the conclusion reached in the EC Report is not supported by the facts.

Some of the other arguments advanced in the EC Report which merit further observation and comment are:

1. The statement is made in the Conclusion to Appendix I, that XLPE "is the most developed cable technology". This is not the case, (see page 11 for a description of the evolution of cable technology).

2. Tables are presented detailing UGC circuit lengths in various European countries (Tables 2 and 3). The information regarding the UK in Table 2 is incorrect and in Table 3, is inconsistent. It is believed that the errors in these tables are likely to have arisen as a result of the inconsistent manner in which circuit length and cable length are often quoted.

3. When describing capital costs, no reference is made to civil engineering costs which can make up to 30% of the project value.

4. The cable manufacturing market is not studied in the report, therefore, the comment made in paragraph 4 on page 31 that "it [could] be expected that a massive production of cables will create a real new market resulting to substantial reductions of prices of cables" is speculation.

5. The report refers in paragraph 7 on page 16 to the 'invisible' nature of UGCs. Although this is a clear advantage of undergrounding, there are also risks associated with the restoration and regeneration of habitats following the

installation of EHV cables in trenches and also the potential for damage to archaeological features. There is also visual impact associated with the SECs of any cable circuit. In addition, the route of the cables is readily identifiable for cables installed in troughs.

6. The statement is made in paragraph 8 on page 16 that “property values in proximity to underground cables would be higher than in the case when overhead lines were used instead” yet there is no evidence offered to support this statement.

   It might reasonably be argued that, the construction of an OHL would reduce neighbouring property prices although no evidence has been found by the current study to quantifiably support such a view.

7. The EC report describes the access requirements for cable solutions being ‘very much smaller’ than for overhead lines (1.4b, p 33). This is not the case. For EHV cable installation, cable drums 4m diameter, weighing in excess of 25T must be delivered to points along the cable route at least 900m intervals. In addition, excavation equipment must have access to the whole cable route. In practise, this means that, during construction, more than one site access point is often needed as well as a temporary “haul road” to service to whole route. These requirements are illustrated in various figures included herewith.

8. The EC report also suggests that the land around an overhead line cannot subsequently be used for its original purpose or inhabited due to magnetic fields (1.3b, page 31). This is not the case as EHV power lines span numerous residential (and other inhabited) properties whilst land adjacent to and beneath OHLs is often grazed or farmed. Likewise, the report states that land above a cable route can be developed: this is not the case as, with the exception of where cables are installed in tunnels, the land can not be built upon because in the event of a cable fault, subsequent access is required to effect repairs.