SCOTTISHPOWER
SP Transmission Ltd

Beauly-Denny Overhead Transmission Line Project

Stirling Visual Impact Mitigation Scheme Consultation Report

Connecting Scotland's Sustainable Future

Beauly Denny 400kV Overhead Transmission Line

PART 2: UNDERGROUNDING IN THE STIRLING AREA OF THE BEAULY DENNY 400kV LINE

Prepared by Cable Consulting International Ltd and PB Power; Part 2 presents the findings of a review of the technical and cost elements of the Beauly – Denny Public Inquiry documents on undergrounding. The review also considers any significant developments in terms of costs or technology updates since the end of the Beauly Denny Public Inquiry. The outcome of the review was presented to SPT to be evaluated against their statutory duties, the findings of which are presented in Part 1.

Stirling Visual Impact Mitigation Scheme

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TITLE: **Undergrounding in the Stirling Area of the Beauly-Denny 400kV line.**

REPORT No: **ER 439 rev 1**

CUSTOMER: **Scottish Power Transmission**

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DATE: **24th September 2010**

Summary

SPT have engaged Cable Consulting International Ltd. (CCI) and PB Power to provide a review, in the form of this report, of 400kV/275kV AC undergrounding around the Stirling area.

A total of seven route alternatives have been studied with an attempted cost accuracy of +/- 20%. Costs have been provided by independent commercial companies competent to supply and/or install EHV cable systems in Europe.

Overhead line costs along each route vary between £1.5m and £27.5m whereas the cost of undergrounding varies between £60.3m and £480.2m. The additional cost of undergrounding varies between £58.9m and £452.7m. All options involving the undergrounding of circuits are shown to be significantly more expensive than the overhead line originally proposed.

The technical position with regard to underground cable or overhead lines has not changed significantly since the public inquiry. Underground cables would still be significantly more expensive to install than overhead lines across the Stirling Area.

Examination of projects in other areas of the world where less expensive underground cable connections are installed reveals that the power transfer requirements are significantly lower than those required for the Beauly-Denny line. The cost ratios of UGC to OHL have been shown within this report to be a convenient rather than a reliable indicator of comparative cost. When calculated on a project by project basis the estimated difference in total cost is a far more useful indicator.

Distribution: Scottish Power, PB Power, File

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1 Introduction

On 06 January 2010, Scottish Ministers granted to ScottishPower Transmission Limited (SPT) section 37 consent and deemed planning permission for the Beauly-Denny Transmission Line. One of the conditions attached to the section 37 consent/deemed planning permission requires SPT to bring forward for approval a scheme to mitigate the visual and landscape impact of the overhead line between towers TD199 and TD244. Following the issue of the section 37 consent/deemed planning permission, the Scottish Government Energy Consent and Deployment Unit ("ECU") also issued a briefing note regarding the requirements of the Stirling Visual Impact Mitigation Scheme. This is included within Appendix 4. The ECU require that the scheme will see the mitigation of the affected sections of overhead line through possible measures including re-routing, re-sizing of towers, screen planting or undergrounding. The possibility of undergrounding sections of the overhead line has also been raised in correspondence from several parties including Keith Brown MSP. The correspondence promotes an exploration of undergrounding part of the line as a means of providing the landscape and visual mitigation required in terms of condition 19.

SPT have engaged Cable Consulting International Ltd. (CCI) and PB Power to provide a review, in the form of this report, of 400kV/275kV AC undergrounding around the Stirling area. Scottish Power also engaged PB Power to assist in the preparation of this report with contributions regarding Overhead Lines (OHL), tunnelling technology, as well as compiling the cost tabulations. PB Power was also involved along with CCI in the preparation of two reports on undergrounding, APL 5/16 (Appendix 10) and APL/STG-41 (Appendix 11), which were presented to the Beauly-Denny Public Inquiry and which are referenced within this report.

Civil costs for undergrounding, other than tunnelling, were provided by Scottish Power to CCI for inclusion in the cable costing. These costs were obtained by SPT from Balfour Beatty; Balfour Beatty being an experienced Extra High Voltage (EHV) cable installation contractor in the UK.

The report is split into sections as follows:

- Section 2 contains a briefing note agreed with Scottish Power for this report.
- Section 3 identifies the contributions to this report from other companies and outlines the level of detail provided.
- Section 4 lists the main reference documents which are also attached as appendices.
- Section 5 provides a technical update since 2007.
- Section 6 provides a commentary on the service experience of EHV underground cables.

- Section 7 gives an update of the cost estimates for undergrounding of the Beauly-Denny connection in the Stirling area.
- Section 8 contains a review of recent documentation received by Scottish Power and forwarded to the authors for comment in this report.
- Section 9 provides the conclusions reached by the authors on the subjects contained within this report.

The appendices provide reference documentation for the reader.

- Appendix 1 contains information on the references and notes indicated in the report.
- Appendix 2 and Appendix 3 contain route maps identifying possible cable routes in areas requiring visual mitigation of the overhead line connection.
- Appendix 4 contains a copy of the ECU briefing note on visual mitigation of the overhead line.
- Appendix 5 contains a copy of the letter from Ken Brown MSP to Scottish Power.
- Appendix 6 contains a copy of a letter from Graeme Cook (SPICe).
- Appendix 7 contains a copy of a letter from Caroline Paterson dated 18th Feb 2010.
- Appendix 8 contains a copy of a letter from Peter Pearson dated 20th February 2010.
- Appendix 9 contains SPT Photographs between Logie Villa and Glenside
- Appendix 10 contains a copy of document APL 5/16 submitted during the strategic session of the public inquiry by SHETL and SPT.
- Appendix 11 contains a copy of document APL/STG-41 submitted by SHETL and SPT during the Stirling local session of the Beauly-Denny connection public inquiry.

2 SPT Briefing

Following the granting of section 37 consent/deemed planning permission, and in light of the terms of the briefing note and correspondence referred to above, SPT require that CCI and PB Power produce a report which:

1. Reviews the technical and cost elements of the Beauly – Denny Public Inquiry documents APL 5/16[1] and APL/STG-41[2]. This review shall advise of any significant EHV OHL or cable system developments in terms of costs or technology updates since the end of the Beauly-Denny Public Inquiry. This work shall supply updated costs for the following routes as described in APL/STG-41:
    a. West of Stirling routes
        i. UGC4 – SNH Option 1
        ii. UGC4 – SNH Option 2
        iii. UGC4 – SBP
    b. East of Stirling
        i. UGC4 – UoS

2. Estimates the cost of undergrounding the sections of overhead line between:
    a. the top of the scarp of the Ochils at Cocksburn Wood (TD199) and Airthrey Castle (TD203); and
    b. the section south of the tower at Logie Villa (TD203) and to the east of Stirling to the tower at Glenside (TD244).
    c. both of the above sections from towers TD199 to Denny Substation as one complete section of undergrounding.
3. Provides a review of the following documentation which has been received by SPT since the Public Inquiry in so far as they concern the use of underground cables:
    a. Letter from Graeme Cook, Principal Research Specialist, Scottish Parliament
    b. Letter from Keith Brown MSP to Phil Henderson, Government Affairs, SPT dated 8th March 2010.
    c. Information Centre to Ellen Forson, dated 5th February 2010.
    d. Letter from Peter Pearson, dated 20th February 2010
    e. Letter from Caroline Patterson, 18th Feb 2010
    f. The Minute from the initial meeting of the community councils/key stakeholders/interest groups as held on 06 March 2010.
    g. A review of National Grid publications regarding the "Hinkley Connection" in England insofar as it concerns underground cables.
    h. Energy Consents and Deployment, Business, Enterprise and Energy Directorate briefing note emailed to SPT on the 28th January 2010.

The approach taken has been to employ the technological and cost approach published in documents APL 5/16 and APL/STG-41 for Beauly-Denny public inquiry. For items under paragraph 1, a technological and cost review was required which included the need for revised costs from experienced contractors, these costs being included in the same manner as those presented to the public inquiry. The items in paragraph 2 required the determination of additional possible cable routes to the east of Stirling, these would be laid out by CCI and a site inspection performed by SPT and a landscape architect from MTLA. Paragraph 3 required a considered review by an experienced cable consultant from CCI.

3 Contributors to this report

The cost of civil works, excluding tunnelling, have been obtained by SPT from Balfour Beatty (Balfour Beatty, are experienced EHV cable installers and civil contractors). These costs are a like for like update of the costs produced for the schedules given in APL/STG-41.

The costs of cable system materials, specialist supervision, jointing and system testing have been obtained from EHV cable system suppliers by CCI.

Six suppliers were requested to provide CCI with information on products and budgetary costs. These were, ABB (Sweden), Prysmian (Italy), Nexans (France), NKT (Germany), Suedkabel (Germany), and Silec (France). Three of these manufacturers responded and

the information provided has been used in the production of this report. In order to maintain commercial confidentiality the identity of suppliers who responded, and information on which costs belong to which supplier, has not been included.

It was recognised that comparisons with an overhead line option would be made by stakeholders with regard to costs.

PB Power have reviewed the OHL and tunnelling technology since the Beauly-Denny Public Inquiry and provided updated costs for OHL, sealing end compound and tunnelling works.

PB Power also produced the cost tables contained within this report which are updates and additions to those prepared for the Beauly – Denny public inquiry in document APL/STG-41.

4 Reference Documents

There are two reports from the Beauly Denny public inquiry submitted by SPT/ Scottish Hydro Electric Transmission Limited (SHETL) in evidence that the reader of this report should have to hand when reading this report. These are:

- "Proposed Beauly to Denny 400kV Overhead Transmission Line, The Use of Underground Cable as an alternative to Overhead Line in Specific Locations, Final Report, January 2007" PB Power, PI document, referred to in the public inquiry and in this report as document **APL 5/16** and attached as Appendix 10.
- "Proposed Beauly to Denny 400kV Overhead Transmission Line, The use of underground cable as an alternative to overhead line: STIRLING, Final Report October 2007", PB Power, PI document referred to in the public inquiry and in this report as documents **APL/STG-41** and attached as Appendix 11.

5 Technology Updates

This section provides a technology update on underground cable (UGC) and overhead line (OHL) since the end of the Beauly – Denny Public Inquiry in December 2007.

5.1 Underground cable technology update

This section of the report describes technological developments in EHV power cable system design since the Beauly-Denny Public Inquiry.

5.1.1 Coated conductors

A large cross section conductor is known to suffer from an increased AC resistance due to a phenomenon known as 'skin effect'. When carrying an AC current, the electrons in the conductor find the lowest impedance path by tending to travel along its outer surface

or edge. This means that the AC current density inside the conductor is non-uniform and the density of the current increases at the perimeter of the conductor. This phenomenon increases the conductor resistance when carrying an AC current. This increase in resistance results in a higher conductor temperature than would otherwise be the case if the skin effect phenomenon did not exist and limits the amount of current, and hence power, that a conductor may carry.

To decrease the skin effect phenomenon manufacturers have for many years used a Milliken design of conductor (named after its inventor). For practical and cost reasons manufacturers employ up to six conductor segments (each segment is sector shaped which looks in cross section rather like the segments of an orange) within which the wires of each segment are spirally wound before being assembled together into a single conductor. Each segment is sector shaped and assembled to form a round conductor where individual wire strand paths travel from the outer to the inner regions of the conductor thus better equalising the conductors current density and lowering its resistance.

A further development has been introduced whereby a significant percentage of the wire strands in each segment are provided with a high resistance coating. This is normally either a copper oxide or an enamel coating to stop electrons jumping between wire strands. Since completion of the Public Inquiry the use of oxidised and enamelled conductors is becoming more common place for large conductor (1600mm^2 and above) installations. Manufacturers were asked to provide prices for enamelled conductors (which have a lower AC resistance than oxidised or plain conductors) which can carry marginally more current.

5.1.2 Radial moisture barriers

The ingress of any water into an EHV power cable insulation is likely to result in eventual primary insulation failure. For this reason EHV cable designs employ a radial water barrier. This radial barrier can consist of either an extruded seamless tube, called a metallic sheath (normally made of lead or aluminium) or a seamed longitudinal wrap of a thin metal sheet or an even thinner foil (of either copper, stainless steel or aluminium). The seam on the longitudinally applied tape is usually laser welded and the seam on the foil glued.

Because the ingress of water into a power cable is likely to considerably shorten its life there has been an understandable caution from most experienced utilities in the adoption of radial moisture barriers which employ longitudinally applied tapes or foils. However, confidence in the seamed designs is growing and at 275kV and 400kV the use of a longitudinally welded tape is now considered as acceptable for use on EHV circuits by United Kingdom's largest EHV cable user, National Grid. However, cable designs which employ longitudinal foils are still restricted to dry environments, such as underground tunnels.

For this report manufactures were invited to provide designs with both seamless, longitudinal tape and foil radial water barriers; the latter only being considered for use in a tunnel under the Ochils.

5.1.3 Oversheathing materials

The most common oversheath material being used on EHV power cables is high density polythene (HDPE). This is a more durable polymer than lower density polythene or PVC oversheathing materials.

HDPE is however extremely flammable and like XLPE has a similar calorific content to petroleum. Whilst National Grid have permitted the use of HDPE cable coverings inside their cable tunnels, others transmission companies require a fire resistant coating on the cable.

For the purposes of this report manufacturers were not asked to place a fire resistant covering on their cables. In the event that SPT might require a specialist fire retardant over-sheathing material any resultant increase in cost to the cable price is unlikely to be a deciding factor.

5.2 Overhead line technology update

PB Power overhead line experts were consulted on any new technologies that would be relevant to the Beauly – Denny overhead line. The PB Power engineers advised that the use of any specialist technology, such as high operating temperature conductors, would be likely to increase the cost of the overhead line construction.

6 Service experience

Cable installations using XLPE insulation technology at 275kV and above are increasing. However, not all manufacturers that claim to have a capability to produce a 275kV cable actually have significant service experience; and even less so at 400kV.

Demand over the last five years has been such that some manufacturers have carried out significant investment programmes to increase manufacturing capacity and soak up the demand. European manufacturers have installed a number of new EHV extrusion lines and the previous decline in EHV cable manufacturers has abated.

A number of manufacturers are continuing to export to the Middle East and the Far East and a number of manufacturing joint ventures are running, particularly in China.

Power cables are not immune from failure. In 2006 a serious EHV cable failure was reported by the State Grid Electric Power Institute in China which resulted in the loss of six 220kV cable circuits in the same tunnel.

Figure 1 - Fire Damage in a Cable Tunnel in China

Whilst XLPE cable designs present a lower risk of fire damage than oil filled cables, they do not eliminate this risk of a serious fire entirely. Precautions against fire are still necessary in a power cable tunnel system design, particularly with regard to the safety of personnel and the provision of escape routes. On the left hand photograph of Figure 1, in the foreground bottom left, are the remains of power cables after serious fire in a cable tunnel. The cables can be seen with their copper conductors still inside the aluminium sheaths but all the XLPE insulation has burnt away. In the right hand photograph the intensity of the fire is illustrated by the heat damage causing concrete to crack and expose the reinforcing bar beneath on both the walls and the ceiling. The fuel for this fire was the XLPE cables following an electrical fault.

To date the tunnels containing EHV XLPE cables in the UK have not experienced a fault and precautions such as, fire resistant coatings, non-auto reclose (where the circuit tries to reenergise immediately after a fault) and fast switching circuit breaker operation may ensure such damage does not occur on a UK circuit. However the risk is a real one.

If the Beauly – Denny 400kV and 275kV cables were placed in a single cable tunnel the repair time would be several months if a fire occurred with both circuits being lost. The cost analysis for the Beauly-Denny connection has considered a single tunnel. However, an alternative plan such as erecting an emergency OHL connection would need to be considered. A further mitigating consideration might be to place the 275kV and the 400kV circuits in separate tunnels but this would significantly increase costs.

7 Cost of undergrounding in the Stirling area

Case 5 unit costs reported in APL 5/16 were applied to the specific circuit compositions considered in report APL/STG-41 since the character of the landscape in the Stirling area is similar to that of the previous Case 5. Therefore, the update of the costs presented here has been based on the update of the component costs of the unit costs given in APL 5/16.

The most significant assumptions made in the development of the costing are included in section 3.6.1 of APL/STG-41.

7.1 Cost updates since the Beauly-Denny Public Inquiry

Updates of cable costs have been provided by CCI based on manufacturers information as described in section 3 of this report.

Costs of civil works associated with the installation of cables have been sourced by SPT from Balfour Beatty.

Tunnelling costs have been based upon recent experiences of PB Power, in particular costs for a similar sized tunnel to be constructed in London have been adjusted for the hard rock and steep gradient of the tunnel which would be required between Cockburn Wood and Logie.

Overhead line costs have been updated by PB Power using recent metal prices and conductor costs.

Updated unit costs are given in Table 1.

7.2 UGC4 – SNH Option 1

SNH option 1 suggests that the proposed 30.3km of overhead line between Braco and Denny substations is replaced by 6.5km of overhead line from Braco substation and Milour Moor and then 24km of direct buried cable from Milour Moor to Denny. Further detail of this proposal is given in a schematic in chapter 1, aerial photographs in appendix 5 and OS maps in appendix 6, all of report APL/STG-41.

Table 2 shows that the updated cost of the complete route as an overhead line is £27.5m compared to the cost estimate for the alternative of £352.8m, an additional cost of approximately £325.3m.

7.3 UGC4 – SNH Option 2

SNH option 2 also suggests that part of the proposed 30.3km of overhead line between Braco and Denny substations is undergrounded, however, with this option only the 13.8km section from Milour Moor to Gatur is replaced by direct buried cable and the 6.5km section from Braco substation to Milour Moor is overhead line, as is the 10.2km section from Gatur to Denny substation. Again, further detail of this option is given in a schematic in chapter 1, aerial photographs in appendix 5 and OS maps in appendix 6, all of report APL/STG-41.

Table 3 shows the updated cost of the complete route as an overhead line to be £27.5m compared to the cost estimate for the alternative of £217.0m, an additional cost of approximately £189.5m.

7.4 UGC4 – SBP

UGC4-SBP was so named as it was an attempt by the authors of APL/STG-41 to meet what they understood to be the undergrounding route preferences of the action group Stirling Before Pylons. The authors acknowledge that Stirling Before Pylons did not select this route but for consistency with document APL/STG-41, and ease of reference to earlier documentation, the route title UGC4-SBP has been retained in this report.

The 'SBP option' suggests that the whole of the 30.3km overhead line route between Braco and Denny substations is undergrounded along a 33.4km route. Again, further detail of this option is given in chapter 1, aerial photographs in appendix 5 and OS maps in appendix 6, all of report APL/STG-41.

Table 4 shows the updated cost of the complete route as an overhead line to be £21.6m compared to the cost estimate for the alternative of £480.2m, an additional cost of approximately £452.7m.

7.5 UGC4 - UoS

The UoS option proposes replacing a 5.3km section of overhead line between Braco and Denny substation with an overhead line diversion of 0.6km, connecting to a 3.9km cable, of which 2.6km would be laid in a tunnel, and then connecting back to the original overhead line route via a further 0.3km diversion.

Since the UGC4 – UoS option includes a tunnel, which was not part of APL 5/16 case 5, the estimated cost of the tunnel for APL 5/16 case 2 was utilised. Consequently, the updated UoS option costs are based on revised costs for cases 5 and 2 as given in Table 5.

Table 6 shows that whilst the proposed overhead line circuit would cost £5.2m, the alternative option including the section of cable through a tunnel would cost £114.5m, an additional £109.3m.

Table 1 – Unit Costs – APL 5/16 Case Study 5

Stirling Area Undergrounding Costing Study - Unit Costs Updated August 2010		
Item	**Unit Cost**	**Source**
a. Case Study 5 - West of Stirling (mainly agricultural land) - Applied here to all Stirling trenched UGC options:-		
1. OHL unit cost per km:-		
Total OHL cost per km (£k/km): all study average = £1074k / km)	908	Comparative APL 5/16 Case Study 5, p111, Table 5-26 2007 value = £943k/km
less 10% contingency (of £83k / km)	83	
OHL unit cost per km before contingency (£k/km) =	826	= Stirling Source Ref 1 Comparative 2007 value = £858k/km
Contingency Rate =	10%	
2. SEC cost (end costs), per pair:-		
Total cable-end for section (£k)	5,761	Comparative APL 5/16 Case Study 5, p112 Table 5-27(A) 2007 value = £5072
plus Maintenance (£k)	282	Comparative APL 5/16 Case Study 5, p112 Table 5-27(B) 2007 value = £259
SEC Unit cost per pair (£k) =	6,042	= Stirling Source Ref 2 Comparative 2007 value = £5,331k/km
Contingency Rate =	10%	
3. UGC unit cost per km:-		
Total cable route for section (£k)	56,894	Comparative APL 5/16 Case Study 5, p112 Table 5-27(A) 2007 value = £52,736
plus Wayleaves (£k)	122	Comparative APL 5/16 Case Study 5, p112 Table 5-27(B) 2007 value = £122
plus 40-year replacement (£k)	5,126	Comparative APL 5/16 Case Study 5, p112 Table 5-27(B) 2007 value = £4,734
all divided by Length (km):	5.039	Comparative APL 5/16 Case Study 5, p112 Table 5-27 2007 value = 5.039
UGC unit cost per km before contingency (£k/km) =	12,332	= Stirling Source Ref 3 Comparative 2007 value = £11,429k/km
Contingency Rate =	15%	

Table 2 - UGC4 Option 1 - SNH: Milour Moor to Denny

UGC4 Option 1 - SNH: UGC Strathallan to Denny: SEC 1 (Milour Moor) to SEC 4 (Denny)					Costs Updated August 2010		
Proposed OHL being displaced	**Item**	**Units**	**Quantities**	**Lifetime Unit cost (£k)**	**Source Ref**	**Contingency Rate (%)**	**Cost incl. Contingency (£k)**
Milour Moor (tower n/a) - Denny (tower n/a)	OHL	km	30.255	826	=StSR1	10%	27,479
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source:	tudy No.	0 5					
Additional OHL required to connect to north and south SECs	OHL	km	6.456	826	=StSR1	10%	5,864
UGC4 Option 1 - SNH: UGC Strathallan to Denny: cable between SEC 1 and SEC 4	UGC	km	23.995	12,332	=StSR3	15%	340,296
North and South SECs	SEC	pair	1	6,042	=StSR2	10%	6,647
NB:							
1. SEC costs include lifetime maintenance cost estimates							
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.							
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.							
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.							

Summary - UGC4 Option 1 - SNH: UGC Strathallan to Denny	**Item**	**km**	**£k**
Totals for the proposed OHL	OHL	30.3	27,479
OHL totals for the UGC option	OHL	6.5	5,864
UGC totals for the UGC option	UGC +SEC	24.0	346,942
Whole route totals for the UGC option	All	30.5	352,806
Comparisons between the undergrounding and OHL options:		**km**	**£k**
Differences: UGC Option less proposed OHL		0.2	325,327
Route length increase of UGC over proposed OHL (%)		0.6%	
Cost Factor: UGC over OHL (times)			12.8 times

Table 3 - UGC4 Option 2 - SNH: Milour Moor to Gartur

UGC4 Option 2 - SNH: UGC Strathallan to Cambusbarron: SEC 1 (Milour Moor) to SEC 2 (Gartur) — Costs Updated August 2010

Proposed OHL being displaced	Item	Units	Quantities	Lifetime Unit cost (£k)	Source Ref	Contingency Rate (%)	Cost incl. Contingency (£k)
Milour Moor (tower n/a) - Gartur (tower n/a)	OHL	km	30.255	826	=StSR1	10%	27,479
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source: tudy No.		0 5					
Additional OHL required to connect to north and south SECs	OHL	km	16.704	826	=StSR1	10%	15,171
UGC4 Option 2 - SNH: UGC Strathallan to Cambusbarron: cable between SEC 1 and S	UGC	km	13.764	12,332	=StSR3	15%	195,200
North and South SECs	SEC	pair	1	6,042	=StSR2	10%	6,647

NB:
1. SEC costs include lifetime maintenance cost estimates
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.

Summary - UGC4 Option 2 - SNH: UGC Strathallan to Cambusbarron	Item	km	£k
Totals for the proposed OHL	OHL	30.3	27,479
OHL totals for the UGC option	OHL	16.7	15,171
UGC totals for the UGC option	UGC +SEC	13.8	201,847
Whole route totals for the UGC option	All	30.5	217,018

Comparisons between the undergrounding and OHL options:	km	£k
Differences: UGC Option less proposed OHL	0.2	189,539
Route length increase of UGC over proposed OHL (%)	0.7%	
Cost Factor: UGC over OHL (times)		7.9 times

Table 4 - UGC4 Option 3 - SBP: Braco to Denny

UGC4 Option 3 - SBP: UGC Braco to Denny: SEC 3 (Braco) to SEC4 (Denny) — Costs Updated August 2010

Proposed OHL being displaced	Item	Units	Quantities	Lifetime Unit cost (£k)	Source Ref	Contingency Rate (%)	Cost incl. Contingency (£k)
Braco (tower TD165) - Denny (tower n/a)	OHL	km	30.255	826	=StSR1	10%	27,479
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source: tudy No.		0	5				
Additional OHL required to connect to north and south SECs	OHL	km	0	826	=StSR1	10%	-
UGC4 Option 3 - SBP: UGC Braco to Denny: cable between SEC 3 and SEC4	UGC	km	33.391	12,332	=StSR3	15%	473,550
North and South SECs	SEC	pair	1	6,042	=StSR2	10%	6,647

NB:
1. SEC costs include lifetime maintenance cost estimates
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.

Summary - UGC4 Option 3 - SBP: UGC Braco to Denny	Item	km	£k
Totals for the proposed OHL	OHL	30.3	27,479
OHL totals for the UGC option	OHL	0.0	-
UGC totals for the UGC option	UGC +SEC	33.4	480,196
Whole route totals for the UGC option	All	33.4	480,196

Comparisons between the undergrounding and OHL options:	km	£k
Differences: UGC Option less proposed OHL	3.1	452,717
Route length increase of UGC over proposed OHL (%)	10.4%	
Cost Factor: UGC over OHL (times)		17.5 times

Table 5 – Unit Costs – Tunnelling Option

Stirling Area Undergrounding Costing Study - Unit Costs - Unit Costs Updated August 2010		
Item	**Unit Cost**	**Source**
b. Tunnelling Estimate - Applied to Cocksburn Wood - Logie Villa tunnel section:-		
1. OHL unit cost per km:-		
Total OHL cost per km (£k/km):	984	Comparative APL 5/16 Case Study 4, p103, Table 5-21 2007 value = £1,246k/km
less 10% contingency (of £89k / km)	89	
OHL unit cost per km before contingency (£k/km) =	895	= Stirling Source Ref 4 Comparative 2007 value = £1,133k/km
Contingency Rate =	10%	
2. End costs for tunnelled cable (not inc. tunnel shaft headworks):-		(Sources as for Tunnel - Appin of Dull estimate:)
Total cable-end for section (£k)	5,980	Comparative APL 5/16 Case Study 2, p85 Table 5-12(A) 2007 value = £5,173
plus Maintenance (£k)	248	Comparative APL 5/16 Case Study 2, p85 Table 5-12(B) 2007 value = £227
SEC Unit cost per pair (£k) =	6,229	= Stirling Source Ref 5 Comparative 2007 value = £5,399
Contingency Rate =	10%	
3. UGC unit cost per km (trenched section):-		(Source as for Case Study 5 - West of Stirling, previous table)
UGC unit cost per km before contingency (£k/km) =	12,332	= Stirling Source Ref 6 Comparative 2007 value = £11,429k/km
Contingency Rate =	15%	
4. Tunnelled UGC unit cost per km:-		(Sources as for Tummel - Appin of Dull estimate:)
Cables supply and install - no civils (£k per km)	5,774	Comparative APL 5/16 Case Study 2, p85, Table 5-12(Aii), lines 1-4 2007 value = £5,202k/km
Tunnel, 4m dia., -inc. vent & end shafts & headworks (£k per km)	19,690	PB Power budget estimates Comparative 2007 value = £13,720k/km
Mechanical and Electical Installations (M&E)	1,809	
Total tunnelled UGC unit cost per km before contingency (£k/km) =	27,273	= Source Ref 7 Comparative 2007 value = £21,862k/km
Overall Contingency Rate =	25%	No geological investigations to date

Table 6 – UGC4 Option 4 – UoS: Cocksburn Wood to Manor Powis

UGC4 Option 4 - UoS: UGC Cocksburn Wood to Manor Powis: SEC 5 (Cocksburn Wood) to SEC 6 (Manor Pow				Costs Updated August 2010			
Proposed OHL being displaced	**Item**	**Units**	**Quantities**	**Lifetime Unit cost (£k)**	**Source Ref**	**Contingency Rate (%)**	**Cost incl. Contingency (£k)**
Cocksburn Wood (tower TD197) - Manor Powis (tower TD208)	OHL	km	5.32	895	=StSR4	10%	5,235
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source:	nate for	0	Tunnel				
Additional OHL required to connect to north and south SECs	OHL	km	0.941	826	=StSR1	10%	855
UGC4 Option 4 - UoS: UGC Cocksburn Wood to Manor Powis: cable between SEC 5 ar	UGC	km	1.354	12,332	=StSR6	15%	19,202
North and South SECs	SEC	pair	1	6,229	=StSR5	10%	6,851
Cost of tunnelled UGC section	Tunnel	km	2.56	27,273	=StSR7	25%	87,620
NB:							
1. SEC costs include lifetime maintenance cost estimates							
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.							
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.							
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.							

Summary - UGC4 Option 4 - UoS: UGC Cocksburn Wood to Manor Powis	**Item**	**km**	**£k**
Totals for the proposed OHL	OHL	5.3	5,235
OHL totals for the UGC option	OHL	0.9	855
UGC totals for the UGC option, including extra cost of tunnel	UGC +SEC	3.9	113,674
Whole route totals for the UGC option	All	4.9	114,529

Comparisons between the undergrounding and OHL options:	**km**	**£k**
Differences: UGC Option less proposed OHL	-0.5	109,293
Route length increase of UGC over proposed OHL (%)	-8.7%	
Cost Factor: UGC over OHL (times)		21.9 times

7.6 Undergrounding between Tower TD199 Cocksburn Wood to Tower TD203A Airthey Castle.

Section 19-(2)(A) of the consent for the line requires proposals for: "*the mitigation of the visual and landscape impact of the line between the top scarp of the Ochil Hills at Cocksburn Wood (TD199) and Airthey Castle (TD203)*".

If mitigation were to be achieved by the use of an underground power cable system then the start and end points of the mitigation have been taken to be the location of the proposed towers TD199 and TD203A.

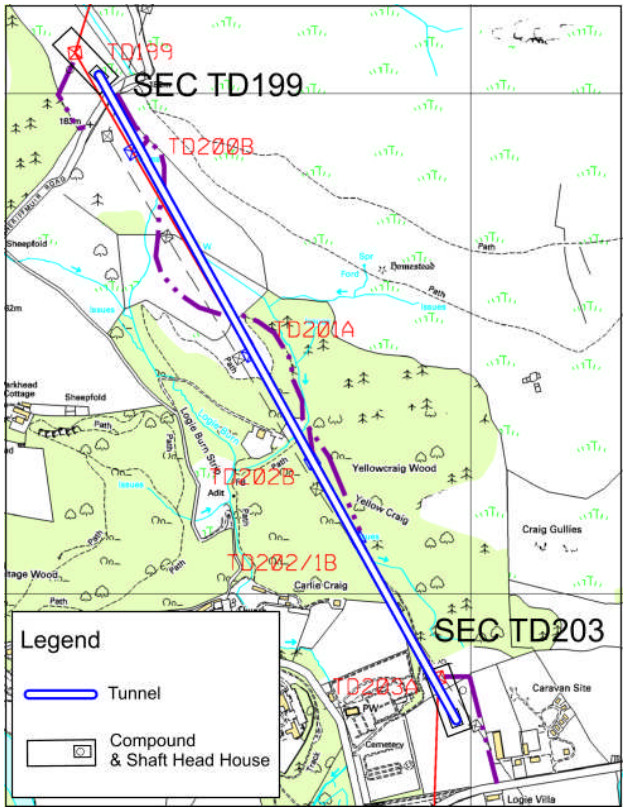
This installation would need to be inside a tunnel[3] and a description of a tunnelled installation is described in APL/STG-41, Chapter 4, "Ochils Escarpment Route East of Stirling Appraisal" and is very similar to route UGC4 in the same document.

The location atop the Ochils in APL/STG-41 placed the tunnel shaft head house close to tower TD197A. However the mitigation requirements of the consent move the shaft head house closer towards Black Hill at tower position TD199. The location of tower TD199 has been used in costing this undergrounding as it provides a shorter route (and therefore a less expensive route) to the limit of the mitigation at TD203A, Airthey Castle; near Logie Villa.

In Figure 2 the tunnel has been shown as a straight line between the tunnel shaft head houses that would be located at TD199 and TD203A. Figure 2 is an overlay on an OHL route map showing the positions of the tunnel sealing end compounds which include a shaft head building. One of these buildings will contain the necessary air cooling fans required to provide an air flow through the tunnel to remove heat generated by the cables. This would most probably be the head house at TD199 to take advantage of the natural updraft of the tunnel shaft.

The horizontal tunnel distance as shown is 1479m. The fall in elevation between ground level at TD199 and TD203A is around 165m. It would be necessary to have a shaft at both ends of the tunnel and for the cables to exit the tunnel shafts and connect to the overhead line.

Figure 2 - TD199 to TD203A Tunnel Route



The tunnel shaft head houses containing the necessary fans and control systems would occupy an area of around 33m x 25m and the cable sealing end compound would be in the order of 140m x 55m. These dimensions are based on the existing compound at the 400kV Dartford river crossing in Kent. Making allowance for tunnel length, shaft depths (175m & 10m), cable length inside the SEC (2x100m) and termination heights (2 x 8m), the average cable circuit length required in order to connect between any new overhead line towers at TD199 and TD203 is thus estimated to be 1880m.

7.6.1 Costing TD199 to TD203

Table 7 shows that whilst the proposed overhead line circuit would cost £1.5m, the alternative option including the section of cable through a tunnel would cost £60.3m, an additional £58.9m.

This costing is calculated on the basis of using the cable which would normally be direct buried inside the tunnel, however, a less expensive cable could be employed saving approximately £1.8m per km of cable in the tunnel. Consequently, the cost of the alternative could be reduced to £57.6m.

Table 7 - Undergrounding between Tower TD199 Cocksburn Wood to Tower TD203A Airthry Castle

UGC Cocksburn Wood to Airthey Castle: SEC 5 (Cocksburn Wood) to 0 (Airthey Castle)					Costs Updated August 2010		
Proposed OHL being displaced	**Item**	**Units**	**Quantities**	**Lifetime Unit cost (£k)**	**Source Ref**	**Contingency Rate (%)**	**Cost incl. Contingency (£k)**
Cocksburn Wood (tower TD199) - Airthey Castle (tower TD203)	OHL	km	1.479	895	=StSR4	10%	1,455
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source:	nate for		0 Tunnel				
Additional OHL required to connect to north and south SECs	OHL	km	0	826	=StSR1	10%	-
UGC Cocksburn Wood to Airthey Castle: cable between SEC 5 and 0	UGC	km	0.2	12,332	=StSR6	15%	2,836
North and South SECs	SEC	pair	1	6,229	=StSR5	10%	6,851
Cost of tunnelled UGC section	Tunnel	km	1.479	27,273	=StSR7	25%	50,621
NB:							
1. SEC costs include lifetime maintenance cost estimates							
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.							
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.							
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.							

Summary - UGC Cocksburn Wood to Airthey Castle	**Item**	**km**	**£k**
Totals for the proposed OHL	OHL	1.5	1,455
OHL totals for the UGC option	OHL	0.0	-
UGC totals for the UGC option, including extra cost of tunnel	UGC +SEC	1.7	60,309
Whole route totals for the UGC option	All	1.7	60,309
Comparisons between the undergrounding and OHL options:		**km**	**£k**
Differences: UGC Option less proposed OHL		0.2	58,854
Route length increase of UGC over proposed OHL (%)		13.5%	
Cost Factor: UGC over OHL (times)			41.4 times

7.7 Undergrounding between TD199 Cocksburn Wood and TD244 Glenside

Neither APL 5/16 nor APL/STG-41 looked at any underground cable routes to the East of Stirling for underground routes to the south of TD209B. Report APL/STG-41 was produced for the public inquiry in response to the submission of maps and/or documentation by Scottish Natural Heritage and others. None of the submissions for underground cable routes considered this underground cable route and no costings have previously been produced.

The SPT maps given to the report authors indicate that there are two tower locations with the prefix TD244. These are TD244E which is the closest to Glenside and TD244/1C which is one tower further westward towards Denny Substation.

During the underground cable routeing performed for this report it was initially considered that any cable section would terminate at tower position TD244E on the assumption that this would be the shortest undergrounding route between TD203A and any TD244 suffixed tower. However, on plotting the shortest practicable cable route it was found that the cables would have to pass close by tower TD244/1C to reach tower position TD244E.

As both locations would appear to meet the consent requirements for the cable route, it would be less expensive and thus preferable to terminate the UGC route at tower TD244/1C.

When plotting an underground cable route between TD203A and TD244/1C the cable routeing strategy outlined in APL 5/16 was followed for this preliminary routeing.

The cost of installing an underground cable system is generally dependent upon its length, a straight line was thus plotted between the shaft head house at TD199 and TD244/1C to determine the absolute shortest length between the two locations.

In order to keep the tunnel length to a minimum, due to costs, it was decided to retain the same tunnel connection between TD199 and TD203A as was described in section 7.6 above. This tunnel also adheres favourably to the general line of the shortest route.

From TD203A to TD244/1C the cable route generally follows the route of the existing 132kV Beauly-Denny line. Route deviations away from the straight line connection are due to the preference to follow linear features such as main roads, the use of the existing 132kV Beauly Denny overhead line wayleave and the benefits of reuse of access tracks, the crossing of the M9 and the railway at suitable locations and the avoidance of wooded areas.

The mapped straight line distance between TD203A and TD244/1C has been scaled to be 11,415m. This would be the minimum distance for any direct cable connection between these two points ignoring changes in elevation, obstructions and all other considerations. However, this is not a practical proposition as obstructions do exist.

Following a preliminary route drawing by the underground cable consultant a site assessment was undertaken by SPT engineers and a landscape architect and after discussion, the following minor route modifications were applied:

The cable route should:

- avoid the sinks, land drains, burns and other water courses south of Tower TD219,
- avoid Sauchenford smallholdings by finding another crossing point under the M9, (one was selected further West).

The site visit team also advised that it would be possible to install the majority of the route between tower locations TD203 and TD244E by means of a direct buried installation as described in APL 5/16, Chapter 2 with directional drilling being employed where required for road, rail and river crossings.

At service crossings (such as large hydrocarbon fuel lines) it would also be necessary to consider special constructions such as horizontal directional drilling or, if the fuel line company preferred a significantly sized open cut excavation. Both methods would be likely to require installing the cables at greater than normal depth with a wider spacing to meet the circuit current rating requirements.

For this report a series of three underground cable route drawings have been prepared taking into account the site visit team's observations. These underground cable route maps can be found in Appendix 2. During the route survey SPT captured photographs of some of the areas through which an underground cable route could pass based on the route drawings. These photographs are attached as Appendix 9.

The cable from the sealing end compound at the top of the Ochils near Cocksburn Wood (at tower position TD199) to Logie Villa (Tower 203) would need to be installed inside a purpose built cable tunnel[4]. A description of the installation is described in Chapter 4, "Ochils Escarpment Route East of Stirling Appraisal" of APL/STG-41.

A tunnel head house compound would be required near tower TD203A (Logie Villa). The cable route would then leave the tunnel and proceed towards Glenside (TD244/1C) as a direct buried installation.

The length of the tunnelled section was calculated as follows: Using the same tunnel as described in section 7.6 but without the need for a sealing end compound (SEC) at TD203A, tunnel length 1479m, shaft depths (175m & 10m), cable length inside the SEC (1x100m) and termination heights (1 x 8m), the average cable circuit length required in

order to connect between any new overhead line towers at TD199 to the top of the shaft at Logie Villa (TD203A) has been estimated to be 1,772m.

From Logie Villa (TD203) the cable route differs from the overhead line route and is plotted to the West of the settlements of Plean and Cowie. The UGC route selected is shorter than the overhead line route, the latter of which diverts around settlements by traversing to the East.

An estimate of the cable route length from the top of the cable tunnel shaft at Logie Villa (TD203) to Glenside (TD244/1C) has been calculated to be 12,034m[5], this includes the termination height allowance at Glenside (TD244/1C). Adding this length to the length of cable required between TD199 and TD203 gives a total average cable length of 13,806m.

Taking scale measurements from drawings the total length of overhead line that would be replaced by the UGC would be 15,973m (14,398m between TD197A and TD239A and a further 1,575m between TD240A and TD244/1C. These measurements do not take into account any changes in elevation.

The cable route is shorter than the overhead line as it is able, in this instance, to take a more direct route than the overhead line which skirts around settlements.

The balance involved in selecting an underground cable route is much more complex than that for an OHL. This is because of the need to strike a balance not only between underground cable system technical requirements, environmental and financial considerations, but also with the length of cable route which is directly related to both cost and disturbance. With underground cable, the cost is the dominant consideration.

It must be noted that this report does not include an environmental impact assessment of this route, its impact on local people and no examination of the geology or impacts of the Ochils has been performed to confirm that the sinking of shafts and tunnelling is feasible.

7.7.1 TD109 to TD244/1C Costings

Table 8 shows that whilst the proposed overhead line circuit would cost £15.7m, the alternative option including the section of cable through a tunnel would cost £229.1m, an additional £213.4m.

Again, this costing is calculated on the basis of using the cable which would normally be direct buried inside the tunnel, however, a less expensive cable could be employed saving approximately £1.8m per km of cable in the tunnel. Consequently, the cost of the alternative could be reduced to £226.4m.

Table 8 - Undergrounding between TD199 Cocksburn Wood and TD244 Glenside

UGC Cocksburn Wood to Glenside: SEC 5 (Cocksburn Wood) to 0 (Glenside)					Costs Updated August 2010		
Proposed OHL being displaced	**Item**	**Units**	**Quantities**	**Lifetime Unit cost (£k)**	**Source Ref**	**Contingency Rate (%)**	**Cost incl. Contingency (£k)**
Cocksburn Wood (tower TD199) - Glenside (tower TD244 1C)	OHL	km	15.973	895	=StSR4	10%	15,719
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source:	nate for		0 Tunnel				
Additional OHL required to connect to north and south SECs	OHL	km	0	826	=StSR1	10%	-
UGC Cocksburn Wood to Glenside: cable between SEC 5 and 0	UGC	km	12.1034	12,332	=StSR6	15%	171,650
North and South SECs	SEC	pair	1	6,229	=StSR5	10%	6,851
Cost of tunnelled UGC section	Tunnel	km	1.479	27,273	=StSR7	25%	50,621
NB:							
1. SEC costs include lifetime maintenance cost estimates							
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.							
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.							
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.							

Summary - UGC Cocksburn Wood to Glenside	**Item**	**km**	**£k**
Totals for the proposed OHL	OHL	16.0	15,719
OHL totals for the UGC option	OHL	0.0	-
UGC totals for the UGC option, including extra cost of tunnel	UGC +SEC	13.6	229,122
Whole route totals for the UGC option	All	13.6	229,122

Comparisons between the undergrounding and OHL options:	**km**	**£k**
Differences: UGC Option less proposed OHL	-2.4	213,403
Route length increase of UGC over proposed OHL (%)	-15.0%	
Cost Factor: UGC over OHL (times)		14.6 times

7.8 Undergrounding between TD 203 and TD244, Logie Villa to Glenside

Section 19-(2)(A) of the consent for the line requires proposals for: *"the mitigation of visual and landscape impact of the line between Logie (TD203) and Glenside TD244."*

As previously stated in section 7.7 above, neither APL 5/16 nor APL/STG-41 looked at any underground cable routes to the east of Stirling for underground routes to the south of TD209B.

This route assumes that underground cables are installed from a cable sealing end compound (SEC) located at TD203A and installed to a further cable SEC at TD244/1C. The cable SEC at TD244/1C being selected (rather than TD244E) for the same reasons as described in section 7.7 above.

It would be necessary to construct a cable sealing end compound at the location of tower TD203A and the cables would run south of this location and cross the A91 at the same location as the route described in section 7.7 above. From this location the entire route is identical to the route described in Section 7.7. An UGC route map is given in Appendix 3. This map shows only the region of the route that varies from that described in Section 7.7 and for the remainder of the route reference should be made to sheets 2 and 3 of Appendix 2.

An estimate of the cable route length from Logie Villa SEC (at TD203A) to Glenside (TD244/1C) has been calculated to be 12,142m. The reader may note that this is greater in length than that given in section 7.7. This is due to the extra length required between the tunnel shaft head house and tower TD203A and the addition of the cable termination height (12,034+108=12,142m).

Taking scale measurements from drawings the total length of overhead line that would be replaced would be 14,510m (12,935m between TD203 and TD239A and a further 1575m between TD240A and TD244/1C). These measurements do not take into account any changes in elevation.

It must be noted that this report does not include an environmental impact assessment of this route or its impact on local people.

7.8.1 Costs for TD 203 to TD244/1C

Table 9 shows that whilst the proposed overhead line circuit would cost £13.2m, the alternative underground option is estimated to cost £178.8m, an additional £165.7m.

Table 9 – Undergrounding between TD203 and TD244, Logie Villa to Glenside

UGC Logie to Glenside: 0 (Logie) to 0 (Glenside)					Costs Updated August 2010		
Proposed OHL being displaced	**Item**	**Units**	**Quantities**	**Lifetime Unit cost (£k)**	**Source Ref**	**Contingency Rate (%)**	**Cost incl. Contingency (£k)**
Logie (tower TD203) - Glenside (tower TD244 1C)	OHL	km	14.51	826	=StSR1	10%	13,179
UGC Option - UGC costs are for direct-buried / tunnelled cable							
Unit cost source:	tudy No.	0 5					
Additional OHL required to connect to north and south SECs	OHL	km	0	826	=StSR1	10%	-
UGC Logie to Glenside: cable between 0 and 0	UGC	km	12.142	12,332	=StSR3	15%	172,197
North and South SECs	SEC	pair	1	6,042	=StSR2	10%	6,647
NB:							
1. SEC costs include lifetime maintenance cost estimates							
2. Cable costs include wayleaves and 40 year replacement cost estimates. Tunnel costs also included, where appropriate.							
3. Costs for ducted cable are estimated to lie within 1% of that for direct-buried, and so are not shown separately.							
4. At each SEC where a terminal tower is not required (Braco, and Denny) around £87k may be subtracted from the SEC cost.							

Summary - UGC Logie to Glenside	**Item**	**km**	**£k**
Totals for the proposed OHL	OHL	14.5	13,179
OHL totals for the UGC option	OHL	0.0	-
UGC totals for the UGC option	UGC +SEC	12.1	178,844
Whole route totals for the UGC option	All	12.1	178,844

Comparisons between the undergrounding and OHL options:	**km**	**£k**
Differences: UGC Option less proposed OHL	-2.4	165,665
Route length increase of UGC over proposed OHL (%)	-16.3%	
Cost Factor: UGC over OHL (times)		13.6 times

8 Review of third party documentation provided by Scottish Power

8.1 Review of SPICe document

Graeme Cook, a Principal Research Specialist at the Scottish Parliament Information Centre in Edinburgh wrote a letter is dated 5th February 2010 with the titled subject of *"Electricity wire visual amenity mitigation measures"*. A copy of this letter is attached as Appendix 6 to this report.

This report provides a commentary on the technical and cost references made by Mr Cook under the section considering *"UNDERGROUNDING"*. This report does not consider matters of policy or planning or any other matters which are considered to be outside of this report's brief.

The letter from Mr. Graeme Cook makes no reference to APL 5/16 or APL/STG-41 both of which give essential information on the possibilities of undergrounding the Beauly-Denny line in the Stirling area and were made available at the public inquiry.

8.1.1 Draft National Policy Statement for Electricity Networks

Reference is made to the "Draft National Policy Statement for Electricity Networks Infrastructure (EN-5)"[6], with particular reference to paragraphs 2.7.6 to 2.7.11. These paragraphs provide information for the Infrastructure Planning Commission (IPC) on a number of general issues regarding undergrounding. The paragraphs referenced by the SPICe letter are reproduced below.

"UNDERGROUNDING

2.7.6 In considering whether lines should be placed underground to obtain the benefits of reductions in landscape and/or visual impacts, the IPC will need to balance those reductions in visual intrusion against the costs (economic, environmental and social) and technical challenges of undergrounding.

2.7.7 The IPC should take into account that the cost of undergrounding electricity cables is between ten and twenty times as much per unit length as for an overhead line, depending on whether the line is buried directly in open agricultural land and the higher figure where more complex tunnelling and civil engineering through conurbations and major cities is required.

2.7.8 Maintenance and repair costs are also significantly higher than for overhead lines as are the costs associated with any later uprating. With an overhead line this can be achieved by using different conductors which may or may not require additional tower works (strengthening), whereas uprating an underground cable installed as part of a route can only be achieved at considerable expense by new excavations and installation of larger or additional cables.

2.7.9 There are, in addition, costs which are environmental and social. To match overhead line performance for a 400kV double circuit as many as twelve separate cables in four separate trenches may be needed resulting in a cable swathe of up to 40 metres. This can disturb sensitive habitats and damage heritage assets, in many cases more than an overhead line would. Access for maintenance and repair is required for the duration of the system's life (about 60 years). And when faults occur 400kV underground cables are on average out of service for a period 25 times longer (between two and six weeks) than a comparable overhead line, mainly due to the longer time taken to locate, excavate and undertake technically involved repairs. During this time excavations may result in road closures and traffic management measures with consequent traffic disruption.

2.7.10 The IPC should not refuse consent for overhead line proposals on the basis that undergrounding is preferable unless it is satisfied that the benefits from undergrounding outweigh the extra economic, social and environmental costs and the technical difficulties are surmountable.

2.7.11 The previous paragraphs will also be relevant in terms of consideration of undergrounding to mitigate or avoid other impacts beyond landscape and visual."

In paragraph 2.7.6 of EN-5 above, the IPC is required to consider that the cost of undergrounding electricity cables is between ten and twenty times as much per unit length as for an overhead line. A reference for this cost ratio is taken from the National Grid[7]. The internet reference given in EN-5 does not however refer to a National Grid document but is a reference point to several documents one of which *"Undergrounding high voltage electricity transmission: The technical issues"*[8] gives an UGC to OHL cost ratio of between 12 to 17 times. This National Grid document as well as EN-5 was published recently (in 2009).

8.1.2 Undergrounding abroad

Graeme Cook's letter makes reference to some examples of undergrounding abroad and provides a reference to a paper published by Leonardo-Energy which presents *"the main benefits of underground high voltage cables"* with the title *"Wiring Europe for the Future"*. The website acknowledges that:

"The European Copper Institute - the driving force behind the Leonardo ENERGY initiative - is a joint venture between the world's mining companies, represented by the International Copper Association, and the European copper industry. Its mission is to promote copper's benefits to modern society across Europe, through its Brussels office and a network of eleven Copper Development Associations"

The paper must therefore be read with the full understanding that the publication is likely to be predicated to the use of power cables which have a significant quantity of copper in their build.

Graeme Cook's research letter refers to the case studies contained in section 4 of the paper;

- Case Study 1: Use of Cables in Areas of Outstanding Natural Beauty
- Case Study 2: Cables Enable the Development of Valuable Project at Madrid Airport

Graeme Cook also makes reference to the Fujikura Technical Review 2003, which describes a long length installation in Japan.

A number of European cross border projects as published in the UCTE Transmission Development Plan have also been identified by Mr. Cook.

Mr Cook also refers to a European commission background paper on undergrounding of electricity lines in Europe dated 10th December 2003. This paper has been largely discredited and details are provided below.

The Energy Networks Association (ENA) briefing "Overhead lines or Underground Cables[9]" is also identified by Mr Cook.

All of the above documents are discussed the following paragraphs.

8.1.2.1 Case Study 1 : Use of Cables in Areas of Outstanding Natural Beauty

This case study refers to the 400kV Aalberg – Århus line/cable installed in Denmark.

The Arhus-Alborg project was listed in the review of XLPE insulated cable circuits in operation listed in Table 7-1 of APL 5/16 as presented to the Beauly-Denny Public Inquiry.

This project has received much attention from parties comparing UGC to OHL cost ratios. The headline ratio given for the cost of undergrounding compared to an overhead line system is given as a ratio of 3.6:1 in a workshop paper[10]. This paper was submitted into evidence at the Beauly-Denny Public Inquiry and would therefore have been in the documentation for consideration and taken into account by the reporters. A cost ratio of 3.6:1 at first sight appears to be remarkably low ratio for the undergrounding of a 400kV system. However, the Danish project included a significant quantity of installation of 150kV and 60kV cabling and the figures as presented in the paper require some analysis.

Some assistance in understanding may be found from a presentation given by the cable company Sagem (now Silec) who supplied cable for the project and provided their own cost ratio breakdown during a presentation[11] in 2004. An on-line copy[12] of this presentation can be found on the Highland Council internet site. The sixth slide of the presentation shows a comparison of cables and overhead line for two 400kV cable circuits installed on a single overhead line tower at a cost of 3.9M DKK/km. The cost of

undergrounding of the same overhead line using two cores per phase is given as 22.8M DKK/km and a cable termination cost of 16M DKK/km. This gives a cost ratio for the Ferslev-Skudshale undergrounding section (of 4km) of the 400kV Aalberg – Århus to OHL cost ratio of 6.9:1.

The Ferslev-Skudshale undergrounding to OHL ratio of 6.9:1 is still a lower cost ratio than the cost ratios reported in APL 5/16 and APL/STG-41. There are however, a number of material differences between the Ferslev-Skudshale undergrounding on the Aalberg – Århus line and that on any routes in the Stirling area on the Beauly-Denny connection. These include the power transmission requirement and the nature of the terrain being traversed, as set out below.

The following text has been extracted from a technical paper[13] on the installation which describes the rating design philosophy used on the Denmark line.

"The overhead line has a nominal rating equal to app. 2000 MVA (2800 A) and the short time load capacity is for safety reasons (sagging limits of conductors) limited to only a few minutes.

The two cable circuits in parallel have a nominal continuous rating of only 1000 MVA (1400 A). However, if the short time load capacity of the cables is taken into account the 400 kV cables can be loaded at 2000 MVA (2800 A) for nearly 30 hours provided that the cables have been preloaded at a load of 500 MVA (700 A) or less. At the end of the 30 hours time period the conductor temperature is still less than 90 Degrees C. Thus the 400 kV cables will not be operated at overload.

Maximum load during normal operation is expected to be app. 800 MVA (1100 A) and at a typical preload of 500 MVA (700 A) or less each cable circuit can be loaded at 800 MVA (1100 A) for more than 100 hours. This time should be sufficient to do a repair on one phase of a cable circuit and therefore, an outage of one 400 kV circuit is not expected to have any consequences for the operation of the transmission line."

In accordance with the power transmission requirements of the Beauly – Denny line, which was examined in some detail by the public inquiry, a comparison of the continuous rating requirements (as required for Beauly-Denny) are given in Table 10.

It can be seen from Table 10 that:

- The overhead line used in Denmark would be capable of meeting 82% of the required pre-fault continuous rating for the Beauly-Denny line.
- The power cables used in Denmark only meet 41% of the rating of the Beauly-Denny.

If the cable and overhead line maximum continuous ratings of the Denmark OHL and UGC were required to be matched, as on the Beauly Denny line, simplistically the cost ratios would increase from 6.9:1 to around 13.8:1 if the number of cables were doubled. Even using this arrangement the cables would only meet 82% rating requirement of the

Beauly – Denny connection using the values extracted from technical papers. It must be acknowledged that there would be some economies of scale to this assessment that a change of cable design (e.g. a larger conductor would be more appropriate).

The UGC to OHL cost ratios given in APL/STG-41 varied between 7.1:1[14] and 15.6:1[15]. An update of the APL/STG-41 cost ratios have been recalculated based on current prices in this report to be between 7.9:1 and 21.9:1.

Table 10 - Denmark v's Beauly Denny Power Transmission

Continuous Circuit Ratings	OHL continuous load pre-fault	UGC continuous load pre-fault.	Acceptable System Overload/Emergency Loadings
Beauly – Denny Line[16]	3400A	3400A	4050A for 24 hrs
Denmark Line (Eltra)	2800A	1400A	1100A for 100hrs 2800A for 30hrs
Denmark ratings as a % of the Beauly-Denny Rating	82%	41%	Not comparable

The ground conditions in Denmark also appear to be more favourable to cable installation. The soil thermal resistivity used for the Denmark project was 1.0mK/W and no allowance appears to have been required for the backfill drying out which occurs in the UK. Both of these factors will improve the current carrying capacity of the cables in Denmark.

The soil in Denmark is understood by the author to consist largely of sand and loamy soil which is easy to excavate compared to more rocky and more difficult conditions in Scotland. The technical papers refer to new installation techniques which appear to consist largely of battering back the sides of the trench rather than using trench wall shuttering. Such a technique in soils with a rock content, such as in Scotland, poses risks of cable trench contamination by stones and rock. All three UK transmission companies and UK contractors are wary of the risk of trench collapse incidents due to unsupported trench walls which can, and have, proven to be lethal. The installation in Denmark was no doubt designed to be safe and the soil conditions are likely to have influenced their choice of installation method.

The author is not aware of any case where headline figure cost ratios of less than 3.6:1 for a 400kV installation have been declared. Whilst headline UGC to OHL cost ratios are a convenient indicator they are also an unreliable measure when comparing between projects, particularly when comparing different countries and different transmission

systems. Consideration of local factors and transmission requirements must be taken into account to avoid misleading comparisons.

8.1.2.2 Case Study 2: Cables Enable the Development of Valuable Project at Madrid Airport

This project involved the undergrounding of an existing line to avoid interference with aircraft automatic navigation systems. Two circuits[17] of 400kV cables were installed, each being 13km in length and provided by two different suppliers. This project was the subject of a technical paper[18] presented at JICABLE'03[19]. The paper was written jointly by the owners of the connection and the cable system manufacturers.

The Madrid Airport project was listed in the review of XLPE insulated cable circuits in operation listed in Table 7-1 of APL 5/16 as presented to the Beauly-Denny Public Inquiry.

The underground cables were installed in a tunnel manufactured from pre-fabricated rectangular concrete sections which were installed in an open cut trench and subsequently backfilled. This is known as a "cut and cover" tunnel construction and is used for shallow buried tunnel.

The tunnel installation at Madrid Airport also required the tunnel sections to be force ventilated in order to remove the heat generated by the cables from the cable tunnel. The ventilation points along the tunnel were positioned every 1.2km and half of these would have required an above ground structure to contain fans and ventilation control equipment as well as access and egress points.

A winter rating of 1720MVA requires each cable to carry at least 2482A. This is less than the 3400A continuous overhead line rating required for the Beauly – Denny connection. In order to reach the rating requirements of the Beauly-Denny overhead line the design would require multiple cables per phase in a tunnel.

It may be technically feasible to install a cut and cover tunnel across the Carse of Stirling but environmental considerations (the volume of soil removal is much greater, and the higher cost of installation compared to direct buried cable would make cut and cover tunnels across the Carse both unnecessary and more disruptive.

The "cut and cover" construction would not be suitable for use between Cocksburn Wood atop the Ochils down to Logie Villa in Stirling. A Stirling option would require both shafts and machine tunnel boring or blasting to be performed using equipment suitable for deep tunnelling.

In summary, the Beauly – Denny tunnel would need to be installed using a different (and more costly) method than used in Spain and there would be twice the number of cables in the tunnel, albeit they may be of smaller conductor cross section than 2500mm^2. There

are therefore significant differences between the tunnel installed at Madrid Airport and any use of cable tunnelling for the Beauly-Denny connection both in terms of technique and cost per km.

8.1.2.3 The 500kV Shinkeiyo Toyosu Line in Japan

Graeme Cook's letter refers to a paper published by the Fujikura Technical Review in 2003 with the title, "Construction of the World's First long-Distance 500kV XLPE Cable Line"[20]. This paper describes one cable company's contribution to a 500kV transmission line in Tokyo.

This underground link was installed to bring power from the outlying overhead line network into Tokyo city where it would not be technically possible to install an overhead line due to a lack of available space.

As with most, if not all, underground EHV transmission lines in Tokyo the cable circuits are installed in tunnel and ducts. This particular circuit is of technical interest because of both its length and the transmission voltage of 500kV. An earlier paper[21] presented by Tokyo Electric Power on this transmission line prior to its completion describes that two 40km 500kV circuits were required.

Each circuit length is 40km with a transmission capacity of 1039A (900MVA) per circuit with an upgrade possibility in future to 1386A (1200MVA) per circuit.

A total of 120 EMJs (extrusion moulded joints) were installed on each circuit giving an average section length between joints of 1000m. The extrusion moulded joint is only found in Japan and is a labour intensive joint to assemble on site and involves extruding hot cross-linking compound into the joint and curing this under high temperature and pressure. These joint designs were developed for the Japanese state owned transmission companies as research projects with cable companies. This type of joint is not known to be used on any undergrounding project anywhere outside of Japan. The Japanese manufacturers when exporting use the same or similar PMJ (pre-moulded joint) with slip-on components which are used in Europe and are both easier to install and believed to be considerably less expensive.

The joints and accessories, of any type or design, are generally considered to be the weakest link in any EHV cable system. Whilst in Tokyo cable lengths of up to 1800m were installed from drums weighing up to 92.5 tonnes these were brought to Tokyo by sea and offloaded reasonably close to the tunnel. The technical paper advises that the limits of normal road transportation in Tokyo restricted lengths of 500kV cable to 550m.

There is no mention of the increase in reactive compensation equipment necessary on the network to accommodate these cables or any costs associated with its supply or installation. However, the Tokyo network has a number of high energy circuits and the

reactive compensation required to compensate for the high cable capacitance is likely be installed inside the electrical network, possibly as a separate contract.

Whilst this installation is a notable technical achievement this is a reference of limited value to the Beauly-Denny project other than to indicate that 40km EHV cable installations are possible. The sections of the Shinkeiyo-Toyosu connection at 500kV are listed in Table 7-1 of APL 5/16 as presented to the Public Inquiry and this information was available to the Public Inquiry Reporters at the time.

8.1.2.4 UCTE Transmission Development Plan[22]

Graeme Cook's letter refers, and provides an internet link to the 2009 update of this plan and refers in particular to three cross border connections:

- France – Spain 400kV DC interconnection
- France – Italy DC connection
- Luxembourg – Belgium 220kV

The *Union for the Co-ordination of Transmission of Electricity* does not cover the United Kingdom. The UK has no AC transmission connections with mainland Europe the only transmission connections operate using a DC link.

The France to Spain DC connection will receive up to €225M in funding from the European Commission as one of 14 cross-border gas and electricity projects selected for European funding. This funding was announced[23] early in 2010.

In order to achieve undergrounding of the length of circuit involved the connection will be DC rather than AC. This is stated in the UTCE report as being required as an AC connection "only allows the undergrounding in limited sections". This is believed to be due to the problems of reactive load present on AC systems. DC systems do not require reactive compensation but do need converter stations at either end to connect the DC line to each countries AC grid network.

The project will provide increased cross-border capacity, up to 2800 MW from France to Spain (currently 1400MW). The exact route length of the underground cable connection is not known but is given by the European Network of Transmission System Operators for Electricity to be 60km.

This new HVDC bipolar interconnection will use 320kV DC (rather than 400kV) underground cable (which has a different build to AC cable but externally looks very similar) and will use existing infrastructures corridors and converters in both ending points. According to European Network of Transmission System Operators for Electricity the system capacity is expected in the range 2x825-2x1000MW installed for a total line length of around 68km.

The Beauly – Denny connection is capable of transmitting almost twice the power 3980MVA (3400A both at 400kV and at 275kV) as this DC link between France – Spain. The DC link is shorter than the Beauly-Denny line, of lower power and appears to have been given up to a €225M subsidy from the EU.

The technical advantages and disadvantages of various connection methods, including the use of a DC connection were examined during the Beauly-Denny Inquiry.

On page 47 of the UTC plan, reference is made to a DC connection between Piossasco in Italy and Grande Ile in France at 1000MW. The following text has been extracted from the EDF website[24]:

"A new project has recently been launched to build a 1000 MW direct current line between Grande Ile station in the Maurienne Valley and Piossasco station on the outskirts of Turin. This fully-underground line will cross the Alps through the safety gallery under construction alongside the Frejus motorway tunnel. This new line will increase the interconnection capacity between the two countries, from just under 3000 MW to 4000 MW, equalling interconnection capacity between Italy and Switzerland."

This project again transmits less energy than the Beauly-Denny line and is likely to be a much longer connection than any undergrounding that may be considered around Stirling.

There would be no technical benefit in having a DC connection rather than an AC connection for short length transmission of the sort being considered by this report for the Stirling area. An AC connection UGC or OHL of any sort around Stirling would be less expensive than undergrounding using DC cables, primarily due to the cost of AC - DC converter stations. There are also technical difficulties to be considered if the reversal of power flow is required, for example due to a fault on another part of the system, as the converter station equipment may not be able to react quickly enough to maintain grid supply requirements.

Mr Cook's letter also refers to a 220kV connection between Luxembourg and Belgium between Bascharage and Aubange. The following is an extract from the CEGEDEL annual report[25] in 2007.

"Based on these conclusions, the Board of Directors has decided in favour of a direct link between the Bascharage substation and the Aubange substation in Belgium, with a view to enhancing the security of supply. This link will consist of two 220 kV lines constructed entirely in cable and is scheduled to come into service in 2012.

The required level of investment, currently estimated at around EUR 34 million."

From an ELIA (Belgium Transmission Supply Operator) publication[26] this connection appears (the publication is in Dutch) to be a 700MW connection, this is less than one fifth of the transmission capability of the Beauly-Denny connection.

The population centres of Bascharage and Aubange are about 8km apart. If this is the circuit length then an AC cable connection would be suitable.

The lower voltage of the transmission connection and the low power requirement makes any direct cost comparisons with Beauly-Denny unreliable.

8.1.2.5 Undergrounding of Electricity Lines in Europe[27]

This paper was produced in 2003 and contains a significant quantity of unreliable data.

The Highland Council, together with Scottish Natural Heritage and the Cairngorms National Park Authority, commissioned Jacobs Babtie consultants to provide a report[28] into the technical, economic and environmental issues relating to the possible undergrounding of very high voltage (400 kV) electricity transmission lines.

This report would not seek to endorse the Jacobs Babtie report in every respect but it is considered to be a more reliable study than the EC background paper. Appendix 2 of the Jacobs Babtie report roundly, and rightly, criticises the EC background paper for its inconstancies, inaccuracies, misleading data, selective costing and lack of factual evidence.

The EC report has thus been largely discredited by the Jacobs Babtie report and a further analysis of the paper by this report is not considered necessary. In summary the EC background paper should not be relied upon as it is a high level document based upon what appears to be a poor piece of research.

8.1.2.6 "Overhead lines or Underground Cables[9] ", ENA Briefing Paper

The Energy Networks Association (ENA) represents the interests of its member companies who operate the national and regional networks for energy to transport gas and electricity into UK homes and businesses. The briefing paper considers power transmission using OHL or UGC at all voltages at or above 11kV.

This paper gives the undergrounding cost ratios "*from about 2:1 at 11kV to 20:1 or more at 400kV*" but adds *"this is only a guide to relative costs, which depend on many local factors such as ground conditions"*. This paper was published in 2006.

The following summary has been extracted from the ENA briefing paper.

"*Summary*

- *Electricity transmission systems carrying large quantities of electricity over long distances need to operate at high voltage.*
- *Overhead lines are visually more intrusive than underground cables, but land disruption during installation and repair is greater for underground cables, particularly those operating at high voltage.*
- *At voltages below 11 kV, overhead lines are more susceptible to weather-related damage and hence less reliable than under-ground cables. At higher voltages, lines are less susceptible in this respect and although high voltage underground cables are even less prone to faults, their complex nature means they take much longer to repair.*
- *Underground cable installations are more expensive to install than overhead lines, with the capital cost ratio increasing rapidly from about 2:1 at low voltage to around 20:1 at the highest voltage.*
- *Below 11 kV there is less difference between the overall costs, including maintenance, of lines and cables.*
- *At progressively higher voltages, the disadvantages of underground cables outweigh their advantages when compared to high voltage overhead lines. They are only installed in dense urban areas and in special circumstances.*
- *Overhead bundled insulated conductors are increasingly used for low voltages as a way of minimising visual intrusion."*

In general the above statements reflect a similar position to that given by SPT and SHETL at the Beauly-Denny public inquiry. The last bullet point regarding bundled overhead conductors is not applicable to EHV systems as the insulated conductors would not be suitable for twisting together and suspending from an overhead line tower due to their size and weight.

8.2 Review of letter from Keith Brown MSP

A copy of the letter from Keith Brown MSP to Mr Phil Henderson of SPT is attached to this report in Appendix 5.

The letter refers to a stakeholder meeting on 6th March 2010 which Mr Brown and others attended. Mr Brown provides five bulleted main points in his letter which are listed and addressed below. These bullet points relate to all forms of visual mitigation of the line. This report shall focus on the possibility of mitigation by undergrounding only.

8.2.1 Changes and Developments in UGC and OHL Systems

"The technical and cost issues of both an overhead and underground line in the Stirling area need to be re-examined and re-appraised to take account changes and developments which may have occurred since the reports used in the public inquiry were commissioned by Scottish Power over four years ago." Keith Brown MSP.

The reports on undergrounding which were commissioned by the Applicants for the Beauly – Denny Public Inquiry were completed in January (APL 5/16) and October 2007 (APL/STG-41).

This report has re-examined and re-appraised the commercially available technology (Section 5.2 and Section 5.1) for UGC and OHL. As outlined above, there have been no technological step changes in underground cables since the publication of APL 5/16 and APL/STG-41 appropriate to the Beauly-Denny connection.

There has been gradual bedding-in of new technologies that were present, and described, during the public inquiry. These include; coated conductors, longitudinal radial water blocking and more rugged oversheaths.

Since the end of 2007, the number of EHV circuits in service has grown as has the service experience and the use of XLPE insulated underground cable systems. Of particular note from a UK perspective is the 20km 400kV XLPE circuit with a 2500mm^2 conductor installed in a power cable tunnel connecting central London (St. John's Wood) to North London (Elstree). This has been in service since 2005 without incident. It is not possible to know if all of the circuits listed in Chapter 7 of APL 5/16 under the title "Review of XLPE insulated cable circuits in operation" have performed equally as well. As the use of 400kV XLPE insulated cable systems increases one may also expect an increase in the number of system failures. CCI are aware of 400kV XLPE cable system failures in the UK, the United Arab Emirates and Germany (380kV) and there are certain to be others that CCI are not aware of. There have also been failures of XLPE insulated transmission cable systems at lower voltage levels. In the UK these have been at 275kV and 132kV. Since the experience list was produced in 2007, there have been a number of additional 400kV installations that have been commissioned and new circuits are planned.

A healthy demand for power cable systems in the last 10 years has encouraged manufacturers to install new plant and equipment to boost production and the availability of manufacturing capacity for large projects has improved since the Public Inquiry.

The main market for power cables at this time is the Middle East and the Far East, particularly in China.

Based on information obtained from the suppliers contacted, cable system prices have maintained their levels. This is despite copper a copper price of US $6,400/tonne which is US$1600/tonne less than that used to obtain the prices in APL/5/16 and APL/STG-41.

8.2.2 Examples in other areas of the world

"Attention should be given to examples in other areas of the world where undergrounding 400kV lines has been achieved at significantly less cost that the estimates provided for the Beauly to Denny line – particular reference was made to the Danish and Japanese examples given in the information provided by Spice of which I believe you have been sent a copy.

Why are there such differences in the costs of these compared to the costs given for the Beauly to Denny line? Could these examples be used to work up alternative costings for the Stirling area?" Keith Brown MSP.

It was appreciated by SHETL and SPT that the cost of undergrounding would be a key point of interest and debate at the Beauly-Denny Public Inquiry. In order to provide information relevant to the line SHETL and SPT commissioned a number of reports from consultants on the specific costs of undergrounding the Beauly-Denny overhead line through a number of landscape types. With respect to the area around Stirling these reports were APL 5/16 from the Strategic Session which provided a number of costed case studies along the route and APL/STG-41 which considered undergrounding routes in the Stirling area either proposed by objectors or as interpreted by the consultants. These interpretations were based upon descriptions received by SPT/SHETL from objectors and other interested parties.

The cable costings in APL 5/16 were assembled by compiling engineering designs to meet the power transmission requirements, obtaining material costs from suppliers with materials delivered to Scotland, visiting each site with a recognised EHV cable installing company estimator and assembling material and installation costs based on the Scottish environment.

The costing method in APL/STG-41 and updated for this report to current prices provides a more accurate costing than methods where a comparison with other projects is used, particularly overseas projects, where the power transmission requirement differs, the ground conditions differ, the labour rates differ and engineering solutions are applied which are not suitable for the Beauly – Denny connection. Often very limited cost information is available and incorrect assumptions are made regarding headline values.

Information on the Danish transmission line was submitted to the Beauly Denny Public Inquiry and listed in Table 7-1 of APL 5/16 as presented to the Public Inquiry.

This project is often quoted but as discussed in Section 8.1.2.1 above, the headline cost ratios are misleading when used in comparison to those compiled for APL 5/16, APL/STG-41 and this report.

With regard to the Japanese example, the 500kV Shinkeiyo Toyosu line has been examined in Section 8.1.2.3 above. This project is a long length installation in tunnels and ducts at 500kV installed through the centre of Tokyo. The engineering of this project was particular to the environment in Tokyo and the difficulties of installing a cable route through a busy and densely populated city centre rather than the more open landscape around Stirling. The general point of interest with this project is the circuit length of 40km.

No costs are given, and none found, for the project work however the method used of tunnels, extrusion moulded joints (a technology particular to Japan) which are difficult and costly to install and the delivery of very long length land cables on oversize drums weighing some 90 tonnes to reduce the number of joints is a solution particular to Japan. There would be issues with access for such heavy weight vehicles on public roads in the UK as each laden vehicle would exceed 100 Tonnes gross weight and reconsideration of the haul road would be required to ensure that the cable drum transportation vehicle would be able to reach the delivery point. This method of installation would not be expected to yield lower costs than those estimated in this report.

8.2.3 Routeing Costs

"Clarification as to whether there are significant cost variations to the costs of undergrounding different sections of the line in the Stirling area." Keith Brown MSP

The terrain types do vary in the Stirling Area in particular the area around the Ochils where a tunnel and shaft installation would be required to descend the escarpment. The terrain of the Carse does not present many technical difficulties apart from the river, road and rail crossing(s). Directional drilling beneath the river bed would be required. There is however some concern from ecologists at the possibility of damage to the river ecology if drilling materials break-though the bed of the river and cause a pollution incident. Some of these matters are discussed in more detail in APL 5/16 and APL/STG-41 as presented to the public inquiry.

8.2.4 Comparative costs of mitigation measures

"Comparative costs of all the mitigation measures under consideration would be useful" Keith Brown MSP

The cost of undergrounding in the Stirling area has been covered in Section 7 of this report. The cost of mitigation other than by the use of undergrounding will be covered by SPT elsewhere.

8.3 Letter from Peter Pearson, Stirling Before Pylons, 20th February 2010

The main thrust of Mr Pearson's letter is concern over health issues and corporate responsibility. These issues are outside of the scope of this report. This report focuses on the technical practicalities and costs of installing underground cable systems.

Mr Pearson refers in the sixth paragraph of his letter to "*recent examples elsewhere in Europe indicate a factor of 4/5 times for undergrounding using current XLPE technology, rather than up to 20 times using outdated oil cooled technology*".

It is assumed by the author that when Mr Pearson refers to "oil cooled technology" he is actually referring to low pressure fluid filled cable technology more commonly known as oil filled or fluid filled cables. Oil cooled cables are normally installed in high pressure pipelines but these were never proposed for use by Scottish Power or SHETL. It is important that this is clarified as high pressure oil filled cables (without cooling) have been used in the UK. Mr Pearson subsequently refers to oil filled cables in his correspondence. These cables use the insulating fluid as an insulating dielectric and not as a transport medium for heat transfer (i.e. oil cooling).

The research performed in the production of this report clearly shows that the cost ratios are not in the order of 4 or 5 times that of an overhead line for a comparable power transfer requirement in the UK.

400kV XLPE cable systems are currently the preferred choice for AC underground insulated cable systems (but not a 400kV DC subsea cable where the currently preferred choice is still a paper and oil compound insulated system). The costs published for the Beauly – Denny public inquiry (to be found in inquiry documents APL 5/16 and APL/STG-41) and those given in this report are all for XLPE insulated systems and are not based on fluid filled cable systems.

The National Grid have published information following their most recent assessment that undergrounding costs are between 12 and 17 times that of an overhead line. These ratios are of a similar order to those given APL 5/16.

Mr Pearson attached to his letter a Stirling Before Pylons's "Final Briefing : November 2009". The sixth bullet point under the first heading states that "*Heavy construction traffic requires an 8 kilometre access track to be made across Sheriffmuir –required for the 4-year construction phase*". The installation of a tunnel under the Ochils would also require a track to enable machinery, cables and spoil to access the Cockburn Wood area from the A9. The current consideration is that the same track as that used by the OHL constructors could also be used for access to the tunnelling operations.

In the November 2009 SBP briefing, under the heading "*Undergrounding – the solution*" there is a statement that "*The applicants have consistently and repeatedly quoted greatly exaggerated costs for undergrounding. They base their costs on the old, oil-filled cable*

technology and their experts acknowledged at the public inquiry that this is now obsolete, and that XLPE (cross-linked polythene) technology would in fact be used". This is not correct. A considerable amount of research was undertaken by the applicants in exploring the use of underground cable as an alternative to overhead line and in every case the costs were based on the use of XLPE cable and not oil filled cable. The reports which were both published in 2007 as documents APL 5/16 and APL/STG-41 were both lodged as public enquiry documents and their content was subject to detailed cross examination. Copies of the two reports are appended for completeness. This report further updates the costs for the routes investigated in APL/STG-41.

The subsequent bullet point states that "*Experience of using XLPE in Europe and North America suggests that its costs are typically around 2 – 5 times those of overhead lines*". There is no evidence given by SBP to support this particular statement but on each occasion, given to date, where a comparative assessment has been performed (as provided in this report) such low cost ratios have not been substantiated.

In the fifth from last bullet point *"Some £450m is being spent putting an extra-high-voltage power line underground through the site of the London Olympics"*. The two cable tunnels installed under the Olympic Park are 6km in length and contain both 400kV and lower voltage cables. It has not been possible to find a breakdown of the costs but details published on the London2012 internet site[29] cost the entire undergrounding project at £250m rather than £450m as per the SBP briefing note.

8.4 Letter from Caroline Patterson, 18th Feb 2010.

The main thrust of this letter is concern over health issues of the project. Health issues are not within the scope of this report or the expertise of its authors.

It must be pointed out however that in the third paragraph of this letter there is a statement that "High-voltage overhead power lines are dangerous, which is why many countries bury them when they pass through populated areas". The meaning taken is that the author considers bare uninsulated overhead lines to be generically dangerous in that if one were to breach the electrical clearance then an electrical flash-over would occur. Such a flash-over, where the insulation breaks down and a large power arc strikes from the conductor to earth, would indeed be a violent and hazardous event. This is also true of cables where, if the insulation thickness is breached a similar hazardous event would occur, e.g. if a workman punctures the cable with a pick axe or a thief attempts to cut a live cable for its metal content.

Reasons that overhead lines are not generally used in densely populated urban areas include the lack of adequate electrical clearance (the overhead line relies on air as its electrical insulator and thus a clearance corridor is required) and that there is insufficient ground room or practicability to install towers.

High speed railways even of the most modern type use an overhead line (called a catenary) to transfer power to trains, this operates at 25kV and may be used right into the heart of a city. This is possible because the clearance requirements are smaller than an EHV transmission line and space is available above the railway line. Admittedly this is not a like for like comparison with a double circuit overhead line but it does indicate that modern technology has not abandoned overhead bare conductors as a means of electrical power transfer at any voltage level.

8.5 Stirling Council Notes of Meeting Saturday, 6 March 2010

A copy of the notes of an "Initial Meeting of Community Councils / Key Stakeholders / Interest Groups" held on the 6th March and issued by Stirling Council was made available.

This document contains a number of bullet points and in so far as they concern underground power cable this report together with APL 5/16 and APL/STG-41 should provide additional information for interested parties.

8.6 Hinkley Point 'C' Connection

During consultations between SPT and interested parties a view was expressed to SPT by one party that the National Grid company considered the cost of cabling on their proposed new connection to Hinkley Point 'C' to be negligible. No further information was available to CCI and thus inquiries were made on the project.

Information on the Hinkley Point 'C' connection may be found on the National Grid Hinkley Connection web site[30].

In summary, the project involves the connection into the grid of a new nuclear power station, Hinkley Point 'C', located on the North coast of Summerset at Hinkley Point. The project also includes the reinforcement of the electricity grid in the south west of England to carry the power generated by some additional future power plants and to allow the grid system to continue operate as required during adverse fault conditions.

National Grid are proposing the construction and connection of a 400kV double circuit overhead line connection between Bridgwater and Avonmouth, depending upon the final route, the new line would be approximately 37 miles long and is due to be built in 2016.

The National Grid have produced two 'optioneering' reports[31,32] for the Hinkley Connection which are also available on the National Grid internet site. These include options for subsea cabling as both connection points are close to the Severn Estuary. Cabling connections using AC and DC power transmission systems have also been considered.

The following Cost Summary has been extracted from Table 10 of the National Grid Hinkley Point C Connection – Strategic Optioneering Report - Additional Information published in June 2010

Table 11- Hinkley Point Connection Cost Summary

Option	Description	Cost Estimate
H5	HVDC Subsea Cables from Hinkley Point to Aberthaw	£2.186bn
H5a	AC Subsea Cables from Hinkley Point to Aberthaw	£1.814bn
H6	HVDC Subsea Cables from Hinkley Point to Seabank	£1.642bn
H7	HVDC Subsea Cables from Hinkley Point to South Wales	Over £2.186bn
H7a	AC Subsea Cables from Hinkley Point to South Wales	Over £1.814bn
H10	Hinkley Point to Seabank Overhead Line	£655m
H10a	Hinkley Point to Seabank Overhead Line utilising the existing WPD 132kV route	£697m
H20	AC Subsea Cables from Hinkley Point to Seabank	£ 1.926bn

Options H10 and H10a are those for an OHL connection, all other options contain subsea cable connections.

It can be seen from the cost summary in Table 11 that the overhead line options vary from £655m to £697m whereas all subsea options vary from £1.642bn to over £2.186bn.

Subsea cable connections are generally less expensive than land underground cable connections as the cables are installed in long lengths from the back of a cable laying vessel with cable installation taking days or weeks rather than months. This is not to say that subsea cable installation is not without its difficulties, these include seabed conditions, sea bed burial requirements, tidal conditions and weather windows but these are not within the scope of this report.

In a publication[33] available on-line a statement has been made that:

".. in England, the National Grid has accepted that sections of line will have to be buried around Avonmouth and through the Mendip Hills."

In the Hinkley Point C Connection – Strategic Optioneering Report - Additional Information published in June 2010 the National Grid report states:

> *"2 UNDERGROUND CABLES*
> *2.1 Underground cables are amongst the suite of technical solutions National Grid can use when seeking to add capacity to the transmission system. However, a number of significant issues with the use of underground cables affect its deployment and therefore there is limited use on the high voltage transmission system (e.g. 675km out of a total transmission network of 7,900km).*
> *2.2 These issues include operability issues, such as the management of charging currents, potential cable cooling systems, impact on system voltage and the need for supplementary reactive compensation equipment. As well as these operability issues there are significant construction issues which together account for 400kV underground cables costing significantly more, between 12 and 17 times as much, than the equivalent overhead line.*
> *2.3 Given its duties as set out above, to develop the transmission system in an efficient, coordinated and economical manner, National Grid must therefore, in the first instance, considers adding transmission capacity and connecting new generation by overhead line connections, rather than by underground cables. As a result, the use of underground cables as a total connection solution is not considered at the Strategic Optioneering Stage.*
> *2.4 However, undergrounding some sections of route may well be considered when detailed route alignments are being developed and following public consultation. These will include of nationally or internationally designated areas of amenity value, exceptionally constrained estuaries or major river crossings and exceptionally constrained urban areas.*
> *2.5 National Grid's policy related to the use of underground cables, which reserves consideration of their use to areas of technical constraint and to areas of the highest recognised amenity value, can be found at:*
> *http://www.nationalgrid.com/uk/LandandDevelopment/SC/Undergrounding/ ."*

No further information was available on the National Grid web site and on the 4th August 2010, the National Grid were contacted with regard to the Caledonian Mercury article. A spokesperson for the National Grid advised that the National Grid follow their published policy on the use of underground cables and that no decision with regard to undergrounding any part of the proposed 400kV overhead line had yet been taken.

The NG spokesperson was unaware of any statements by National Grid that the cost of underground cables was negligible and considered that any such quotation to that effect was either incorrect or taken out of context.

In summary, with regard to costs, the National Grid consider the cost of undergrounding to be some 12 to 17 times more costly than overhead line. All the cabling options on the Hinkley Connection Project are more costly than the overhead line options.

8.7 ECU Briefing Note

The ECU Briefing Note requires that mitigation of the visual impact of the line in the Stirling area be provided. The Briefing Note suggests that this may be achieved possibly by re-routeing, re-sizing of towers, screen planting or undergrounding.

9 Conclusions

The SPT briefing note required (paragraph 1) that the technology discussed in APL 5/16 and costs for the routes considered in APL/STG-41 be reviewed. Paragraph 2 of the briefing note required a new cost of undergrounding in the areas requiring visual mitigation (as identified within the EDU briefing note. The conclusions of this report on paragraphs 1 and 2 of the SPT briefing note are set out in Section 9.1.

The conclusions of the review of documentation submitted to SPT for consideration are set out in Section 9.2 as required by paragraph 3 of the SPT briefing note.

9.1 Findings of the review of technical developments and costs all routes

In the field of AC EHV cable systems there have been no major technology or cost breakthroughs since the Beauly-Denny public inquiry in 2007. The following technological advances were included in the documents presented to the Public Inquiry:

1. XLPE insulated cable systems rather than fluid filled cable systems
2. Polymeric joint and termination designs for EHV systems
3. Lower ac resistance (and therefore lower loss) coated conductors

The use of welded seam metallic sheaths has increased for new installations and these are now allowed by the National Grid in the UK with at least two European manufacturers offering welded aluminium sheath cable designs. At current price levels these welded sheath designs offer a lower cost alternative (as provided by the cable suppliers to the author) than lead sheath designs and thus these designs have now been included in the cost update provided by this report. Manufacturers are still offering lead sheathed cables and these are also being purchased by the National Grid.

A total of seven route alternatives have been studied with an attempted cost accuracy of +/-20%. Costs have been provided by independent commercial companies competent to supply and install EHV cable systems in Europe.

Since the reports APL 5/16 and APL/STG-41 were published in 2007 the commodity price for metals used in the manufacture of conductors and sheaths has continued to

fluctuate. Typical round number metal prices as seen in June/July 2010 were given to manufacturers for pricing.

Table 12 - Metal Prices Used For This Report

Metal	UGC Metal Prices Used for this Report
Aluminium (Al)	US$ 2000 /tonne
Copper (Cu)	US$ 6400 /tonne
Lead (Pb)	US$ 1700 /tonne

Table 13 contains a summary of the costs for each of the four undergrounding route options considered in APL/STG-41 together with three additional options considered for this report. The latter three routes were selected to include those areas where visual mitigation of the overhead line is now required. The figures in Table 13 are those taken from Table 2 through Table 9 of this report. The figures in brackets are those published in Table 3-5, 3-6, 3-7 and 4-3 in APL/STG-41 in 2007.

Table 13 - Cost Ratios 2010 (APL/STG-41 bracketed)

	Undergrounding Cost UG [£m]	Overhead Cost OH [£m]	Ratio UG/OH
UGC4 – SNH Option 1	352.8 (327.3)	27.5 (28.5)	12.8 (11.5)
UGC4 – SNH Option 2	217.0 (202.5)	27.5 (28.5)	7.9 (7.1)
UGC4 – SBP	480.2 (444.7)	27.5 (28.5)	17.5 (15.6)
UGC4 – UoS	114.5 (94.0)	5.2 (6.6)	21.9 (14.2)
TD199-TD203A	60.3	1.46	41.4
TD199-TD244	229.1	15.7	14.6
TD203-TD244	178.8	13.2	13.6

Table 13 illustrates that the use of cost ratios of UGC to OHL are not a reliable sole comparisons of costs between the two technologies. It can be seen that the costs ratios for each undergrounding option vary between 7.9 and 41.4 dependent upon the type and length of the proposed installation.

Table 14 – Summary of cost estimates

Option	Length of Displaced Overhead Line: km	Estimated OHL cost: £m	Total length of OHL in alternative: km	Total length of buried cable in alternative: km	Total length of cable in tunnel in alternative: km	Estimated Cost of Alternative: £m	Additional Cost of Alternative: £m
West of Stirling							
UGC4 – SNH Option 1	30.3	£27.5m	6.5	24.0	0	£352.8m	£352.3m
UGC4 – SNH Option 2	30.3	£27.5m	16.7	13.8	0	£217.0m	£189.5m
UGC4 – SBP	30.3	£27.5m	0	33.4	0	£480.2m	£452.7m
East of Stirling							
UGC4 – UoS	5.3	£5.2m	0.9	1.3	2.6	£114.5m	£109.3m
TD199-TD203A	1.479	£1.5m	0	0.2	1.479	£60.3m	£58.9m
TD199-TD244	15.973	£15.7m	0	12.134	1.479	£229.1m	£213.4m
TD203-TD244	14.510	£13.2m	0	12.142	0	£178.8m	£165.7m

A summary of cost estimates for the undergrounding of each route option are given in Table 14.

Overhead line costs along each route vary between £1.5m and £27.5m whereas the cost of undergrounding varies between £60.3m and £480.2m. The additional costs of undergrounding vary between £58.9m and £452.7m. All options involving the undergrounding of circuits are shown to be significantly more expensive than the overhead line proposal. No recent technological changes or alterations in the metal prices (compared with 2007) have made any deciding difference on the cost comparisons between the two technologies as applied to the Beauly-Denny connection.

9.2 Conclusions of the review of documentation

The SPICe document (Section 8.1) refers to a number of UGC projects that had been completed prior to the public inquiry and information of which was available to the Inquiry Reporters and mentioned in APL 5/16. Apart from the use of EHV power cables

the projects in Denmark, Madrid and Japan have been shown to be different to each other in terms of power transfer requirements and installation method. They have also been shown to differ significantly in power transfer requirements and installation methods from any attempt at undergrounding in the Stirling Area.

The UCTE Transmission development plan (Section 8.1.2.4) provides information on cross-border connections, these include the use of DC connections which are a different technology to the AC cables to be used on the Beauly-Denny connection and therefore not relevant. The only AC connection mentioned is a 220kV connection between Luxembourg and Belgium with a power rating of one fifth of the Beauly-Denny connection.

The paper "Undergrounding of Electricity Lines in Europe" (Section 8.1.2.5) has been largely, and rightly in the authors view, discredited by the consultants Jacobs Babtie in their report submitted to the Public Inquiry.

The ENA briefing paper (Section 8.1.2.6) sets out the view of its members on undergrounding and a similar view to that given by SPT at the public inquiry.

The letter from Keith Brown MSP sets out five questions for which this report has provided answers so far as undergrounding is concerned. The response to Mr Brown's questions can be summarised as follows:

- The technical position with regard to underground cable or overhead lines has not changed significantly since the public inquiry. Underground cables would still be significantly more expensive to install than overhead lines across the Stirling Area.
- Examination of projects in other areas of the world where less expensive underground cable connections are installed reveals that the power transfer requirements are significantly lower than those required for the Beauly-Denny line. The cost ratios of UGC to OHL have been shown within this report to be a convenient rather than a reliable indicator of comparative cost. The estimated difference in total cost is a far more useful indicator and should be calculated on a project by project basis.
- The type of terrain and the method required to be employed has a significant bearing on cost, as does the length of the installation. Overhead line costs along each route vary between £1.5m and £27.5m whereas the cost of undergrounding varies between £60.3m and £480.2m. The additional costs of undergrounding vary between £58.9m and £452.7m. All options involving the undergrounding of circuits are shown to be significantly more expensive than the overhead line proposal.

The letter from Peter Pearson (Section 8.3) states that SPT have provided costs only for oil filled cables. This is not the case as can be seen from documents APL 5/16 and APL/STG-41 where only costs for XLPE cable systems were provided to the Reporters at

the Public Inquiry in 2007. Statements are made by Mr Pearson of low UGC:OHL cost ratios on other projects but references are not given such that these may be examined. Where comparative assessments have been performed (as provided in this report on other projects) the low cost ratios forwarded by Mr Pearson have not been substantiated.

The letter from Caroline Patterson (Section 8.4) is largely one regarding health concerns which the authors of this report are not qualified to address. However, clarifications have been provided on the reasons why large overhead line connections are not installed in urban areas. The engineering reasons for the restrictions on the use of OHL in urban areas are the space for towers and the electrical clearances for conductors.

This report has also conducted a review on the Hinkley Point 'C' connection alternatives being considered by the National Grid in Summerset. In summary, with regard to costs, the National Grid consider the cost of undergrounding to be some 12 to 17 times more costly than overhead line. All the cabling options on the Hinkley Connection Project are more costly than the overhead line options.

Appendix 1 - References and Notes

[1] "Proposed Beauly to Denny 400kV Overhead Transmission Line, The Use of Underground Cable as an alternative to Overhead Line in Specific Locations, Final Report, January 2007" PB Power, PI document APL 5/16.
[2] "Proposed Beauly to Denny 400kV Overhead Transmission Line, The use of underground cable as an alternative to overhead line: STIRLING, Final Report October 2007", PB Power, PI document APL/STG-41
[3] The alternative route through the University of Stirling (case study 4 of APL 5/16) having been withdrawn at the public inquiry during proceedings for environmental reasons.
[4] The alternative route through the University of Stirling (case study 4 of APL 5/16) having been withdrawn at the public inquiry during proceedings for environmental reasons.
[5] This UGC length would be increased by 220m if it was required that the cables were terminated at TD244E at Glenside.
[6] "Draft National Policy Statement for Electricity Networks Infrastructure (EN-5)", Energy Planning Reform, Department of Energy and Climate Change, (http://data.energynpsconsultation.decc.gov.uk/documents/npss/EN-5.pdf)
[7] www.nationalgrid.com/uk/LandandDevelopment/DDC/Undergrounding
[8] "Undergrounding high voltage electricity transmission: The technical issues", Issue 2, August 2009, National Grid, http://www.nationalgrid.com/NR/rdonlyres/A7B84851-242F-496B-A5E8-697331E15504/36546/UndergroundingTheTechnicalIssues3.pdf
[9] "Overhead Lines or Underground Cables", Environment Briefing 02, Energy Networks Association, July 2006. This document has been relocated by the Electric Networks Association to a new internet address http://www.energynetworks.org/ena_env_briefings/ENV2TransportingElectricity.pdf
[10] "400kV Interconnection Århus – Aalborg", S.D. Mikkelsen, Workshop 380kV, 23rd Sept 2002, Wien (2002)
[11] "The In-service 400 kV Cable System of Eltra in Denmark and the Cost Ratio Underground/Overhead for the Three Different Sections", ICC, Transnational Luncheon, St. Petersburg, Florida, 2nd November 2004.
[12] http://www.highland.gov.uk/NR/rdonlyres/9CD19514-26DD-495D-B0FB-93FF6AEACF70/0/app6.pdf
[13] "New 400 kV Underground Cable System Project In Jutland (Denmark)", Pierre ARGAUT, S D Mikkelsen, JICABLE ' 03, 2003.
[14] Table 3-6 in APL/STG-41
[15] Table 3-7 in APL/STG-41
[16] Winter ratings from Table 5-1 of APL 5/16.
[17] The Leonardo-Energy paper refers to the installation of three single core cables, in fact the installation consisted of a double circuit 400kV installation.
[18] "Undergrounding the first 400kV transmission line in Spain using 2500mm^2 XLPE cables in a ventilated tunnel: the Madrid Barajas airport project", Granadino R. et al, JICABLE 03, Paris (2003).

[19] The JICABLE conferences are held in Paris every 4 years and are an international forum for the exchange of information in the fields of research, industrial development, installation, operation and diagnoses relating to insulated power cables and their accessories from low voltage and special cables up to ultra high voltage cables and cables of new technologies.
[20] "Construction of the World's First Long-Distance 500kV XLPE Cable Line", Yonemoto et al, Fujikura Technical Review, 2003.
http://www.fujikura.co.jp/eng/rd/gihou/backnumber/pages/__icsFiles/afieldfile/2008/10/10/32e_06.pdf
[21] "Construction of long distance 500kV XLPE cable line", Ohata, K. et al, JICABLE '99, Paris, 1999.
[22] "UCTE Transmission Development Plan", Union for the coordination of transmission of electricity, Update 2009,
http://www.entsoe.eu/fileadmin/user_upload/_library/publications/ce/otherreports/tdp09_report_ucte.pdf
[23] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/231
[24] http://italy.edf.com/edf-in-italy/about-edf-in-italy-47430.html
[25] http://www.paperjam.lu/rapports/Cegedel_Net/Cegedel_Net_2007_GB.pdf
[26] http://www.elia.be/repository/Lists/Library/Attachments/777/ELIA-Jaarverslag_2008-NL.pdf , page 33
[27] "Background Paper, Undergrounding of Electricity Lines in Europe", Commission of the European Communities, Brussels, 2003
http://ec.europa.eu/energy/gas_electricity/studies/doc/electricity/2003_12_undergrounding.pdf
[28] "Undergrounding of Extra High Voltage Transmission Lines", Jacobs Babtie, 2005. http://www.highland.gov.uk/NR/rdonlyres/2FC57E93-5D8B-407A-8FD4-AF8D5F300C84/0/app2.pdf
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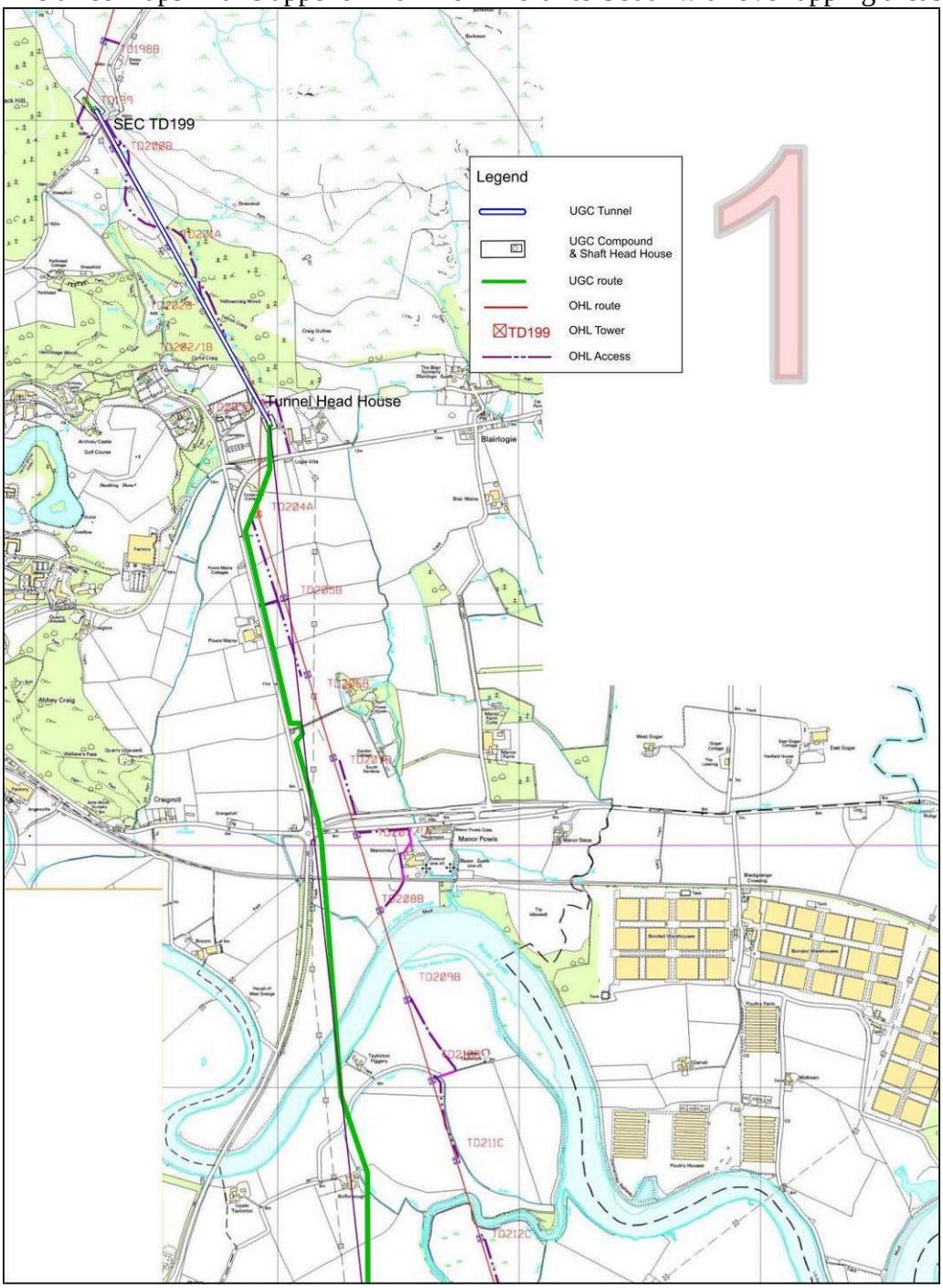
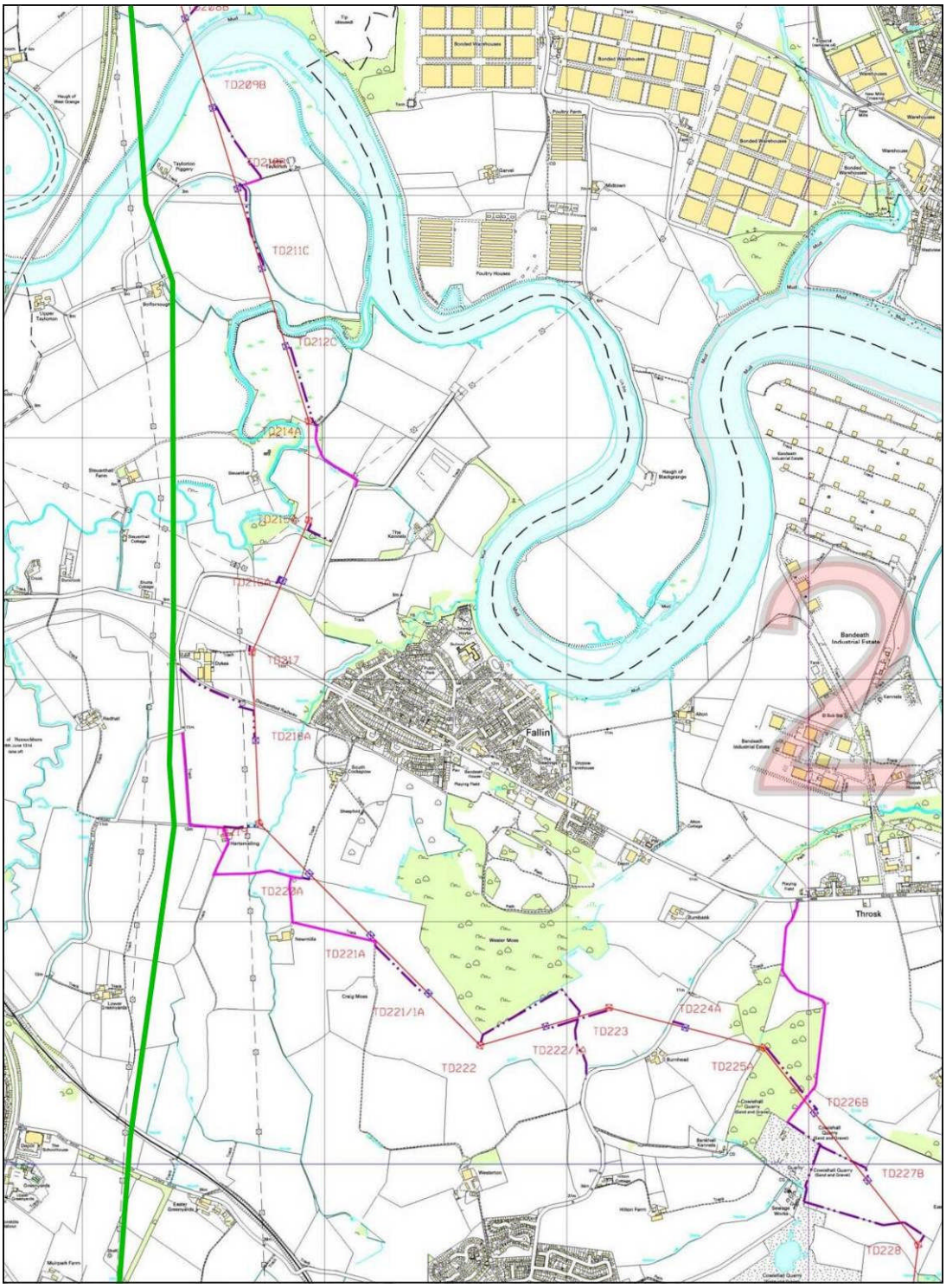
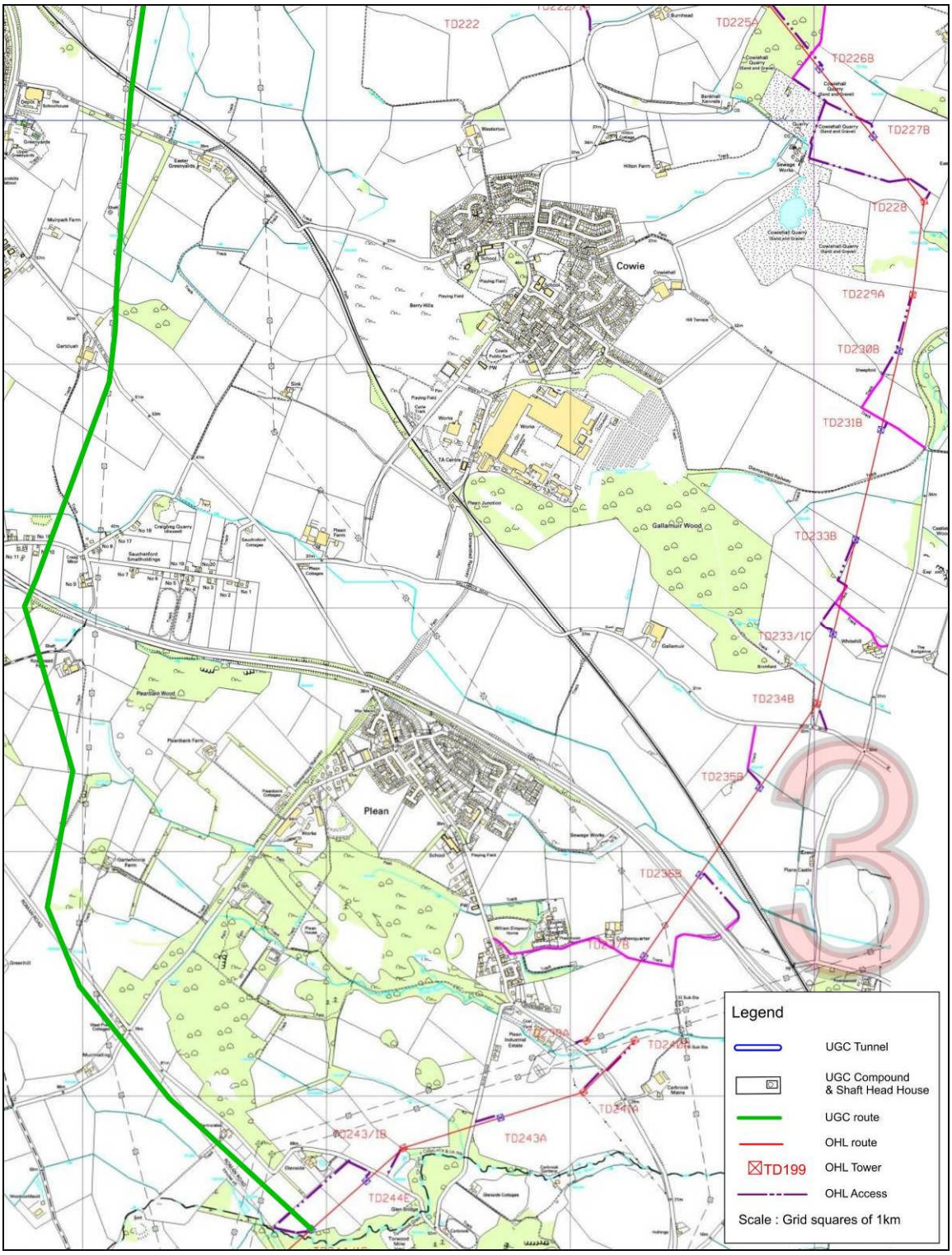
[30] Hinkley Point 'C' connection National Grid web site URL http://www.nationalgrid.com/uk/Electricity/MajorProjects/HinkleyConnection/
[31] URL for the Hinkely Connection Strategic Optioneering Report by National Grid in Dec 2009. http://www.nationalgrid.com/NR/rdonlyres/B8E33312-3BA0-4A66-A51A-28932554A647/38744/HinckleyPointCStrategicoptioneeringreportv3.pdf
[32] URL for the Hinkely Connection Strategic Optioneering Additional Information Report by National Grid in June 2010. http://www.nationalgrid.com/NR/rdonlyres/6EA38D82-89CB-4573-97E0-71B5EF3C2DB3/41719/HPAddendumV2_110610.pdf
[33] URL of Caledonian Mercury article by John Knox http://politics.caledonianmercury.com/2010/08/02/pylon-campaigners-claim-underground-cable-evidence-ignored/

Appendix 2 - Route Maps TD199 to TD244/1C

The three maps in this appendix run from North to South with overlapping areas.

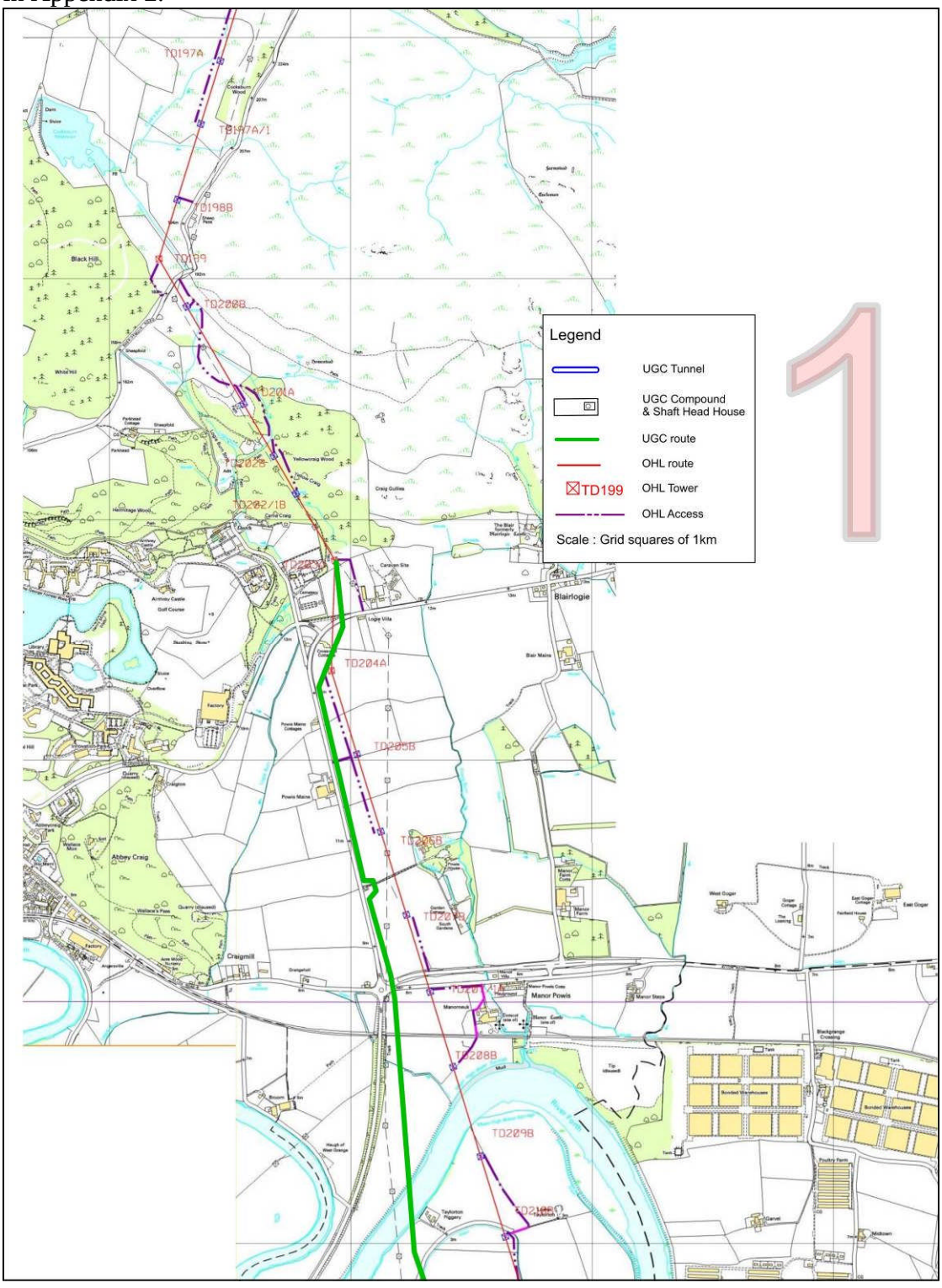



TD209B
TD211C
TD212C
TD214A
TD217
TD218A
TD220A
TD221A
TD221/1A
TD222
TD222/1
TD223
TD224A
TD225A
TD226B
TD227B
TD228
Fallin
Throsk
Bandeath Industrial Estate


TD222
TD225A
TD226B
TD227B
TD228
TD229A
TD230B
TD231B
TD233B
TD233/1C
TD234B
TD235B
TD236B
TD237B
TD238A
TD241B
TD243/1B
TD243A
TD244B
Cowie
Plean
Gallamuir Wood
Legend
UGC Tunnel
UGC Compound & Shaft Head House
UGC route
OHL route
TD199 OHL Tower
OHL Access
Scale : Grid squares of 1km

Appendix 3 - Route Maps TD203 to Denny Substation (Page 1 only)

For the UGC cable route South of the area shown on this map, see map sheets 2 and 3 in Appendix 2.



Appendix 4 – ECU Briefing Note

Beauly to Denny Overhead Transmission Line
Condition 19: Stirling Visual Impact Mitigation Scheme - Briefing Note

Background
The decision letter from Colin Imrie to Nick Horler at Scottish Power Transmission Limited on 06 January 2010 granted consent, subject to certain conditions, for the application of the development of the overhead transmission line between the Wharry Burn, near Dunblane and the proposed substation north east of Dunipace, Denny[1]. Condition 19 of the consent (attached at Annex A for reference) refers to a "Stirling Visual Mitigation Scheme".

Purpose
To provide guidance on the Scottish Government's intentions with regards to the Stirling Visual Impact Mitigation scheme.

Purpose of the Scheme
To mitigate the visual impact of the proposed line in the Stirling area and to ensure the views of local communities are fully taken into account, particularly though Stirling Council, before any proposals are approved and as development of the line progresses. The Scheme will see the mitigation of around 8km of the new 400kV line, possibly by re-routeing, re-sizing of towers, screen planting or undergrounding.

Rationale
The issue of impacts on visual amenity has been the focus of significant discussion among the applicants, the statutory consultees and in the evidence presented to the Public Local Inquiry (PLI). It is also an issue which has generated a significant amount of discussion at local level, showing a clear and sustained depth of concern in the community of Stirling.

The PLI reporters endorsed the iterative route selection process adopted by the developers and concluded that the route as now consented was logical and justified. Nevertheless, the PLI report clearly shows that in relation to a number of areas around Stirling there were strong concerns about the extent of the impacts of the now consented line on landscape character and visual amenity. This is particularly the case in respect of the proposed route line from the top of the scarp of the Ochil Hills down to the Carse of Forth. At paragraph 1.11.69, the reporters note that "the applicants accept that any route descending the scarp slope would be a prominent feature". The reporters further conclude at paragraph 1.6.3 of Volume 6 that "if the proposed 400kV line is to cross the Ochils the best route would be to follow the existing 132kv line".

Details of Location

[1] A second letter was sent to Scottish and Southern Energy Plc (SSE) on 06 January 2010 granting consent for the application of the development between a proposed extended substation at Beauly, near Inverness, and the Wharry Burn, near Dunblane.

The proposals must include measures to mitigate the landscape and visual impact of 8km of the new line in the Stirling area between Cocksburn Wood and Glenside. These sections of line are located as follows:

1. between the top scarp of the Ochil Hills at Cocksburn Wood and Airthrey Castle. Discussion of the landscape and visual impact on this area is at paragraphs 1.11.68 to 1.11.87 of Volume 5 of the PLI report.
2. between Logie Villa at the base of the scarp slope and Glenside, near Plean. Discussion of the landscape and visual impact on this area is at paragraphs 1.11.88 to 1.11.100 of Volume 5.

The Scottish Government's Intentions with Regards to the Stirling Visual Impact Mitigation Scheme

The Stirling Visual Impact Mitigation Scheme will comprise of measures to be undertaken by Scottish Power Transmission Limited for mitigating the landscape and visual impact of the line in the Stirling Council area.

Condition 19 states that: "Neither the overhead transmission line, nor the towers carrying the line, shall be installed or constructed..." in the whole Stirling Council area until the requirements at (1)(a) and (b) are fulfilled.

Part (2) of the condition details certain sections of the line which must be included in the mitigation scheme. The condition requires the developers to bring forward proposals to mitigate the landscape and visual impact of the overhead line along two specific sections: between the top of the scarp of the Ochils at Cocksburn Wood (TD199) and Airthrey Castle (TD203); and the section south of the tower at Logie Villa (TD203) and to the east of Stirling to the tower at Glenside (TD244E).

The Scottish Government is required by Condition 19 to consult with Stirling Council before approving any scheme proposed by the developers. In particular, the Council has a crucial role to play in representing the views of the local community. It is our view that the Council should be consulted from the outset in the design of the scheme by SPT and we and we understand the company fully intends to do so. To this end, we intend to set up a meeting between Scottish Power Transmission Limited, Stirling Council, and the Scottish Government in early course.

Process

The Condition lays out three requirements that must be fulfilled before the overhead transmission line or the towers can be erected. It is the intention of the Scottish Government that these three requirements run sequentially, as follows:

1. The Developers come forward with proposals for the scheme, after consultation with Stirling Council. It is important that proposals are made as soon as possible, in order that the appropriate consultation can then be undertaken.

2. The Scottish Government will allow 30 days for consultation with Stirling Council on any proposal. Ministers decide if the proposals appropriately fulfil the purpose of the scheme.
3. Provided that approval for the proposal has been given by Scottish Ministers, the Developers obtain any further permissions and consents required to implement the approved scheme.

Further Advice and Actions

The Scottish Government will seek to arrange the meeting described above as soon as possible. We would be grateful if you would consider the Council's full involvement in the process of developing the visual impact mitigation scheme, including appropriate attendance at that early meeting. More generally, the Scottish Government is very keen to engage with Stirling Council where we can be of assistance on these matters. If you require any further clarification please do not hesitate to contact me at the number or email address below.

Simon Coote

The Scottish Government
Head of Energy Consents and Deployment
Business, Enterprise and Energy Directorate
Tel: 0300 244 1238
Email: simon.coote@scotland.gsi.gov.uk

ANNEX A

The Stirling Visual Impact Mitigation Scheme condition

Stirling Visual Impact Mitigation Scheme

19.—(1) Neither the overhead transmission line or the towers carrying that line shall be installed or constructed in the area of Stirling Council until–

(a) the applicant has submitted to the Scottish Ministers for approval a scheme prepared in accordance with this condition setting out proposals to mitigate the visual impact of the 400kv line in the Stirling area ("the Stirling Visual Impact Mitigation Scheme"); and

(b) the Scottish Ministers have, after consultation with Stirling Council, approved the Stirling Visual Impact Mitigation Scheme.

(2) The Stirling Visual Impact Mitigation Scheme is to include proposals for:

(a) the mitigation of the visual and landscape impact of the line between the top scarp of the Ochil Hills at Cocksburn Wood (TD199) and Airthey Castle (TD203)

(b) the mitigation of visual and landscape impact of the line between Logie (TD203) and Glenside TD244,

(3) The Development shall be carried out in accordance with the approved Stirling Visual Impact Mitigation Scheme unless otherwise agreed in writing by the Scottish Ministers.

Appendix 5 - Letter from Ken Brown MSP

The Scottish Parliament
Pàrlamaid na h-Alba

Phil Henderson
Government Affairs
Scottish Power Corporate Office
1 Atlantic Quay
GLASGOW
G2 8SP


Keith Brown MSP

Ref: KB/EF

8 March 2010

Dear Phil

Beauly to Denny Power Line

It has now been several weeks since Scottish Power's meeting with Bruce Crawford and myself where we had initial discussions about the mitigation conditions imposed by Scottish Ministers as part of the approval of the Beauly to Denny power line upgrade.

On Saturday 6 March, Stirling Council held an initial consultation meeting with the main stakeholders from the communities along the route of the line which both Bruce and I attended as the local MSPs. At this meeting several issues were raised and details of how consultation with the wider community will proceed, was confirmed. It is very clear from this meeting that undergrounding the line will be one of the main areas of discussion and this seems like an ideal opportunity to recap the main areas discussed at our meeting and find out how these are progressing.

As I understand it we requested that Scottish Power ensure that all potential mitigation options are fully explored and in particular that undergrounding of the line in the Stirling area requires careful consideration. The main points raised with regard to undergrounding were:

- The technical and cost issues of both an overhead and underground line in the Stirling area need to be re-examined and re-appraised to take account changes and developments which may have occurred since the reports used in the public inquiry were commissioned by Scottish Power over four years ago.
- Attention should be given to examples in other areas of the world where undergrounding 400kv lines has been achieved at significantly less cost that the estimates provided for the Beauly to Denny line – particular reference was made to the Danish and Japanese examples given in the information provided by Spice of which I believe you have been sent a copy.
- Why are there such differences in the costs of these compared to the costs given for the Beauly to Denny line? Could these examples be used to work up alternative costings for the Stirling area?

Parliamentary Office: Scottish Parliament, Edinburgh, EH99 1SP (tel) 0131 348 6335
Constituency Office: 80 Mill Street, Alloa, FK10 1DY (tel) 01259 219 333
Keith.Brown.msp@scottish.parliament.uk
http://www.scottish.parliament.uk/msp/membersPages/keith_brown/

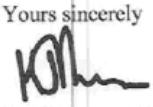
- Clarification as to whether there are significant variations to the costs of undergrounding different sections of the line in the Stirling area.
- Comparative costs of all the mitigation measures under consideration would be useful.

I appreciate that these issues may take some time to answer, and indeed there may be further questions raised as the consultation proceeds, it would however be helpful to know how the matter is progressing.

The Minister has confirmed that approval must be obtained from Ofgem with regard to the additional cost of the agreed mitigation measures before they can be carried out but that he does not consider that such expenditure will prove an obstacle to ensuring that the visual and environmental impacts of the 400kV line are acceptably mitigated. I can confirm that I have requested a meeting with Ofgem to discuss this further

Please do not hesitate to contact me if you require any further information.

Yours sincerely



Keith Brown MSP
Ochil Constituency

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Constituency Office: 80 Mill Street, Alloa, FK10 1DY (tel) 01259 219 333
Keith.Brown.msp@scottish.parliament.uk
http://www.scottish.parliament.uk/msp/membersPages/keith_brown/

Appendix 6 – Graeme Cook letter (SPICe), 5th Feb 2010

SPICe
The Information Centre

Scottish Parliament Information Centre
Edinburgh
EH99 1SP

Tel.: 0131 348 85086
Fax: 0131 348 5086
Email: graeme.cook@scottish.parliament.uk

5 February 2010

Dear Ellen,

Electricity wire visual amenity mitigation measures

Thank you for your enquiry requesting examples of electricity wire visual amenity mitigation measures that have been used worldwide by power companies.

I did approach both Scottish and Southern Energy and Scottish Power to ask if they were aware of any off the shelf publications which included examples of best practice but neither were aware of such information. I know you need this response before 8 February 2010, so if you would like me to look into anything further please get back in touch.

Firstly, you mentioned that you'd heard that the largest section of wire ever undergrounded in Europe was around 19 km in Madrid. In particular you wanted to know who the power company behind this project was. I have included some information on this later in my response.

You might be interested to know that the UK Department for Energy and Climate Change has published a new Draft National Policy Statement for Electricity Networks Infrastructure (EN-5)[1]. This policy statement relates to the work of the new Infrastructure Planning Commission, which focuses on England and Wales, though the Draft Statement says:

> In Scotland the IPC will not examine applications for nationally significant electricity network infrastructure. However, energy policy is generally a matter reserved to UK Ministers and this NPS may

[1] http://data.energynpsconsultation.decc.gov.uk/documents/npss/EN-5.pdf

therefore be a relevant consideration in planning decisions in Scotland.

Section 2.7 of the document specifically relates to the landscape and visual impacts of electricity networks, stating at 2.7.2 that:

> New above ground electricity lines, whether constructed using lattice steel towers or wood poles, can give rise to adverse landscape and visual impacts, dependent upon their scale, siting, degree of screening and the nature of the landscape/local environment through which they are routed. New substations, sealing end compounds and other above ground installations that form connection, switching and voltage transformation points on the electricity networks can also give rise to landscape and visual impacts. Cumulative landscape and visual impacts can arise where new overhead lines are required along with other related developments such as substations, wind farms and/or other new sources of power generation. Sometimes positive landscape and visual benefits can arise through the reconfiguration or rationalisation of existing electricity network infrastructure.

There are 4 main visual amenity mitigation measures employed by those installing and running electricity wires. These are:

1. **Routing**
2. **Wirescape rationalisation**
3. **Undergrounding as cables**
4. **Landscape Schemes and Screening**

Each of these is considered in more detail below, though I should say that it is easier to find best practice examples of undergrounding than the other forms of mitigation. This is probably because elements of the other 3 measures would routinely be considered in the development of new overhead wires, and so are probably not reflected in literature as being "best practice", but I could continue to look into this for you if you would like.

ROUTING

Sensitive routing of electricity wires and pylons can minimise visual impacts enormously, and can be planned for well in advance. The DECC Draft National Policy Statement for Electricity Networks Infrastructure (EN-5) quotes the long standing Holford Rules which were originally set out in 1959 and state that developers should:

- avoid altogether, if possible, the major areas of highest amenity value, by so planning the general route of the line in the first place, even if total mileage is somewhat increased in consequence;
- avoid smaller areas of high amenity value or scientific interest by deviation, provided this can be done without using too many angle

towers i.e. the bigger structures which are used when lines change direction;

- other things being equal, choose the most direct line, with no sharp changes of direction and thus with fewer angle towers;
- choose tree and hill backgrounds in preference to sky backgrounds wherever possible. When a line has to cross a ridge, secure this opaque background as long as possible, cross obliquely when a dip in the ridge provides an opportunity. Where it does not, cross directly, preferably between belts of trees;
- prefer moderately open valleys with woods where the apparent height of towers will be reduced, and views of the line will be broken by trees;
- where country is flat and sparsely planted, keep the high voltage lines as far as possible independent of smaller lines, converging routes, distribution poles and other masts, wires and cables, so as to avoid a concentration of lines or 'wirescape'; and
- approach urban areas through industrial zones, where they exist; and when pleasant residential and recreational land intervenes between the approach line and the substation, carefully assess the comparative costs of undergrounding, for lines other than those of the highest voltage.

According to the summer 2009 Scottish Government Consultation on the consenting process for thermal power stations in Scotland:

> Network operators have a duty of care under Schedule 9 of the Electricity Act 1989 to find the most acceptable environmentally and (elsewhere in the Act) the preferred economically efficient route, and this can require time to examine alternative routes before identifying the proposed route.

WIRESCAPE RATIONALISATION

"Wirescape rationalisation" or "wirescaping" is the removal or improvement of existing ancillary electricity lines, pylons and poles. Related to this, the DECC draft statement highlights that the following should be borne in mind:

- consideration of ***network reinforcement*** options (where alternatives exist) which may allow improvements to an existing line rather than the building of an entirely new line;
- selection of the ***most suitable type and design of support structure*** (i.e. different lattice tower types, use of wooden poles etc) in order to minimise the overall visual impact on the landscape.

The Beauly-Denny line includes five 'wirescape rationalisation' schemes involving removing or improving 86 kilometres of existing ancillary power lines, pylons and poles at Stirling, Cairngorms National Park, Balblair (Highland), Errochty (Highland) and Muthill (Perthshire). Such schemes will need to be approved by Scottish Ministers in consultation with the local planning authority.

You may well have seen the map below before, but this is from Scottish and Southern Energy, and shows where it is anticipated such measures will be employed.

UNDERGROUNDING
When electricity lines are to be placed underground, they are then defined as electricity cables.

The Report of the Technical Assessor to the Beauly-Denny Inquiry stated that:

> As it is generally more expensive to use underground cables than overhead lines for high voltage transmission, undergrounding is undertaken for three reasons.

The report then describes the three reasons, indicated below, and also makes some references to undergrounding examples in the UK:

> Firstly, in urban areas high voltage cables are generally undergrounded, e.g. in London, Leeds and Edinburgh. It is also worth noting that high voltage lines have been undergrounded between Newby and Nunthorpe (Yorkshire[2]), where the route passes close to much smaller scale settlements (APL2B/2 section 27).
>
> Secondly, high voltage lines can be undergrounded for environmental and visual amenity reasons, e.g. at Goring Gap west of Reading (400kV Bramley – Didcot line), near Oxford (400kV Cowley – Walham line) and at Longdendale in the south Pennines through the Peak District National Park (400kV).
>
> Thirdly, in a few areas circuits are undergrounded because an overhead route is technically impossible due to the need for very long spans (or excessively expensive), e.g. in Hampshire

The draft DECC document referred to above includes some information on undergrounding. I don't intend reproducing that here, but if you want to read it I'd point you to sections 2.7.6 to 2.7.11.

Some examples of undergrounding abroad are given below[3]:

- In ***Spain*** proposals to build a new runway at Madrid's Brajas Airport required the undergrounding of an existing 400 kV overhead transmission line. The transmission lines, owned by REE, Spain's main Transmission System Operator, were a key element of the grid serving the city of Madrid, and so had to be maintained. The solution is 13 km of 400kV cables in a tunnel under the new runway.

- The ***Denmark*** Aalborg - Aarhus line/cable is an example of the use of undergrounding to protect areas of outstanding natural beauty. A 140km link was constructed to reinforce the 400kV network between Aalborg and Aarhus. The line, with a capacity of 1200MW, is mainly

[2] More on the Yorkshire examples is available online
[3] The Danish and Spanish examples are sourced from http://www.leonardo-energy.org/files/2006/UndergroundingHV.pdf?download (http://www.leonardo-energy.org/)

overhead but is buried in three sections in areas considered to be of scenic or ecological interest The total cost of the project was around €140m. The underground part represents about 10% of the total length and is estimated to have cost €35m. The project took 11 years of political negotiations, but only one year to engineer and two years to construct.

1. Southwest of Aalborg, a 7km section was put underground in an urban area but also one of historical significance.
2. Further south, the 150kV overhead line that crosses the Mariager Fjord was dismantled and 2.5km of 400kV and 150kV cable was laid.
3. Still further south, a 4.5km section passing through the Gudena Valley was placed underground as OHL was not considered appropriate through a picturesque area of lakes and wooded hills.

- In ***Japan***, the Shinkeiyo Toyosu Line goes underground for a period of 20 kilometres. This is a 500kV line (Beauly-Denny is 400kV).

A publication[4] from the Union for the Co-ordination of Transmission of Electricity, updated this year, might be of interest. It gives 3 examples of planned electricity transmission projects which will have elements of undergrounding, namely:

- ***France-Spain*** 400kV DC interconnection (see page 25 and 56)
- ***France-Italy*** (capacity to be defined) DC connection (see page 47)
- ***Luxembourg-Belgium*** 220kV connection (see page 32)

You might be interested in a European Commission publication on the undergrounding of electricity cables lines in ***Europe***. This is dated 2003.

Finally you might find a briefing from the Energy Networks Association on Overhead Lines or Underground Cables of some interest.

LANDSCAPE SCHEMES AND SCREENING

The DECC draft statement says:

> Landscape schemes comprising off-site tree and hedgerow planting are sometimes used for larger new overhead line projects to mitigate potential landscape and visual impacts, softening the effect of a new above ground line whilst providing some screening from important visual receptors. These can only be implemented with the agreement of the relevant landowner

4 http://www.entsoe.eu/fileadmin/user_upload/_library/publications/ce/otherreports/tdp09_report_ucte.pdf

The statement further says:

> Localised planting in the immediate vicinity of residential properties and principal viewpoints can also help to screen or soften the effect of the line, reducing the visual impact from a particular receptor.

The theory behind screening is that selective planting of trees or shrubs can take place to screen pylons. Given that trees of sufficient height would take a long time to grow (and the wires would need an area of clearance around them anyway), one alternative approach is to plant at sites at which the visual impact of overhead cables would be felt most i.e. plant at viewing points rather than around the line itself.

Three visual impact mitigation schemes are conditions on the approval of the Beauly-Denny line. These are in the Stirling area, at Glenside farm near Plean and at Auchilhanzie House near Crieff. Such schemes will need to be approved by Scottish Ministers in consultation with the local planning authority.

Scotland Before Pylons, a group campaigning against the Beauly-Denny line have told me that they[5]:

> can not imagine that any form of tree shielding could be effective for any pylon with a height approaching approaching 60 metres high– even the highest trees take time to reach that height and then have to be felled as part of the management of the habitat. Perhaps of greater importance the trees have to be at least the height of the pylon from the nearest point of the pylon. This would produce a corridor 125 metres wide which is wider than the 80 metres the applicants sought. I imagine that you are looking for examples of screening the pylons/conductors from view. Unless the pylons are placed in valleys, the tops of the pylons & conductors will be visible through most wooded areas, although routing the line through woods/forests may be able to screen the lower and thicker part of the pylon.

I hope this information is useful. Please contact me if you need anything further.

Yours sincerely

Graeme Cook
Principal Research Specialist
Planning, Rural, Environment, Transport Team

[5] Personal communication

Appendix 7 - Caroline Paterson Letter, 18th Feb 2010

Powbank House
Powis Loan
Stirling
FK9 5PS

February 18th 2010

RECEIVED
23 FEB 2010

Dear Nick Horler,

I hope you will take the time to read this letter.

I am writing to you to remind you of the very serious consequences of your actions in facilitating the Beauly to Denny 400kV power line, which scientific evidence shows will seriously threaten hundreds of lives. To make you fully aware of the consequences of your actions I attach our latest health briefing, which shows over 30 years of evidence pointing to the adverse health effects of power line EMFs.

As an ordinary member of the public I have tried over the last 6 years to engage with our democratic system in an attempt to have the health issue addressed, knowing that I represent the concerns of thousands. I have to concede failure, because the public's voice has not been heard. Serious questions need to be asked of our democracy when the voice of over 20,000 objectors is discounted in favour of just 45. I now understand why people feel disenfranchised. Certainly processes exist for the public to engage in (PE812 is the 2nd longest running public petition), even "stakeholder" groups (SAGE) and the like – but robust submissions to both these processes have received scant attention, and we have the distinct impression that the Beauly to Denny decision was made a long time ago in an autocratic fashion with industry at the helm. The Scottish people had higher expectations of its Government and democracy itself.

High-voltage overhead power lines are dangerous, which is why many countries bury them when they pass through populated areas. However, our deepest concern lies with the long term biological effects (cancers, neurological conditions etc) associated with long-term exposure to power line EMFs – which the public can do nothing to protect themselves from. The internationally acknowledged doubled risk of childhood leukaemia associated with power line EMFs was deemed to affect too small a number of children to warrant precautions. Yet behind every statistic is a fellow human being. Moreover, the evidence has now gone well beyond this condition – with the cumulative public health impact of brain cancers, leukaemias, Alzheimer's, miscarriage etc still not being addressed by those responsible for health within Scotland. You too have chosen to dismiss these evidence-based concerns, despite the UK's leading scientist in the EMF field, Prof Denis Henshaw urging the Scottish Parliament in 2005 to "*consider immediate strict precaution against the sighting of power lines near to houses or the converse*".

You could dismiss this letter lightly, but in so doing you would be dismissing the concerns of at least 20,000 people in Scotland. At least 10,000 people in Stirling alone have raised health concerns - a very high percentage of the local population. We know that over 10 EU member states now have meaningful precautions for power line EMFs, including Germany, Italy, the Netherlands, Denmark, Belgium and Sweden.

The UK signed up to the precautionary principle for areas of scientific uncertainty at the Rio and Maastrict treaties in 1992, yet has failed to follow it. Once proof is established the time for precaution has passed.

You personally had an opportunity to make a difference and in your public role I consider you had a moral duty to find a way. Most of you have failed to even acknowledge the health issue, and not one of you has championed it.

The health issue is not going to go away, and neither will the line. If constructed as approved it will stand as a reminder of a terrible mistake made by a few, in which you too were complicit. It will impact adversely on thousands of lives for generations to come. Yet things could have been different, and Scotland could have developed Renewables responsibly without scarring lives.

Compensating a handful of properties and requiring a few new hedges will do nothing to mitigate the serious health effects this new line will impose. Only undergrounding through populated areas will prevent this threat, and I appeal to you, even at this late stage, to adopt a precautionary approach and recommend undergrounding the Stirling section.

Yours sincerely

C Paterson

Caroline Paterson

Ccs Jim Mather, Lewis MacDonald, Dr Arthur Johnson, Shona Robison, Nicola Sturgeon, Alex Salmond, Nick Horler, Ian Marchant, Bruce Crawford, Keith Brown, Timothy Brian, Richard Dent, Ronald Jackson, Giles Scott.

SCOTLAND
before pylons

Update briefing on Powerline Electric and Magnetic fields (EMFs) and ill health

- Public health was not a routing consideration for Scottish & Southern Energy and Scottish Power in the Beauly to Denny 400kV proposal. The proposed High Voltage Overhead Transmission Line (HVOTL) passes close to many homes, schools, halls of residence, care homes etc bringing several thousand people within 600m of the proposed route and some considerably closer.

- This is a new line that will stand for generations – to deny a precautionary approach contravenes the Rio and Maastrict declarations (1992) and is foolhardy when the scientific evidence increasingly points to HVOTLs posing a serious health hazard.

- There is currently no meaningful protection for the public from HVOTLs within the UK, which subscribes to the International Commission on Non-ionizing Radiation Protection (ICNIRP) limit of 100 microtesla **(European Parliament Resolution 2/4/2009 called for this to be reviewed)**. Yet there is an internationally acknowledged doubled risk of childhood leukaemia at exposure levels above 0.4 microtesla (a factor of 250 below the ICNIRP guideline). The International Agency for Research on Cancer (IARC) classified ELF EMFs as possibly carcinogenic (2B) in 2001. Ironically far better protection is afforded to bird flight paths, nesting sites, SSSIs etc than to our own species.

Scottish Context

- The Scottish public is extremely concerned about the potential adverse health effects of living close to HVOTLs - 14,000 objections to the Beauly to Denny 400kV application specifically raised health concerns as a prime reason for rejecting the proposal. There have been debates, motions (S3M – 800), questions, a Cross-Party Group (2005 – 2007) and Petition PE812 (ongoing) in the Scottish Parliament.

- Petition PE 812 submitted in Dec 2004 with unprecedented cross-party support to the Public Petitions Committee. It is the second longest running petition and is regularly reviewed. The UK's leading scientist in the EMF field, Professor Denis Henshaw urged the Scottish Parliament in 2005 to "*consider immediate strict precaution against the sighting of power lines near to houses or the converse*". The Scottish Parliament has asked the Health Protection Agency (HPA) of the scientific basis for their advice and contact with countries which have precautions – but no response has been forthcoming.

- Although powerline EMFs have been under investigation for over a quarter of a century, many critical scientific developments have been made in the last five years.

- 2004: In response to numerous international studies, the World Health Organisation and the National Radiological Protection Board NRPB (now within the HPA) acknowledged the association between powerline EMFs and increased risk of childhood leukaemia. They called on government to consider the need for further precautionary measures. SAGE (The Stakeholders Advisory Group on Extremely Low Frequency EMFs) was established in collaboration with the National Grid & *Children With Leukaemia*.

- June 2005 The government funded Draper report was published (BMJ 330 (7503):1290). This massive study (investigating the records of 30,000 children with cancer), recorded a **doubled risk of childhood leukaemia** for those born within 100m of HVOTL. The risk diminished with distance from HVOTL, but there was still a **70% increased risk of childhood leukaemia within 200m**, with a statistically significant risk recorded up to 600m.

- April 2007 (SAGE) published its First Interim Assessment (www.rkpartnership.co.uk/sage/). As a SAGE stakeholder I observed that it was industry dominated (chief editor an employee of the National Grid), ill-informed and out-of-date (refusal to investigate the much reduced undergrounding costings using XLPE technology as a mitigating option). Extremely limited discussion of the California Health Department Services Report (2002) which examined associated adult conditions (various cancers, motor neurone disease and miscarriage) in addition to childhood leukaemia was allowed. These more commonplace conditions significantly alter any appraisal based on cost benefit analysis. However, the SAGE Report did acknowledge that "the best available option for obtaining significant exposure reduction" would be a building moratorium within 60m of HVOTL, but its actual recommendations for government were limited to providing public information and optimal phasing, which would not result in any significant exposure reduction. Several dissatisfied stakeholders have left the process.

- April 2007 The Royal Institution of Chartered Surveyors (RICS) called on government to legislate to restrict the building of new homes and schools next to existing power lines (George Wimpey Homes already respected a voluntary 200m moratorium).

- June 2007 Lowenthal study (Journal of Internal Medicine) reveals a five-fold increase in certain leukaemias and lymphomas for those who as young children (aged 0-5) lived within 300m of HVOTL.

- July 2007 Westminster Cross-Party Inquiry Report published (www.epolitix.com/forum/cpielfemf). This publication by a group of Westminster MPs calls on the government to adopt precautionary measures for HVOTLs. Its key recommendation is for "**a moratorium on the building of new HVOTL within 60m of existing homes and schools", with the further recommendation that "government consider the case for extending this distance to 200m for the highest voltage lines**" (such as the 400kV Beauly to Denny proposal). The Beauly to Denny proposals would not comply.

- August 2007 The BioInitiative Working Group launched its report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF) (www.bioinitiative.org). The Report investigates the long term biological effects of exposure to ELF EMFs – including a range of cancers, motor neurone disease etc. It dissents from existing ICNIRP and WHO guidelines, and recommends an interim planning limit of 0.1 microtesla for homes near new lines, which in practical terms would equate with a building moratorium of at least 200metres for HVOTLs.

- November 2007 Letter of advice from the HPA to the Minister. Our critique of the HPA advice focuses on the absence of references to any scientific studies published since 2004 – the epidemiological evidence is being denied, together with plausible biological mechanisms (melatonin theory) which would help to explain the evidence. **Once a mechanism is proven, the time for precaution has long since passed**. Early warning signs for ELF EMFs were present decades ago, NOW is the last chance for precautions with regard to Beauly to Denny, which will set a precedent for other new HVOTLs.

- Alzheimer's linked to HVOTLs in two new studies (Garcia et al 2008; Huss et al 2008), with the latter massive study (entire Swiss population over the age of 30) showing a clear and quantifiable association - living within 50m of a HVOTL for 15 years or more shows a doubled risk of the disease. Furthermore, melatonin is lacking in Alzheimer's sufferers, adding further weight to the melatonin theory (Henshaw & Reiter 2005) as a plausible mechanism.

- 2008 Yang et al study identifies a clear mechanistic connection between powerline EMFs and childhood cancers for genetically susceptible children, who are 4.3 times more likely to develop leukaemia if living within 100m of a powerline.

- Sept 2009: publication by De-Kun Li in *Reproductive Toxicology Journal* on "Exposure to magnetic fields and the risk of poor sperm quality" showed a clear adverse effect occurring at exposure levels above just 0.16 microtesla.

- 16th Oct 2009: The Scottish Government responded to the SAGE Report of April 2007 http://www.dh.gov.uk/en/Publichealth/Healthprotection/DH_4089500. This response reflects the failure of the HPA to address the last five years of scientific evidence in this field. The joint governmental response has been condemned by various bodies, including charity co-funders of SAGE, *Children With Leukaemia*. SAGE is likely to now disband. This failure to address the scientific evidence and refusal to adopt meaningful precautions is at odds not only with the European Resolution (April 2009), but also with the 10 EU member states which have already adopted meaningful precautions.

- 14th Nov 2009: A study by the Japanese National Research Institute for Child Health and Development in the Journal of Epidemiology found an association between power line magnetic fields above 0.4 microtesla and an increased risk of brain tumour, equating to an eleven-fold increased risk for children. The scientific evidence continues to flow in the same direction at increasingly alarming rates…….

European Context

- Positive response to the Bio-Initiative Report. Jacqui McGlade, Executive Director of the European Environment Agency described it as *"a compilation of individual contributions from different EMF experts, each of whom summarises the relevant and largely peer reviewed science in their on areas of expertise. It is not a review of the overall evidence on EMF but a collection of separate contributions from experts who feel that aspects of the relevant science are not receiving the attention that they merit"*. In Scotland we had to fight a media campaign, helped by a local MSP to just have the report admitted as evidence for the Beauly to Denny Public Inquiry (initially refused).

- 10th Feb 2009: The European Commission's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) published an updated opinion on EMFs, which confirmed its 2007 opinion that ELF EMFs might contribute to childhood leukaemia, and called for further investigation of the two new epidemiological studies linked to Alzheimer's disease.

- 17th March 2009: Danish government to pay compensation to night-shift workers after IARC acknowledges increased cancer rates resulting from the suppression of melatonin production. The suppression of melatonin production is also induced by magnetic fields, and is a plausible biological mechanism for the range of serious illnesses associated with powerline EMFs. The WHO and HPA continue to deny the existence of such peer reviewed studies.

- 2nd April 2009: The European Parliament adopted a resolution (559 in favour, 22 against) calling for stricter regulation and protection of residents from the potential risks posed by EMFs, including a review of the scientific basis and adequacy of the EMF limits as laid down in the 1999 ICNIRP (International Commission on Non-Ionizing Radiation Protection) guidelines, to which the UK currently subscribes

http://www.next-up.org/parlement_europeen.php#1. Ten EU member states have already adopted serious precautions, including Germany, the Netherlands, Denmark, Sweden and Italy.

- 7th May 2009: German EnLAG (Energieleitungsausbaugesetz) legislation was adopted by a majority in the German Parliament (http://www.iwr.de/news.php?id=14215). This is an attempt to speed up the expansion of the German grid to accommodate new Renewable Energy projects. It recognises the adverse health effects of powerline EMFs and requires that undergrounding be considered where 380kV powerlines are proposed within 200m of individual homes, or 400m of communities. There will be four underground cable pilot projects for high-voltage cables in Lower Saxony and Thuringen, where up to 250km (half) is expected to be undergrounded.

President Barack Obama: *"Science is about ensuring that facts and evidence are never twisted or obscured by politics or ideology. It's about listening to what our scientists have to say, even when it's inconvenient – especially when it's inconvenient"*. Mr Obama has already set up an independent panel to investigate electro-magnetic radiation. He is aware of the emerging science and lack of public confidence in health review bodies.

February 2010
Caroline Paterson (carvik.pater@virgin.net)
SAGE stakeholder (2006-), Scottish Parliament Petitioner (PE812)

Appendix 8 – Peter Pearson Letter, 20th February 2010

Stirling Before Pylons

RECEIVED
24 FEB 2010

Parkhead
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FK9 4LS

Phone: 01786 833399

e-mail: peter@baker-pearson.net

20th February 2010

Dear Ms Barber,

Scottish Power : Beauly Denny Powerline

I am writing to you following a discussion with Councillor Graham Houston, the SNP Leader of Stirling Council, in relation to the recent approval of the above powerline by the Scottish Government. He explained your role was as an Independent Director with responsibility for Corporate Social Responsibility at Iberdola.

As you will no doubt be aware this proposal has been hugely controversial with 20,000 objections from the public. The Ministers approval on the 6th January requires Visual Mitigation Plans for the route from Cocksburn Wood in the Ochils to Dunipace near Plean, covering the vast majority of the Scottish Power route. These have to be prepared by the applicants, in consultation with the Local Authority and presented to the Minister for approval. He has not ruled out undergrounding. We understand that no discussions have yet taken place between the Government, Scottish Power and the Council.

In the Stirling area the view of Stirling Council, Scottish Natural Heritage (SNH) and ourselves has been that there is not a suitable overhead route through the Stirling area. This is because the area is the most constrained part of the whole Beauly Denny line and therefore undergrounding is the only acceptable solution. This is principally because of the landscape (Ochils Area of Great Landscape Value), historical heritage (impacts on the Wallace Monument, Stirling Castle and the Sherrifmuir battlesite) and the potential health impacts on local communities.

Last month the Council's Executive met to reconsider their position and there was all party support for undergrounding the route through Stirling. It is anticipated that this will be confirmed by Full Council when they meet next month following a public consultation exercise. This is also the position held by both local MSPs, who are also Ministers, and the local List SNP, Labour and Conservative MSPs as well as Scottish MEPs. In addition, approximately 10,000 postcards were submitted from the local public to this effect last year.

Scottish Power have yet to make a statement about undergrounding, but their partners, SSE, have been clear that they will not consider it. This is extremely unfortunate as undergrouding would overcome all the potential problems associated with the proposals.

A major concern of the developers is that it would delay the project. As it will take a further 4 years to construct the overhead line, this is not a real constraint. Particularly as the Stirling section would largely follow a pipeline corridor, which already contains gas and oil pipelines. This corridor is in the approved Structure Plan and it would clearly therefore obtain approval. The other concern is cost, but recent examples elsewhere in Europe indicate a factor of 4/5 times for undergrounding using the current XLPE technology, rather than up to 20 times using the outdated oil cooled technology. These additional costs would be shared by all electricity consumers and not fall to Scottish Power.

We believe that the combined negative impacts on Stirling would be the greatest along the whole line, and that if Scottish Power build the overhead proposal their reputation will suffer greatly in the future. Significant questions will be asked about the visual impacts on tourist destinations like the Wallace Monument and Stirling Castle. There will also be financial claims on the basis that the precautionary principle has not been followed in relation to the health risks. The local List MSP, Dr Richard Simpson, Labours Health Spokesman, who introduced the passive smoking legislation, sees much common ground with the health risks associated with 400kV powerlines.

If the proposal were being planned almost anywhere else in western Europe then undergrounding would be being proposed in such a 'sensitive' area. Since the end of the Beauly Denny Public Inquiry, this has been the solution or is planned in Spain, France, Germany, Holland, Denmark, Austria and England for the Olympics. It seems strange that Scottish Power should not wish to be following these examples of current best practice following its tie up with Iberdola.

It is also unfortunate that Scottish Power have been almost invisible since the proposal was originally raised six years ago. They have let SSE take the lead on all public matters and at the Public Inquiry. Scottish Power have only arranged one public meeting that we are aware of during this period in Plean. Unfortunately, at that meeting they refused a request by the Presiding Officer of the Scottish Parliament, George Reid MSP, to even notify affected local people about their application.

In the announcement of his decision to the Scottish Parliament, the Minister made much of a 'new era' of public consultation by the two power companies. We would welcome that and a thorough review of the potential for undergrounding in Stirling. We believe this would not only, be in the wider interests of the area, but also the interests and the reputation of Scottish Power and Iberdola. Currently, the applicants would appear to have lost the media battle, with The Scotsman, the Herald, and the Guardian all running editorials, as well as feature stories, backing the logic of our case.

In fact we see undergrounding as a win/win situation, Scottish Power developing new expertise and being at the forefront of energy transmission in the UK and communities securing the least intrusive solution

I attach our last Information Sheet prepared before the decision was made as background information for you. We would very much like to meet with you and further explain, what is a complicated matter, as we believe there are important issues here for both parties

Yours Sincerely

Peter Pearson

Peter Pearson : Secretary

STIRLING BEFORE PYLONS

- opposing the Beauly to Denny power line in the Stirling area

FINAL BRIEFING : November 2009

WHAT WOULD HAPPEN IF THE APPLICANTS GET THEIR WAY?

- In relation to the entire 220km of proposed route, the largest range and highest concentration of impacts would occur in the Stirling area, which also has a much larger number of local residents affected.
- The line would run close to hundreds of houses, through designated landscapes, close to nationally-treasured heritage sites, right beside graveyards, etc.
- The Stirling area would have *more* giant pylons than there are existing pylons, not fewer, with an increase from 74 to 78.
- The pylons would be nearly twice the height, and about 7 times the volume, of existing ones.
- The new line would be even more conspicuous due to double stringing with much heavier wires, and a requirement to clear-fell woodland to leave an 80m clear swathe along the line.
- Heavy construction traffic requires an 8-kilometre access track to be made across Sheriffmuir – required for the 4-year construction phase.

HOW HAVE STATUTORY BODIES RESPONDED?

- **Scottish Natural Heritage** (SNH) objected to the proposals in just 2 areas – the Ochils and the Cairngorms – on grounds of visual impact.
- They propose the line should be put underground instead. In the Stirling area, they rejected the route proposed for the overhead line as unsuitable for undergrounding, and instead identified and proposed a potential route to the west of Stirling, utilising the pipeline corridor identified in the Structure Plan and already in use for gas and oil pipelines.
- SNH's proposed route was accepted as feasible – and slightly improved – by the applicants' expert witnesses (power industry consultants) at the public inquiry.
- **Stirling Council** objected to the proposals, with unanimous, all-party agreement; this has been endorsed by the current SNP-led administration.
- Stirling Council endorsed SNH's proposals for undergrounding, at the public inquiry.

THE STIRLING BEFORE PYLONS / FRIENDS OF THE OCHILS POSITION

- All the many grounds for objection were set out clearly from day 1, and repeated many times, but have been systematically ignored or discounted by the applicants.

Heritage

- The **National Wallace Monument** (110,000 paying visitors annually climb to the top) would be significantly affected:
  - views from the top, towards the Ochils, would have around 10 new giant pylons prominently in view, marching up the Ochils scarp through a wide gash in the woodland, and visible as a "stack" going off across Sheriffmuir.
  - views of the Monument, from the A91 and the A907, would be framed by giant pylons and thick wires.
- Magnificent views from **Stirling Castle** (Scotland's second most frequently visited tourist attraction) towards the Ochils and the National Wallace Monument would have the giant pylons highly visible as a backdrop to the Wallace Monument and an intrusion into the views generally.

History

- The line would go through the heart of, and right across, the site of the **Battle of Sheriffmuir (1715).**
- This is a visitor attraction for thousands every year, with hundreds coming together, from across Scotland, to commemorate the anniversary of the battle.
- The battle site is due to become Listed in 2011, when Historic Scotland publishes its first formal list of battlefields to be protected.
- The site is of particular importance to Clan McRae, who lost most of their menfolk from the Kintail area at the battle.

Landscape

- The line crosses 8 kilometres of the **Ochil Hills Area of Great Landscape Value** – the only designated area it crosses (though it also goes through the Cairngorms National Park).
- It would be particularly visually intrusive where it comes down the **Ochils scarp.** This area is described by SNH as
  - "forming a stunning backdrop to the contrasting farmed, settled floodplains of the Devon and Forth rivers....",
  - "one of the most visually sensitive areas in Scotland" and
  - "a landscape experience which is unique in Scotland".
- Its visibility would be particularly emphasised here by the clear felling of an 80-metre swathe of trees through the wood that clothes the scarp.

- **Sheriffmuir** – including Dumyat and the Cocksburn Reservoir - is by far the most heavily-visited and heavily-used part of the Ochil Hills.

Recreation & leisure

- The Sheriffmuir area is used by walkers, cyclists, horse riders, runners, fishermen, picnickers, photographers, birdwatchers, as well as by hundreds of thousands just driving across to enjoy the views.
- The line would go right through the area from which 40,000 per year people set off to climb **Dumyat**. They come from far and wide: 60% live outwith the Stirling area, 18% from outwith Scotland.
- At least a further 10,000 visits (largely from the local area) are made annually to **Cocksburn Reservoir** – their views would be greatly impacted by the giant pylons – which would be much closer to the reservoir than the existing pylons.
- Construction works will render these areas virtually unusable for up to 4 years.
- The whole **AGLV** area will be greatly enhanced if the line is put underground, and the existing power line is dismantled.

Logie Kirk

- The line would go right next to the **cemetery** at Logie, as well as close to the very popular kirk. Evidence from the applicants' expert witness at the public inquiry confirmed that, during damp and wet weather, **noise from the line** (buzzing and spitting) would be clearly and intrusively audible to mourners at funerals.
- The line would also create substantial visual intrusion into the lovely setting of the church.

Community regeneration and social inclusion

- Community regeneration and social inclusion in the Stirling eastern villages Cowie, Fallin and Plean, is "in the balance". These areas suffer from persistent low incomes, poor health, low educational attainment, high crime rate, and an unsatisfactory environment. The line would go very close to them.
- Residents have already suffered the health consequences of living close to the Norboard factory, which in the past was guilty of noxious emissions, and they are very concerned at the potential health consequences of the new power line.
- The new line would also deter potential incomers to the area, who might otherwise help to change the social mix and bring greater prosperity to the area.

Health

- Evidence on the impacts of high-voltage power lines has been building consistently over 30 years. Research in this area continues to attract substantial funding.

- It must be assumed that extra-high voltage lines may have considerably worse impacts than the lines which have been included in most of the research.
- Clear links have been established between childhood leukaemia and living close to high-voltage power lines. New research is showing many other associations, of which a significant increase in Alzheimer's disease is perhaps the most worrying.
- As the power line, once built, would be expected to be in use for 50-60 years, the precautionary principle should apply when considering how close it is allowed to come to houses.
- Stirling has some 600 households too close to the proposed line – by far the largest number for any section of the route.

IMPACTS ON TOURISM AND THE ECONOMY

- Impacts on **tourism** numbers are likely to be significant, given all the above. James Fraser, recently Area Director for Visit Scotland for Argyll, Stirling and Forth Valley, using evidence from the applicants' Environmental Statement, gave evidence to the public inquiry that first year losses to the Stirling area would be £25 million – £38 million, and **£66 million – £117 million over a 5-10 year period**.
- Nick Hanley, Professor of Environmental Economics at the University of Stirling, and an adviser to DEFRA, gave evidence to the public inquiry that the costs of the **environmental (landscape) damage** to the people of Stirling would be valued as at least £6.5 million per year, or **£325 million over the 50-year** life of the pylons.
- The economic costs estimated by these distinguished witnesses would be **easily sufficient to justify putting the line underground** through the whole Stirling area.

UNDERGROUNDING – THE SOLUTION

- Undergrounding is the solution proposed by SNH, and supported by Stirling Council.
- Its feasibility was confirmed by the applicants' expert witnesses at the public inquiry. They accepted that the line would need to go to the west of Stirling, through the much deeper alluvial soils there, and avoiding the near-impossible challenges posed by the very steep scarp slope of the Ochils.
- SNH propose that the line should come above ground for its last 4 kilometres before Braco sub-station; this would take it through an almost unpopulated and little-visited rural area.
- Stirling Before Pylons and the Friends of the Ochils believe that undergrounding is needed throughout the whole Stirling area – to avoid further extended wrangles over possible overhead stretches – but accept that having the most northerly 4km overhead would be likely to generate little controversy.
- The applicants have consistently and repeatedly quoted greatly exaggerated costs for undergrounding. They base their costs on the old, oil-filled cable technology. Their

experts acknowledged at the public inquiry that this is now obsolete, and that XLPE (cross-linked polyethylene) technology would in fact be used.

- Experience of using XLPE in Europe and North America suggests that its costs are typically around 2 – 5 times those of overhead lines.
- There are increasingly numerous European precedents for using XLPE undergrounding in sensitive areas – areas of high landscape value and/or close to settlements or individual houses, especially where the impacts of using overhead lines have held up decisions about new power lines for many years.
- Some £450 million is being spent putting an extra-high-voltage power line underground through the site of the London Olympics.
- The additional costs of using underground cables through the whole Stirling area would be readily justified by the economic costs of the overhead line, as estimated by James Fraser and Prof Nick Hanley in evidence to the public inquiry.
- Significant additional benefits will be gained by the dismantling of the existing power line, particularly where it goes through the AGLV, and close to houses.
- The costs of undergrounding are in fact easily affordable. They would be shared by all electricity consumers across Great Britain over a 20 year period, adding around £1 per annum to household bills.
- An earlier public inquiry in North Yorkshire set the precedents for the criteria to be used in reaching a decision to put power lines underground. The criteria are easily met, and well exceeded, in the Sheriffmuir – Logie – Wallace Monument area alone. Our briefing "Undergrounding – the North Yorkshire benchmark" gives more details.

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FOR MORE INFORMATION, PLEASE SEE THE FOLLOWING:

Stirling Before Pylons and Friends of the Ochils gave extensive **evidence to the public inquiry in 2007**. All the precognitions can be located at http://www.beaulydenny.co.uk/DocumentLibrary/LocalSessions/Stirling/FullPrecognitions/ObjectionGroups.aspx

1. Context and process	Dr Nicki Baker
2. Stirling's landscape and geomorphology	Prof Mike Thomas
3. Ochil Hills - Landscape, amenity, recreation etc	Dr Nicki Baker
4. Landscape and visual impact assessment	Geoff Sinclair
5. Willingness to Pay to avoid non-market impacts	Prof Nick Hanley
6. Stirling's artistic and literary landscape	Dr Elspeth King
7. The Battlefield of Sheriffmuir	Virginia Wills
8. A historic landscape at the heart of the nation	Dr Fiona Watson
9. Historic buildings	Peter Pearson
10. Tourism and economic impact	James Fraser & John Logan
11. The Eastern Villages: regeneration & social inclusion	Peter Pearson
12. The village of Fallin	Archie Bone
13. The village of Plean	Tommy Brookes
14. Local health concerns (1)	Ian Paterson
15. Local health concerns (2)	Caroline Paterson
16. An MSP's perspective	Dr Richard Simpson
17. Approach to route selection in the Stirling area	Peter Pearson
18. Undergrounding	Simon Allen
19. Hydrology (private water supplies)	Dr Nicki Baker
20. Planning policy & related material considerations	Ian Kelly

Further evidence for the Stirling area, to be found at http://www.beaulydenny.co.uk/DocumentLibrary/LocalSessions/Stirling/FullPrecognitions/IndividualObjectors.aspx, included the following -

Community participation, national implications and public health	Keith Brown MSP
Logie Kirk	Rev Stuart Fulton
(Untitled - Kinbuck)	Clare Clark

On the **Stirling Before Pylons** website, at http://www.stirlingbeforepylons.org/meetings.php, the following **briefings** can be found:

Briefing 1 – The proposals for the power line in the Stirling area
Briefing 2 – Health impacts of the proposed power line
Briefing 3 - The implications for the Ochil Hills
Briefing 4 - Programming and planning issues
Briefing 5 – History and Tourism
Briefing 8 – Homes and the proposed power line
Briefing 9 - Undergrounding
Briefing 10 – Key undergrounding questions

The following further briefings are attached:

Undergrounding in Europe (March 2009)
Undergrounding – the North Yorkshire precedent

Appendix 9 - SPT Photographs of UGC Route from Logie Villa to Glenside


Fig. 3 looking south from A91
towards Powis Mains

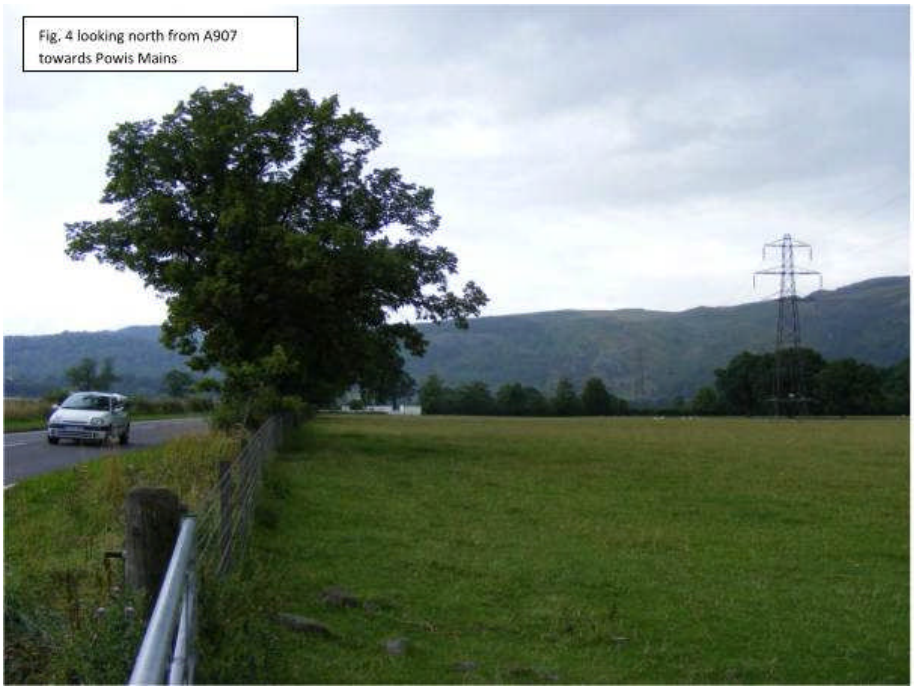
Fig. 4 looking north from A907
towards Powis Mains

Fig. 5 looking south from crossing off A907

Fig. 6 looking east at railway track crossing near Manorneuk

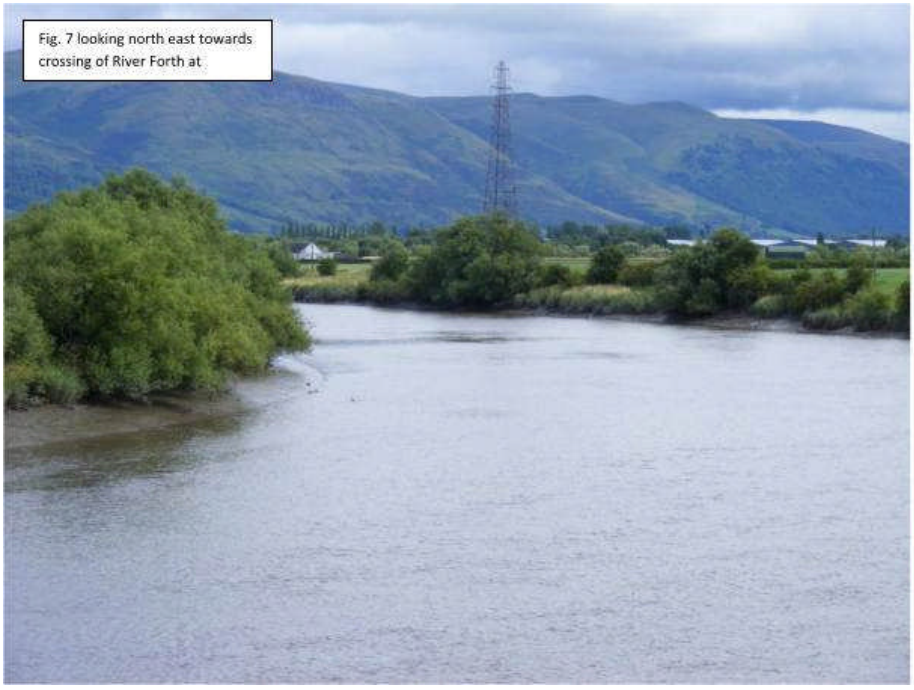
Fig. 7 looking north east towards
crossing of River Forth at


Fig.8 looking north towards
Bolfornought River Forth


Fig. 9 looking south east
towards River Forth crossing

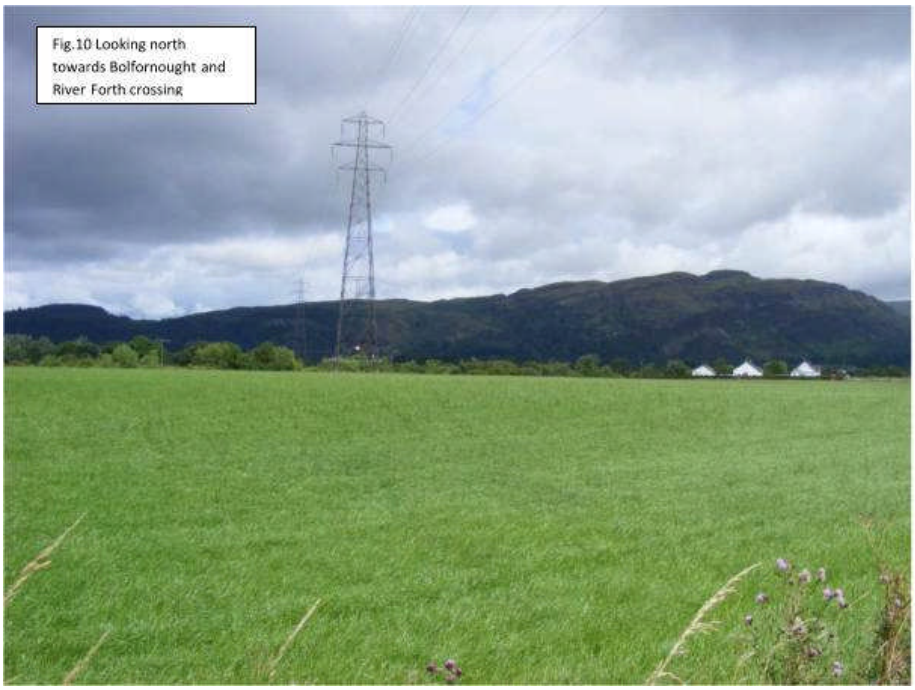
Fig.10 Looking north
towards Bolfornought and
River Forth crossing

Fig. 11 Access track to Bolfornought

Fig. 12 looking east to Bolfornought

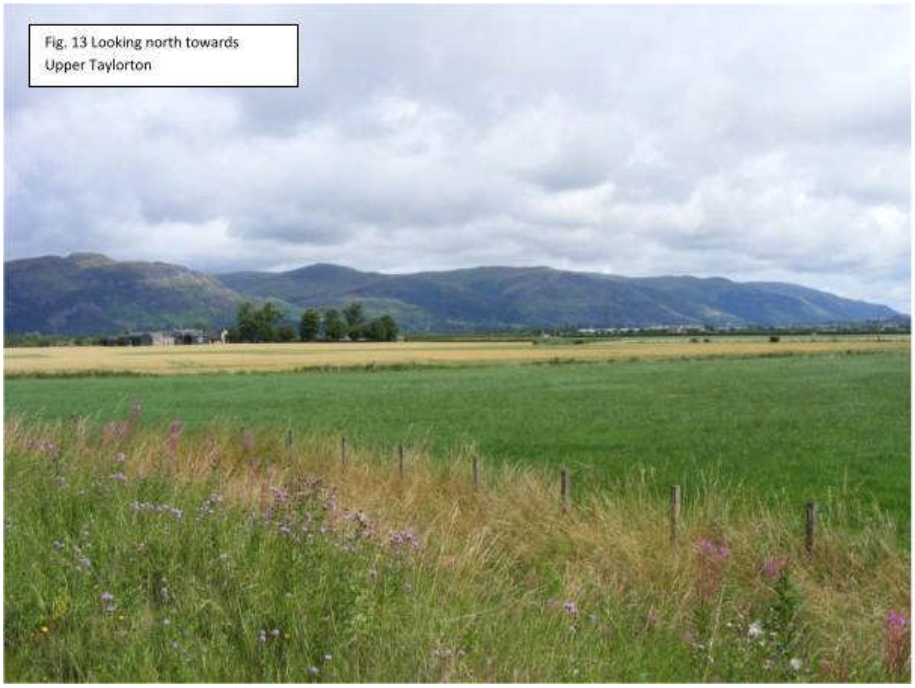

Fig. 13 Looking north towards Upper Taylorton

Fig. 14 looking east at route between Upper Taylorton and SteuartHall Farm


Fig. 15 looking northwest
towards SteuartHall farm

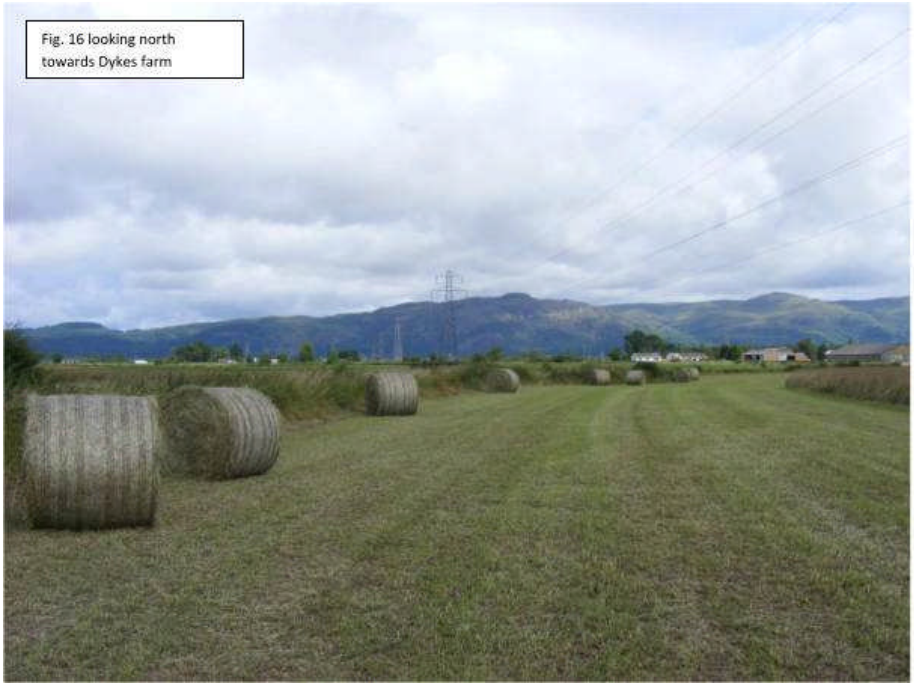
Fig. 16 looking north
towards Dykes farm

Fig. 17 looking east at route between Dykes Farm and Hartsmailing

Fig. 18 looking east towards Lower Greenyards

Fig. 19 looking east at Lower Greenyards Farm

Fig. 18 looking east towards Lower Greenyards

Fig. 19 looking east at Lower Greenyards Farm

Fig. 20 looking south at Lower Greenyards Farm towards railway

Fig. 21 looking north at Easter Greenyards

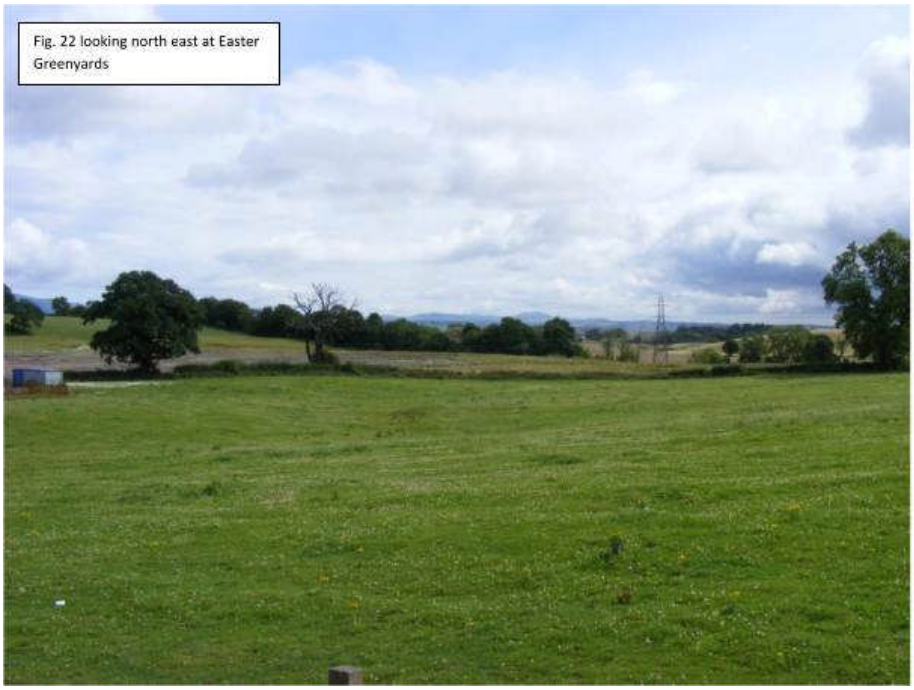

Fig. 22 looking north east at Easter Greenyards

Fig. 23 Looking north from Sauchenford Holdings

Fig.24 looking south towards Sauchenford Holdings

Fig. 25 looking north towards Gartwhinnie

Fig. 26 looking south from road at Greenhill towards corner of road to Woodcockfauld (Alternative route)

Fig. 27 looking south from road at Greenhill towards corner on road to Woodcockfauld (Alternative route)

Fig. 28 Looking south west towards Denny north from crossroads at Muirmailing (Alternative route)

Fig. 29 crossroads at Muirmailing

Fig. 30 looking south west from crossroads towards Denny N

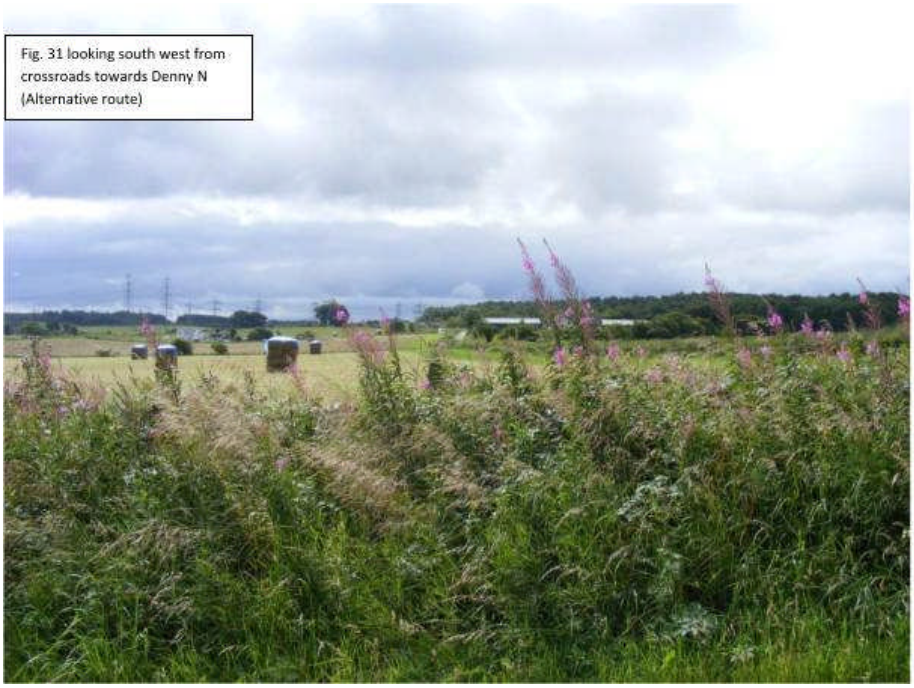

Fig. 31 looking south west from crossroads towards Denny N (Alternative route)

Fig. 32 looking south east from crossroads towards


Fig. 33 looking south east towards
Gartengaber and Glenside

Appendix 10 - APL 5/16

Appendix 11 – APL/STG-41