Campaign to Protect Rural England

Campaign for National Parks
Keeping beautiful places safe

NAAONB
The National Association for AONBs
Cymdeithas Genedlaethol AoHNE

AN INDEPENDENT EVALUATION REPORT OF THE COSTS FOR UNDERGROUND HIGH VOLTAGE CABLES IN GREAT BRITAIN

A submission by the Campaign to Protect Rural England (CPRE), the Campaign for National Parks (CNP) and the National Association for AONBs (NAAONB) in response to the call for evidence

December 2010

Executive summary

Our evidence for this study largely takes the form of a literature review of recent studies that we consider to be authoritative sources on the subject. Based on the findings of these studies, we are concerned that the costs of underground high voltage cables may have been significantly overestimated, and conversely that of overhead lines underestimated, in industry calculations to date. We also believe that insufficient attention has been given to the amenity benefits of undergrounding, some of which have economic values. In our view the terms of reference of this study are too narrow, meaning that a further study is needed of these issues.

Accordingly, we would ask the IET and KEMA to recommend, in the final study, that:

- There is a wide range of international experience in delivering UGC in an economically feasible manner, and National Grid's policy position statement on UGC should be updated to reflect this.
- National Grid should publish a scheme, as part of its Business Plan and made clearly accessible from its website, covering expected new development over a 10 year period, and listing locations where it expects that UGC will and will not be justified. Criteria set out in the final NPS should inform this scheme.
- The final report should draw a clear distinction between the economic feasibility of undergrounding the highest voltage (275 and 400 kV) lines operated by National Grid and the lower (132 kV and below) lines operated by the regional distribution network operators.
- Any additional expense in investment in UGC can be justified with reference to either the Holford Rules or Green Belt policy, or the requirements of offshore renewable generation.
- Further research to be carried out on the amenity benefits of undergrounding, to address the gaps in the costs focus of the IET/KEMA study terms of reference.

Introduction and context

1. The Campaign to Protect Rural England (CPRE), Campaign for National Parks (CNP) and the National Association for AONBs (NAAONB) welcome the opportunity to submit evidence to this study organised by the Institution of Engineering and Technology (IET) and KEMA Ltd. We have been closely involved in current debates over the future development of the electricity network. This is because we are concerned about the visual impact that extra high voltage (above 132 kV) overhead lines have on our countryside, in particular nationally designated areas of landscape (we include Green Belts in this definition) and smaller areas of high amenity value such as conservation areas.

2. We are represented on both the Price Control Review Forum and the environmental issues working group convened by Ofgem to prepare for the next Transmission Price Control Review (TPCR) period. We have regular meetings with National Grid's Land and Development Team and are participating in its emerging 2011 Business Plan process. We also issued a full response to the suite of draft National Policy Statements on energy issued by the

Department for Energy and Climate Change (DECC) for consultation in November 2009 and will issue a further response to the second round of consultation, taking place at the time of this submission. We were also closely involved in discussions regarding the routing of transmission lines created under the most recent major development of the network, during the 1950s and 1960s.

3. We believe this study is a necessary contribution to the debate on the planning of the electricity network. In light of our concerns our clearly stated preference is that overhead lines should avoid these areas as much as possible. The industry has recognised this through maintaining the commitment to the Holford Rules, introduced by the former CEGB. To date the Holford Rules appear to have worked well, with the caveat that they do not cover Green Belt land as we think they should. To illustrate, National Parks and Areas of Outstanding Natural Beauty (AONBs) cover 25% of England's land area, but only 14% of all overhead electricity lines of both the National Grid transmission and regional distribution networks are found within these areas.

4. The urgency of the issue is due to the major planned expansion of the network, on a scale not seen since the 1950s and 60s. At the same time public concern has grown about the adverse impacts of overhead lines, with growing calls for undergrounding in preference to overhead lines where new lines are proposed. We believe that underground cabling (UGC) is the most effective method of mitigating the visual impact of an electricity line, but in our view avoidance of any visual harm, through not developing any new transmission lines and removing those already there, is preferable to mitigation with regard to landscapes of high amenity value. The same reasoning informs the principles underpinning the application of both Strategic Environmental Assessment and Environmental Impact Assessment.

Responses to the consultation questions

5. Our responses to the specific questions posed in the call for evidence follows below.

A recurring issue for the IPC is the relative cost and technical feasibility of underground cables as compared with overhead lines. We would value your factual contributions to the analysis and we would appreciate your time to answer the following questions:

1. Are you able to provide factual/evidenced information with respect to cost information for high voltage transmission options (on a per km base)?

6. National Grid claims that the cost of undergrounding transmission lines is between ten and twenty times greater than an overhead line, and has also stated that underground cables cost £20 million a mile (£12 million per kilometre). The former claim was also restated by DECC in the first draft of National Policy Statement EN-5 on electricity transmission; notably however, it has been removed from the current consultation draft. Transmission operators in both Denmark and Germany[1] are involved in schemes to build new underground lines at the same high voltage, and their experience has shown that not only can the investment cost ratio be significantly less (around 2-5 to 1 rather than 10-20) but also that some of this outlay can be recouped through underground cables being more reliable. Two recent publicly available reports include evidence on these issues: (i) the Ecofys report for the Irish government and (ii) a technical report by Energinet.dk.

Study for the Irish Government by Ecofys Germany, May 2008[2]

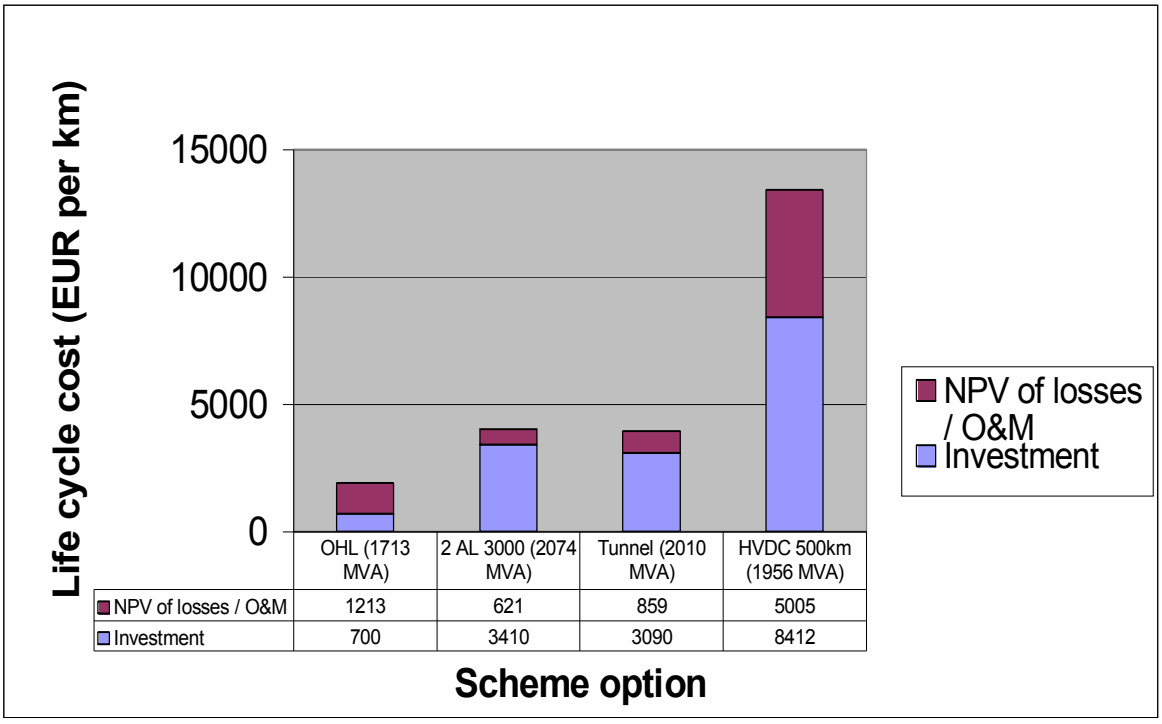
[1] A non-technical summary of the debate on the issue in Germany is at www.tube.de/cipp/md_wiretube/custom/pub/content,lang,2/oid,7766/ticket,g_u_e_s_t/~/Transmission_system_expansion_in_Germany_Underground_cable_or_overhead_lines.html .

[2] Golder Associates / Ecofys, Study On The Comparative Merits Of Overhead Electricity Transmission Lines Versus Underground Cables, Study for the Irish Government, May 2008.

7. This report compared investment and lifecycle costs for six transmission line options at similar voltages (between 300 – 400 kV) and rated capacities (between 1713 and 2074 MVA). The findings for four of these options are illustrated in Table 1. They show ratios of investment cost for UGC compared to overhead lines of between 4.5 and 7 to 1, a marked contrast to the ratios of between 10 and 20 to 1 posited by National Grid and the first draft of EN-5. The analysis of lifecycle costs in this study also makes significant points with regard to the greater reliability of UGC compared to overhead lines (further comments on both lifecycle costs and capacity ratings are contained in the response to Question 3 below).

8. IET and KEMA may wish to compare the costs given in the Ecofys report with those given in a more recent report[3] by Scottish Power Transmission Ltd (SPTL) in relation to the Beauly-Denny transmission project (the project is discussed further below). The SPTL report includes a range of costings used to justify the company's refusal to underground the new line in the Stirling area. Unit costs of, respectively, £826 per km for overhead lines, and £12,332 per km for UGC are provided. Both appear to be at significant variance with the lifecycle costs given in the Ecofys study, with both the cost of overhead lines being significantly lower (£826 per km compared to €1913, or £1,607 at current exchange rates[4]) and underground cables significantly higher (£12,332 per km compared to €3949, or £3,317 at current exchange rates) in the SPTL study compared to the Ecofys study figures for a tunnel shown at Table 1. It does not appear sufficient to explain this discrepancy purely in terms of fluctuating prices of inputs such as labour and raw materials. We urge IET and KEMA to probe the reasons for this.

Table 1: Illustrative comparison of annualised costs of all options for 50km distance (taken from Ecofys 2008, p.183)



	OHL (1713 MVA)	2 AL 3000 (2074 MVA)	Tunnel (2010 MVA)	HVDC 500km (1956 MVA)
NPV of losses / O&M	1213	621	859	5005
Investment	700	3410	3090	8412

[3] SPTL, Beauly-Denny Overhead Transmission Line Project: Stirling Visual Impact Mitigation Scheme Consultation Report, September 2010.

[4] As at 1 December the exchange rate was €0.83 to £1 (www.x-rates.com)

(ii) Energinet.dk technical report on the future expansion and undergrounding of Denmark's electricity transmission grid, April 2008[5]

9. Denmark is a useful international comparator of extra high voltage electricity network development to the UK in a number of respects. In Denmark, minimising environmental impact is recognised as a high level objective of the transmission network, alongside other operational issues such as robustness, maintaining security of supply and ensuring well-functioning competition in the power market. Significantly, Denmark is also planning a major expansion of offshore wind energy development to meet its target of at least 30% of energy demand to be met from renewable sources. In April 2008, Energinet.dk, the country's equivalent of National Grid, issued a technical study on expansion of the national transmission network, with prominent consideration given to increasing the use of underground cables. Energinet.dk firstly considered the overall costs of undergrounding the current network (Table 2).

Table 2: costs associated with undergrounding electricity lines in Denmark[6]

Voltage level	Total no. of km	Km of cable	Km of overhead line	Costs of burying remaining overhead lines (DKK bn)
6-20kV	61566	53428	8138	3
30-60kV	8465	2760	5705	8
132 / 150 kV	4062	611	3451	11.5
220-400kV	1478	164	1314	37

10. Based on figures in Table 2 it costs approximately 28 million Danish Kroner (£3.5 million at 2009 exchange rates[7]) to underground 1km of 400kV line. This is a comparable figure to the €3.09 million per km for a 50km tunnel given in the Ecofys study when one factors in the margin for error arising from exchange rate and price fluctuations over time and other factors.

11. On this basis it can be assumed that the costs of undergrounding lower voltage power lines are also comparable. Undergrounding 132kV lines, at DKK3.3m per km (£412,000), costs less than an eighth, or 12.5%, of undergrounding a 400kV line. The Danish study also states that undergrounding of 132kV lines can be done without any significant technological problems.

[5] Elinfrastrukturudvalget (Denmark), Technical report on the future expansion and undergrounding of the electricity transmission grid – Summary, April 2008.
[6] Taken from p.4 of Elinfrastrukturudvalget (Denmark), Technical report on the future expansion and undergrounding of the electricity transmission grid – Summary, April 2008, downloaded from www.energinet.dk/NR/rdonlyres/CC966C3A-FE78-41D8-9DC7-6B455210B502/0/TechnicalReportSummary.pdf on 19 February 2009.
[7] According to www.x-rates.com, the exchange rate between the pound and the Danish kroner was £1 to DKK8.2763, or DKK1 to £0.120827 (data correct as at 18 March 2009

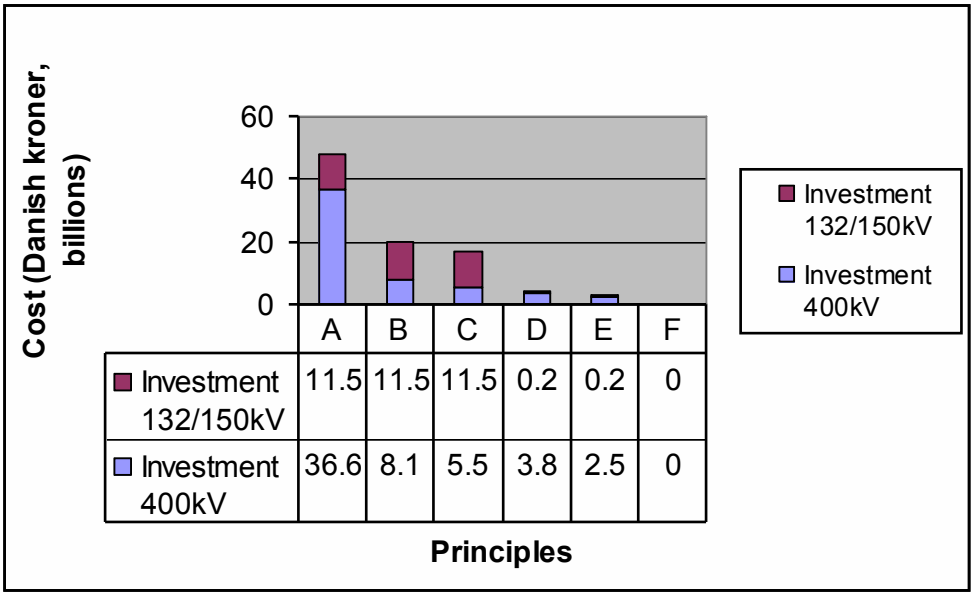
12. The report goes on to set out six 'principles' or scenarios for future network development:

A: Complete undergrounding
B: New power lines in underground cables
C: New power lines in underground cables and new towers in an existing line route
D: New overhead lines in areas where overhead lines have already been constructed
E: New overhead lines
F: No grid expansion

13. The report includes cost analyses of adopting different options (summarised in Table 3 below). Those involving major undergrounding of extra high voltage lines are significantly more expensive than those involving new overhead lines. Nonetheless, Denmark is setting a clear policy direction of travel towards reducing the impact of the existing transmission network and has already undergrounded up to 18% of its extra high voltage lines.

14. We would advise the IET and KEMA to closely consider, in the context of England and Wales, the comparison between the costs of Principles D and B. Principle D appears to be roughly comparable to the current approach to network development taken by National Grid, consisting of new, higher voltage overhead line development on existing route corridors. Principle B seeks to prevent an increase in the visual impact of the network, with undergrounding of new routes the preferred option for achieving this. We note from another study by Jacobs Babtie in 2005[8] that the costs of undergrounding are heavily influenced by underlying geology. As such we would suggest that the Danish experience, with an underlying geology of sand and loamy soil that is comparatively easy to excavate, is likely to be particularly comparable to lowland areas of southern England. Similarly, we would raise doubts as to whether the investigations of UGC in the context of the Beauly-Denny scheme, running through an area of rocky geology[9], are transferable to southern England.

Table 3: investment costs for Danish expansion principles[10]



	A	B	C	D	E	F
Investment 132/150kV	11.5	11.5	11.5	0.2	0.2	0
Investment 400kV	36.6	8.1	5.5	3.8	2.5	0

[8] Jacobs Babtie, *Undergrounding of Extra High Voltage Transmission Lines,* report for the Highland Council, Cairngorms National Park Authority and Scottish Natural Heritage, 2005, section 3.3. Downloaded from www.highland.gov.uk on 2 December 2010.
[9] SPTL 2010 op cit, p.32.
[10] Taken from p.24 of Elinfrastrukturudvalget (Denmark), April 2008.

15. Based on the evidence we have presented we would recommend that:

- There is a wide range of international experience in delivering UGC in an economically feasible manner, and National Grid's policy position statement on UGC should be updated to reflect this.
- National Grid should publish a scheme, as part of its Business Plan and made clearly accessible from its website, covering expected new development over a 10 year period, and listing locations where UGC will and will not be justified. Criteria set out in the final NPS should inform this scheme.

2. Are you able to provide factual/evidenced information with respect to selection criteria for overhead lines or cable circuits?

16. National Grid already runs just under 10% of its electricity transmission network underground, and is also developing new UGC schemes at a number of locations in the London area. Furthermore, the most recent updates to the *National Grid Seven Year Statement* indicate that UGC is being considered for particular stretches of possible new lines in rural areas, such as in the Lake District National Park and Morecambe Bay (on a proposed connection from Sellafield to Heysham) and in Kent (proposed connection between Lydd and New Addington in south London).

17. UGC at other extra high voltages is also being actively developed at the distribution level. SSE Southern, for example, has recently constructed two new 132kV UGC circuits north of Basingstoke in Hampshire[11]. Alongside this, in 2005 Ofgem created a small allowance for the undergrounding of distribution lines. This has resulted to date in 223 km of overhead lines being removed, mostly at lower voltages and at an average price of £100,000 per kilometre[12]. It also appears to have been used, however, to remove part of an extra high voltage overhead line at a Site of Special Scientific Interest on Hayling Island in Hampshire[13]. These developments, plus the findings of the Danish study mentioned above, accordingly lead us to recommend to IET and KEMA that **the final report should draw a clear distinction between the economic feasibility of undergrounding the highest voltage (275 and 400 kV) lines operated by National Grid and the lower (132 kV and below) lines operated by the regional distribution network operators**.

18. These recent and proposed developments appear to have been influenced by both the Holford Rules, which the industry has restated its commitment to, as well as National Grid's more detailed policy on underground connections[14]. The National Grid policy states that UGC will be considered in 'exceptionally constrained areas', which may be found in urban, rural or estuarine contexts. In the rural context, such areas are defined as '*those locations within or immediately alongside those designated areas* [National Parks, AONBs, Heritage Coasts, or World Heritage Sites] *where the scale of new high voltage transmission towers and conductors would dominate unspoilt landscape and cause serious damage to major open views of spectacular panoramas, crests of prominent rides and skylines or attractive small*

[11] Southern Electricity Power Distribution (SEPD), Regulatory Accounts for the year ending 31 March 2009, p.3. Downloaded from www.ssepd.co.uk/SSEInternet/uploadedFiles/Power_Distribution/Financial_information/SEPD_regulated_accounts/SEPDRegulatedAccountsMarch2009(1).pdf on 2 December 2010.

[12] Ofgem *Sustainable Development Focus 2009-2010*, November 2010. Downloaded from www.ofgem.gov.uk/sustainability/sdr/Documents1/Sustainable_Development_Focus_2009_-_2010[1].pdf on 3 December 2010.

[13] Southern Electricity Power Distribution (SEPD), Regulatory Accounts for the year ending 31 March 2010, p.3. Downloaded from www.ssepd.co.uk/SSEInternet/uploadedFiles/Power_Distribution/Financial_information/SEPD_regulated_accounts/SEPDMarch2010RegulatoryAccounts.pdf on 2 December 2010.

[14] Downloaded from www.nationalgrid.com/NR/rdonlyres/43087185-9634-462E-8575-B51F0660F486/36544/UGPolicyNewConnections4.pdf on 2 December 2010.

scale valleys seen from important locations within or immediately alongside the designated areas.'

19. We welcome the apparent recognition of the need to avoid the visual impact of overhead lines in future proposed National Grid schemes that involve crossing areas of high amenity value. But it appears to be somewhat belated, given that National Grid is already promoting two new schemes that involve new, larger, overhead lines (replacing smaller distribution pylons) crossing Areas of Outstanding Natural Beauty in Somerset and Suffolk.

20. In January 2010 the Scottish Government sanctioned the construction of a new overhead transmission line (the Beauly-Denny link) through the newly-designated Cairngorms National Park and an additional number of smaller areas of high amenity value, despite strong objections from a number of campaign groups and the Cairngorms National Park Authority. The inquiry reporters[15] referred to the Holford Rules and noted that the scheme failed to comply with the Rules in at least two significant respects. The developers' proposed scheme was however accepted largely at face value.

21. One of the two developers of the line, Scottish Hydro Electricity Transmission Ltd (SHETL), has been required, as a condition to mitigate the impact of building the new line, to underground over 100km of existing 132 kV pylons, many of them in the Cairngorms. This is in addition to the removal of existing pylons on the route, which will be replaced by larger towers. This can be seen as recognition of the degree to which the Beauly-Denny line contravenes the Holford Rules, and the need to compensate for this. Particularly notable is that the Scottish Government and Highland Council did not see it as sufficient for SHETL to merely remove the existing 132 kV line that the new 400 kV line will replace.

22. Accordingly, we recommend that the final report should state that any additional expense in investment in UGC can be justified with reference to the need to protect areas of high amenity value. In our view reference should be made to either the Holford Rules or Green Belt policy as applicable. The requirements of offshore renewable generation may also be relevant and are discussed further below.

3. Are you able to provide factual/evidenced information with respect to technical and operational considerations (including reliability)?

23. The 2008 Ecofys study considered technical and operational issues. The study commented on the concerns of many in the industry that UGC is an unproven technology in terms of its ability to adequately ensure reliability (a particular issue being forced outage rates) and integrity of whole transmission systems. Ecofys was unable to draw either a positive or negative conclusion on these issues from the evidence available to it, and concluded that further research is needed[16]. It is possible that tunnelling may be a remedy. The 2010 SPTL study states that the UGC tunnel constructed by National Grid between St John's Wood in London and Elstree has been in service since 2005 without incident[17].

24. The same study also found, moreover, that operational and maintenance costs for UGC were significantly lower for a range for options than for overhead lines. As a result, lifecycle cost ratios of UGC to overhead lines were found to be at cost ratios of between 1.8 and 2.9 to 1 (ranges of €4000-4200 compared to ranges of €1600-2300 per km)[18], thus going some way to recouping the additional investment costs referred to in question 1 above.

25. In our ongoing dialogue with industry representatives they have raised concerns that developments on networks in other European countries may not be comparable to the UK due

[15] The Scottish equivalent of planning inspectors.
[16] Ecofys 2008, p.84.
[17] SPTL 2010, p.39.
[18] Ecofys 2008, p.180.

to the rated capacity (as opposed to the voltage) of most of the transmission network being significantly lower in those countries. It is therefore posited by some in the industry that overhead lines are necessary to meet system rating requirements. We would note in response to this that the Babtie report found that an overhead line can be directly matched for capacity by UGC with a lower rating. The reasons for this are complex, but Babtie cites the broad issue of cable thermal design[19]. IET and KEMA may wish to probe this issue further with National Grid and others.

4. Are you able to provide factual/evidenced information with respect to alternative, costed, approaches to electricity transmission?

26. We are aware that some local groups in areas affected by the current National Grid proposals have proposed UGC alternatives such as gas insulated lines (GIL), as well as a nationwide network of High Voltage Direct Current (HVDC) cables located offshore in marine areas around Britain[20]. These groups often have had the benefit of voluntary engineering expertise.

27. Following pressure from CPRE and others, National Grid appears, to some extent, to be developing its own thinking on an offshore network, under the working title of 'integrated offshore grid solutions'. Recent presentations given by National Grid staff[21] outline two possible approaches to connecting the nine Round 3 offshore wind zones across the country through a mixture of HVDC and AC cables. National Grid argues for an 'integrated' approach that uses a limited number of cables to connect each cluster, as well as to connect to neighbouring European networks directly through the clusters rather than separately from them. Such an approach, it is argued, would result in 24% savings for UK customers over the 'radial' approach of connecting each generating station within the clusters separately, as well as 75% fewer onshore (mostly overhead) lines, half the number of onshore substations and landing points, and 20% fewer offshore assets. Importantly, the study does not assess the wider benefits (including economic benefits) of the decrease in required infrastructure on the natural environment.

28. Given this emerging thinking, it is reasonable to think that beginning in the 2020s, such an offshore network would begin to enable the UK to use an offshore network for bulk energy transfer. Indeed, North Seas Countries Offshore Grid Initiative, supported by the UK, envisages such an offshore grid as a vital part of the UK's energy system, which could reduce the need to build balancing infrastructure in England, and reduce the number of onshore lines to connect such infrastructure. This could have particular value for visual amenity in removing the existing onshore overhead transmission line between Dungeness and Exeter, which passes through the South Downs National Park, a number of AONBs, and close to the Heritage Coasts of Dorset and east Devon.

29. We ask IET and KEMA to investigate the options mentioned above and the scope therein to reduce the need for overhead lines.

5. Are you able to provide factual/evidenced information with respect to other fact based areas that you consider relevant to the report?

30. We trust that our contribution above will assist with the production of a robust study within the published terms of reference. But we also believe that insufficient attention has been given to the amenity benefits of both undergrounding and avoiding visual intrusion

[19] Jacobs Babtie 2005, see particularly pages 20/21, 27 and 37.

[20] See, respectively, www.pylon-moor-pressure.co.uk/Report_for_Wraxall_and_Failand_Parish_Council_Dec_09_Final.pdf and www.s258888288.websitehome.co.uk/Underground/UK_Ring_Main.html.

[21] An edited version of this presentation was downloaded from www.bwea.com/pdf/Cables2010/Louise_Wilks.pdf on 2 December 2010.

caused by high voltage overhead lines. With respect to both the IET and KEMA, we posit that the terms of reference of this study, focused on costs, are too narrow to address this gap. Many of the amenity benefits, such as the positive encouragement of rural tourism or informal recreation, have not been properly quantified in economic cost-benefit terms, as the Jacobs Babtie study recognised[22]. **We ask the IET and KEMA to recommend that a further study is carried out of these issues.**

31. To properly consider the benefits of undergrounding alongside the costs, we believe that two actions need to be taken through a partnership between Ofgem, the industry and interested civil society organisations such as ours. The first is a full Strategic Environmental Assessment (SEA) of electricity network development, to gain a full understanding of where visual impact issues are likely to arise and how these might be addressed. National Grid should, in our view, begin this process as part of its Business Plan process beginning in 2011. Alongside this, Ofgem has already carried out research on the public's willingness to pay for intrusion caused by distribution lines in National Parks and AONBs to be avoided or mitigated, as part of the undergrounding scheme for distribution network operators mentioned above. We believe that Ofgem should also undertake such research at a national level with regard to the transmission network within the next Transmission Price Control Review.

32. We acknowledge that certain forms of undergrounding can cause environmental problems of their own, such as high land take, disruption to archaeology and subsoil features. But such issues can often be addressed by methods such as tunnelling, as the literature we have reviewed (including National Grid's own policy on undergrounding) makes clear.

33. Beauty and tranquillity are central to our concerns and they form an important part of the evidence that we will bring to bear in debates on the location of new energy infrastructure. Research carried out for CPRE by Northumbria and Newcastle universities, available from the CPRE website, has highlighted overhead lines as a key detractor from tranquillity. From our point of view it is better to avoid damage to beauty and tranquillity altogether rather than to compensate or substitute for their loss.

34. There are a number of tangible public benefits from tranquillity, and these are recognised by other organisations besides ours. For example, the Country Landowners and Business Association (CLA) noted in a 2008 submission to Ofgem that 'removal of overhead lines reduces potential hazards to those undertaking informal recreation such as boating, hang gliding, angling and kite flying.'

35. Undergrounding is, in our view, the most effective form of mitigation where a new line is inevitable. In National Parks, the primary purpose of the designation is to conserve and enhance natural beauty, and UGC makes a direct contribution to this purpose. But avoidance of new lines in these and other locations of high amenity value should be seen as the most preferable option. Issues of noise and nuisance are unlikely to go away. Network developers and the IPC will need to address them sensitively.

36. CPRE has comprehensively mapped tranquillity, and evidence from this mapping has been used by DECC in reaching its recent decision on proposed sites for new nuclear generation. Such mapping may also assist future electricity network development or rationalisation in rural areas. CPRE can supply more details to IET and KEMA on request.

CPRE / CNP / NAAONB
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[22] Jacobs Babtie 2005, p.61.