The Overview of Valuation of Visual Impacts of Transmission Price Control Review (TPCR)

Final Report

Ofgem

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Executive Summary

- There are few valuation studies – using either revealed or stated preference methods – of the visual impacts (and non-market impacts more generally) of electricity and gas transmission options. Existing studies do, however, offer some interim guide to the economic importance of these impacts.

  One study of house price determinants indicates that households living very close (within 250m) to planned pylons and overhead electricity transmission lines are likely to experience a substantial drop in the value of properties. This is not purely down to the impacts on surrounding visual amenities however.

  A further study of household willingness to pay (WTP) for visual impacts only indicates that these values remain significantly positive for households living up to 5km away from existing pylons and overhead electricity transmission lines.

  Yet another study of WTP found evidence of positive values for removing the visual disamenity created by public service networks of recreational (canal) users.

- New designs for, say, electricity pylons might be one means of reducing the visual impacts of these structures. However, one investigation of this found that simply preferring a new design does not necessarily translate into households being willing to pay to see that new design replace the old. As a result, household WTP was very low (with a majority not being willing to pay anything at all).

- The extent to which benefits transfer can be used in cost benefit analysis for, say, undergrounding or re-routing of electricity and gas transmission proposals is circumscribed by the lack of primary studies which are the bedrock of transfer exercises.

  The existing literature of these (and related) options offer a proximate guide to the merits of new transmission on grounds of visual impacts. Yet, it is arguable that using such data for price control arrangements may impose a greater requirement for (the demonstration of) accuracy and the demonstration of accuracy. If this is the case, it is difficult to escape the conclusion that more original valuation work is needed.

- If the *additional* costs of, say, undergrounding options are well-known and what is required is primarily an indicative guide to whether, for example, visual impacts "tip the balance" towards these options. Then we would only need to know if benefit estimates exceed the 'threshold' of cost or estimate how large WTP would have to be to justify any additional cost (in short, at least as much as the costs). These 'threshold values' could be compared with findings that have emerged so far from the small literature on electricity transmission (as well perhaps as the larger valuation literature on the visual impacts of landscape changes).

  Key considerations here would include the extent to which WTP declines towards zero as households live further away from a transmission project (and so are far less likely to be exposed to its visual impacts). In the case of values expressed for visual impacts based on use, i.e. familiarity and experience, one critical determinant of the cost-benefit case for, say, an undergrounding option is the number of households in the locality.

  An assessment of whether the land in question has non-use value is also vital. For most types of land, non-use value is unlikely to be of empirical importance. However, some types of land such as national parks – which are populated by relatively few households – may be valued by individuals or households elsewhere in a manner that is unrelated to actual experience.

- Household WTP for transmission options that improve visual amenity could be 'captured' in order to finance these schemes.

  However, at least one study of preferences for undergrounding of electricity transmission lines found that – as is the case for a number of environmental goods – *mean* WTP gives 'excessive' weight to a minority of respondents who have strong and positive preferences. As *median* WTP reflects what the majority of people would be willing to pay, passing on to households which enjoy improvements in visual amenity such an amount – in, say, increased electricity or gas bills – would in all likelihood be more 'acceptable'.

  Making the 'beneficiary pay' is clearly only one means of financing transmission options that improve visual amenity. If the electricity consumers that necessitate that a project be implemented can be thought of as 'polluters' (that is, affecting visual amenities elsewhere) then there could also be a case for assigning the burden of paying of more expensive but less visually intrusive projects to these households. The issue of "who pays" is essentially one of property rights.

- The property rights issue is important to the valuation problem as well.

  For example, suppose that households in the vicinity of a planned overhead electricity transmission project have no right to the level of visual amenity that they would enjoy if instead transmission lines were buried underground. A measure of the benefits of the undergrounding scheme would be WTP to secure that improvement. By contrast, if households have a property right to improved visual amenity then a measure of the benefits of this improvement would be the willingness to accept (WTA) compensation were the overhead transmission option (and not the undergrounding project) to take place.

  Stated preference studies have consistently found that WTA exceeds WTP sometimes by a considerable amount. If these findings are more than just an artifact (as many suspect), then if WTA is the correct measure in a gas and electricity transmission context then it makes it more likely (although by no means assured) that less visually obtrusive options such as undergrounding pass a cost-benefit test. Crucially, however, the choice between WTP and WTA depends – as elsewhere – on a judgement about property rights for this policy problem.

- The discussion in this report is focused on households. However, for completeness of a cost benefit analysis or any other decision-making approach, the preferences (and WTP) of and impacts of different options on other actors such as business customers should also be taken into account.

1. Introduction

1.1 Background

The overall policy context for this report is the Transmission Price Control Review (TPCR). The transmission systems in gas and electricity are the onshore networks of high voltage lines and cables and high pressure pipes that enable gas and electricity to be transported from producers to consumers.

Appendix 6 of the TPCR second consultation paper (Ofgem, 2005) lists the environmental factors that should also be taken into account. Two of these factors concern visual impact (p. 138, Ofgem 2005):

- "How might changes in locational patterns of generation and the associated need for transmission reinforcement impact on the environment in general, and on visual amenity in particular?"

- "What are the relative costs and benefits (both financial, and in terms of operational efficiency) of different forms of transmission investment which might be considered to have a lower visual impact on the landscape (e.g. underground cables, low visual impact substation designs, noise reduction measures)? How, if at all, can consumers (or other relevant stakeholders) express their willingness to pay? In the absence of direct mechanisms, how might the value to consumers of any such additional costs be estimated?"

This report aims to target the questions about willingness to pay. This, in turn, requires an understanding of the environmental good that is affected by transmission lines, i.e. the nature of the landscape and the visual impact.

1.2 Objectives

The terms of reference list the following issues to be considered by this short assignment:

- Current/recent research on the value of visual amenity in the context of electricity and gas transmission;
- Characterisation/classification and relative valuation of landscape types in Great Britain;
- Consideration of willingness to pay surveys etc. (in general terms - as an indicator of value, and in specific terms: who pays - beneficiaries or electricity consumers?);
- Feasibility of developing a general transferable tools that could be used in price controls;
- Any preliminary evidence regarding the order of magnitude of value as compared to the cost of undergrounding or re-routing of transmission lines;
- The feasibility of deriving threshold values for undergrounding based on cost of undergrounding/re-routing;
- Net environmental values - trade-off of visual vs. potential for leakage, interruption etc.;
- Existing work on the relative value of alternative transmission tower designs; and
- Any other matters that may be considered relevant.

In all of the above, the context is a change from the current high voltage transmission lines (HVTLs) to (i) new designs and/or (ii) new routes, or (iii) undergrounding.

1.3 Report Structure

On the basis of the above objectives and the initial meeting held between the authors of this report and Ofgem on the 20th January 2006, the report is organised in five sections. Following this brief introduction, Section 2 presents an overview of the conceptual background and specific issues that will influence the interpretation of available evidence and potential new work. Section 3 reviews the landscape research and economic valuation literature of relevance. Section 4 develops research options on the basis of the conceptual overview and current literature. Section 5 concludes the report.

A few short additions and revisions have been made after the second meeting with Ofgem which took place on the 10th May 2006.

2. Concepts

This Section sets the conceptual basis for investigating the economic value of the visual impacts of TPCR. It starts with the definition of the environmental change in question (Section 2.1); an overview of the economic value concept (Section 2.2); an overview of economic valuation methods that are relevant in this context (Section 2.3) aspects of using economic value evidence in appraisal and pricing (Section 2.4) and the institutional context that will shape the way this evidence can be used in practice (Section 2.5).

2.1 The environmental change: landscape and visual amenity

The Countryside Agency and Scottish Natural Heritage (2002) provide the following definition of landscape:

"Landscape is about the relationship between people and place. It provides the setting for our day-to-day lives. The term does not mean just special or designated landscapes and it does not only apply to the countryside. Landscape can mean a small patch of urban wasteland as much as a mountain range, and an urban park as much as an expanse of lowland plain. It results from the way that different components of our environment - both natural (the influences of geology, soils, climate, flora and fauna) and cultural (the historical and current impact of land use, settlement, enclosure and other human interventions). People's perceptions turn land into the concept of landscape. This is not just about visual perception, or how we see the land, but also how we hear, smell and feel our surroundings, and the feelings, memories or associations that they evoke. Landscape character, which is the pattern that arises from particular combinations of the different components, can provide a sense of place to our surroundings."

Landscape can be changed in a number of ways. While some of these changes may enhance visual amenity (e.g. increase in preferred habitat types through agri-environment schemes), other changes, most notably by building of infrastructure, lead to visual disamenity. As mentioned above, there are three types of investment that could be designed to reduce the visual disamenity due to heavy voltage transmission lines (HVTLs): (i) re-routing; (ii) changing the design of existing pylons and (iii) burying transmission lines underground (or "undergrounding").

Undergrounding removes a visual disamenity. However, this option is sometimes said to be associated with other disadvantages, such as greater risk of interrupted electricity supply as, well as possibly longer outages as problems become harder to locate and access when they arise. In many cases, these outage risks affect a broader number of households than those who would benefit from undergrounding. These costs arguably should count in a cost-benefit appraisal of undergrounding options given that affected households are likely to be willing to pay something to reduce outage risks (or avoid increased risks). In addition, changes in outage risks affect businesses, and these commercial entities might place a value on these risks based perhaps on the output that is lost when outages occur. These issues are picked up again in Section 2.4.1.

2.2 Economic value of landscape and visual disamenity

Depending on its location and level of development, land generates a number of benefits maintaining or increasing human welfare (Eftec and Entec, 2002): recreation; landscape; ecology; cultural heritage; hydrology; air quality and climate; tranquility; accessibility; and soil and minerals. The clearest benefit of landscape is that of visual amenity, where landscape character and quality combine to produce familiar and attractive (or neutral or unattractive!) views. These, by their nature, are often highly subjective, although the landscape designation process has established a widely accepted standard.

Economics uses the concept of 'Total Economic Value' to measure these benefits. Landscape generates economic value through the uses people make of it (use value). In addition, people may place value on the landscape for reasons that are not related to their current or future use of it (non-use value), because they value the use made of the landscape by others, by future generations or simply because landscapes that are associated with cultural heritage, identity, wildlife etc. simply continue to exist. Total Economic Value is the sum of use and non-use values.

However, it is important not to loose sight of the full list of benefits of land. While visual amenity is a distinct service provided by landscape, its manifestations may be valued as a bundle together with any of the other benefits on the list, probably most often with recreation, ecology (as the type of habitat determines the look of the landscape), tranquility and accessibility. Cultural heritage characteristics of landscape (e.g. dry stone walls, monuments etc.) may also influence use as well as non-use values attached to a given landscape.

2.3 Economic valuation methods: an overview

Economic value is a measure of individuals' preferences. Preferences are expressed either as individuals' willingness to pay (WTP) for an improvement or to avoid a loss; or their willingness to accept compensation (WTA) to forgo an improvement or to tolerate a loss. In other words, preferences represent the trade-offs individuals are prepared to make, in the context of this study, between the changes in the visual amenity and money (or between disadvantages of undergrounding and money).

In actual market transactions, this is indeed what happens: the price in perfectly functioning markets represents buyers' maximum WTP and sellers' WTA. Such trade-offs for marketed environmental goods and services are also reflected by market price. Contribution of visual amenity to tourism, for example, could be gleaned from spending for recreational trips (market prices, revealed preference methods). However, some of the benefits provided by landscape (as with other natural environment assets) occur outside the market, i.e. they are externalities. Examples include informal recreation (e.g. rambling) and non-use values. The unit of measure in either case is money, data for which comes either from market transactions or specially designed studies that elicit individuals' preferences directly (stated preference methods).

In the context of this study, market prices are not sufficient indicators for measuring visual amenity. Therefore, the focus here is on revealed and stated preference methods.

Revealed preference methods analyse preferences for non-market goods as implied by WTP behaviour in an associated market. Revealed preference techniques include the hedonic price method, the travel cost method and the avertive expenditure or behaviour method. Among these, it is the hedonic price method that has been used by practitioners to evaluate the disbenefits received by those households living in proximity to, for example, electricity transmission lines and pylons. These studies are based on the idea that the price of a property is affected by the bundle of characteristics of that property and the surroundings. These characteristics may include non-market visual amenities provided by the local environment. Other things being equal, the extra price commanded by a house located, for example, in an area of visual beauty would be a measure of the WTP for this amenity.

Stated preference methods use 'hypothetical markets', described by means of a survey, to elicit preferences where there may be no surrogate market. For example, the contingent valuation (CV) method has been widely used in both developed and developing countries, particularly in the last decade, to determine the economic feasibility of policies that seek to achieve improvements in environmental quality. By means of an appropriately designed questionnaire, a hypothetical market is described where the good in question can be 'traded' (Mitchell and Carson, 1989). This contingent market defines the good itself (e.g. undergrounding of HVTLs), the institutional context in which it would be provided (e.g. constructed by contractors working on behalf of an organisation such as the National Grid Company, or NGC), and the way it would be financed (e.g. a per annum addition to a households' standing charge on electricity bills for a specified number of years). A random sample of respondents is then directly asked to express their (individual or household) willingness to pay (or willingness to accept) for a hypothetical change in the level of provision of the good. Respondents are assumed to behave as though they were in a real market. In this respect, CV questionnaires bear some resemblance to conventional market research for new or modified products.

2.4 Using economic value evidence in appraisal

Economic value evidence can be used in a variety of ways such as cost-benefit analysis, determining the level of environmental taxes, pricing such as entry fees to national parks, green national and corporate accounting, and calculating compensation amounts in the case of environmental damage or liability.

In the context of this study, the most relevant use is that of cost-benefit analysis. The advantage of expressing economic value in monetary units is that this allows comparison of all benefits and costs subject to data availability. This section presents a discussion of a number of issues that are likely to affect such a cost-benefit analysis, including whose values should count, whether willingness to pay or willingness to accept is the correct measure, whether to use mean or median willingness to pay, relationship between distance to HVTL and WTP and implicit cost-benefit analysis and threshold values.

2.4.1 Whose values should count?

The cost-benefit case for undergrounding (or re-routing) gas or electricity transmission lines rests on a comparison of the benefits of such a project with its costs. The latter can be measured, by and large, with reference to the estimated outlays (relative to some baseline) on capital and operating expenditures as well as the value of any miscellaneous negative impacts such as decreases in supply reliability and so on. The former can be measured by household WTP to secure an improvement, say, in visual amenity.

This cost-benefit question is arguably distinct to the problem of how to finance the project. Intuitively, it might be argued that knowledge of household WTP for the improvement could be translated into funds to finance the cost of project inputs through, say, higher electricity or gas bills. This bid to 'capture' WTP corresponds to a type of beneficiary or (amenity) user pays principle[1]. But this is not the only way to finance the project. After all, the rationale for policies to reduce air pollution, for example, might be that (aggregate) household WTP for improvements in air quality exceeds the costs of providing this improvement. However, the policy that secures this change might be some tax on or regulation of emissions of air pollutants. Effectively then this assigns the burden of paying for this improvement to polluters which corresponds, broadly speaking, to the polluter pays principle.

The decision of to whom this burden should be assigned depends on a judgement about property rights: i.e. the right of the polluter to the status quo, or the right of the beneficiary to the improvement. The cost-benefit and the burden allocation problems are essentially then different pieces of the policy puzzle. However, see the next section for a discussion of how the property rights question affects the valuation of improvements or deterioration arising from gas or electricity transmission projects.

This discussion focuses on households as requested by the terms of reference of this report. However, the preferences of other actors (e.g. business customers) should also be taken into account if they are affected by transmission projects. The key here is to recognise that a full (social) cost-benefit analysis would consider all such impacts. For example, if undergrounding of electricity transmission lines results in decreased reliability of electricity supply then the value of this increased risk of power outages need to be accounted for. Another example is provided by the observation that a large part of the investment in transmission currently is driven by investment in renewable energy which is required under the renewables obligation. From a (social) cost-benefit perspective, the fact that there is an statutory obligation to implement a particular transmission projects means that, at the very least, what we should be interested in is the net benefit of the project for feasible options that meet this obligation at, say, different levels of financial cost and visual intrusion (perhaps because of undergrounding or re-routing).

2.4.3 Willingness to Pay vs. Willingness to Accept?

As mentioned In Section 2.3, individuals' preferences are measured by willingness to pay for a benefit and willingness to accept compensation for a cost. It is useful for these notions of WTP and WTA to be explored a little more.

For a project that leads to an *improvement in wellbeing,* i.e. a benefit, by perhaps removing electricity pylons and placing transmission lines underground, we need to know by how much the wellbeing of an individual (or household) is increased by this improvement in environmental quality.

- This could entail measuring the maximum amount of income the individual would be willing to pay for the change. This, to use the economic jargon, is the 'compensating variation' for this benefit.

[1] In the case of a transmission project that provided substantial non-use values, presumably the goal would be to capture WTP across the non-user population. The feasibility of this is clearly an empirical question, as it is for the case of capturing the WTP of recreational users of landscapes and so on affected by these projects, such as in the study by Garrod and Willis (1998).

- An alternative is to ask how much an individual would be willing to accept in terms of additional income to forgo the improvement in environmental quality and still have the same level of wellbeing as if environmental quality had been increased. This, to use the economic jargon, is the 'equivalent variation' for this benefit.

If the project leads to a *deterioration in wellbeing,* i.e. a cost, perhaps because it entails constructing new pylons, analogous measures for this change can be derived.

- This could entail measuring the amount of money the individual would be willing to accept as compensation to let the change occur and still leave him or her as well off as before the change ('compensating variation').

- An alternative is to ask how much the individual would be willing to pay to avoid the change ('equivalent variation').

Traditionally, economists have been fairly indifferent about the measure of wellbeing to be used for economic valuation: WTP and WTA have both been acceptable. By and large, the literature has focused on WTP. However, the development of stated preference studies has, fairly repeatedly, discovered divergences, sometimes substantial divergences, between WTA and WTP. These differences still would not matter if the nature of property rights regimes were always clear. WTP in the context of a potential improvement is clearly linked to rights to the status quo. Similarly, if the context is one of losing the status quo, then WTA compensation for that loss could be the relevant measure. By and large, environmental policy tends to deal with improvements rather than deliberate degradation of the environment, so there is a presumption that WTP is the right measure.

How then do these issues relate to the case of gas and electricity transmission? Table 2.1 summarises the implications.

Table 2.1: Measures of Wellbeing for Example of Electricity or Gas Transmission Lines

	Compensating variation: Amount of income that can be taken from an individual (or household) *after* the project such that he/she is as well off as they were *before* the project	**Equivalent variation:** If the project does not occur, the amount of income that would have to be given to the individual to make him/her as well off as if the project did take place
Improvement (Project: e.g. undergrounding)	• *WTP to secure undergrounding option*	• *WTA to forgo undergrounding option*
Deterioration (Project: e.g. new pylons)	• *WTA compensation for deterioration*	• *WTP to avoid deterioration*

To use the example of an improvement which would occur if planned electricity pylons were replaced by burying transmission lines underground: to the extent that there is a statutory obligation to supply electricity, this could be taken to imply that property rights reside with households that require transmission towers to be erected. In this case, the baseline or status quo is the erection of new pylons and households could be said to have property rights to this level of visual amenity only. What this means is that WTP can be used to measure the benefits of undergrounding. If, on the other hand, households in the vicinity of the proposed pylon project have a property right to the (undergrounding) project level of visual amenity then it is WTA that should be used to measure the benefits of undergrounding.

The practical significance of this discussion is the aforementioned plethora of evidence across a range of environmental goods that WTA exceeds WTP perhaps by a factor of four or possibly considerably more for various environmental goods that have public good characteristics (Horowitz and McConnell, 2002)[2]. If WTP is the correct measure then the visual benefits of undergrounding are less likely to be justified by the costs of such proposals. However, if WTA is the correct measure then it could be that undergrounding proposals stand a greater chance of passing a cost-benefit test.

2.4.3 Mean vs. median WTP

Assuming that price control arrangements might seek to 'capture' WTP for environmental improvements carried out in the gas and electricity sectors, the tendency of the distribution of WTP to be skewed is an important issue. For a number of environmental goods, a not uncommon finding in especially stated preference studies is that the distribution of WTP is skewed in that, for example, there are a relatively small number of respondents bidding very large values and a very large number of respondents bidding very small (or even zero) values. In other words, the problem in such cases is that *mean* WTP exceeds *median* WTP and gives 'excessive' weight to a minority of respondents who have strong and positive preferences[3].

While mean WTP is the theoretically correct measure to use in cost-benefit analysis (CBA)[4], median WTP is the better predictor of what the majority of people would actually be willing to pay (when there is a wide distribution of values). From a practical viewpoint this is extremely important. The choice between mean and median WTP is particularly important as regards any future efforts to capture the value of improvements in visual appearance (from, for example, undergrounding electricity transmission lines which would otherwise be placed overhead). As median WTP is better at reflecting what the majority of people would be willing to pay, passing on to these consumers of visual amenity such an amount – in say increased electricity or gas bills – would in all likelihood be more acceptable than an estimate of mean WTP that includes the influence of very large bids (see Table 2.1).

2.4.4 Distance and WTP

One of the most important determinants of a household's WTP for undergrounding transmission lines will be the frequency and the duration with which that household would be likely to encounter the pylons that are already or would be erected. Households encountering the pylons rarely and briefly are unlikely to benefit a great deal from the elimination of this visual disamenity. By contrast, households that encounter these new pylons frequently and for long periods are likely to 'suffer' the disamenity much more. What this means is that WTP to avoid this disamenity should fall as the frequency and duration of encounters with pylons declines.

[2] While the reasons for these differences are not altogether clear there is a growing feeling that observed differences between WTA and WTP are unlikely to be artifacts of questionnaire design.

[3] Mean WTP is average across the sample. The median WTP is the amount in the middle of a distribution: half the sample would be willing to pay above the median and half below the median.

[4] In CBA, a decision-maker accepts measures of individuals' preferences, expressed as WTP sums, as valid measures of the welfare consequences of a given change in provision of say some (public) good. In this system, mean WTP is preferred to median WTP as a more accurate reflection of the variance in preferences across the mass of individuals whose aggregation is considered to represent society's preference.

For practical purposes, frequency and duration of encounters could be proxied by the distance a household lives from the stretch of pylons under consideration. Indeed, decreases in WTP with distance – 'distance decay' – has been examined in a number of studies with interest arising from a crucial question for CBA; namely, the appropriate population across which to aggregate estimates of household or individual WTP across users and even non-users of an amenity (see, for example, Bateman *et al*. 2000; Hanley *et al*. 2002).

The practical benefit of using distance is that this can be simply measured for any household and so facilitates benefits transfer exercises. Imagine, for example, that a cost-benefit analyst wished to estimate the benefits of a scheme proposing the undergrounding of a transmission line in a location where no original valuation study had been undertaken. The analyst could simply use the relationship between distance and WTP revealed by some primary study or studies undertaken elsewhere and then use this information to estimate which households in the transfer location would benefit from the scheme and by how much.

How well does distance approximate the frequency and duration of encounters with pylons? Atkinson *et al*. (2006), which discusses further the study by Day *et al*. (2001) showed that the percentage of respondents stating that they see pylons 'frequently' progressively falls with distance, whilst those stating that they see pylons 'rarely' progressively increases with distance. Those stating they encounter pylons 'only sometimes' first increase with distance then appear to fall off. However, the percentage of respondents stating that they 'never see' pylons remains unchanged at around 10 per cent across all distance bands. While this suggests that distance on its own is unable to capture all those aspects of behaviour that result in encounters with pylons, it is arguable that distance remains a good indicator of encounter frequency. Put another way, we can be reasonably confident that using distance as the basis for benefits transfer exercises does not introduce undue bias. The studies mentioned above are summarised in Section 3.2 and the benefits transfer option is presented in Section 4.2.

2.4.5 Implicit cost-benefit analysis and 'threshold values'

All decisions, however these are made, imply preferences, and all decisions imply money values. Cost-benefit analysis (CBA) seeks explicit preferences rather than implicit ones. To this extent, CBA looks directly for what people want. If a decision to choose project X over project Y was being contemplated, and X costs £15 million and Y costs £10 million, then it follows that the benefits of X would need to exceed the benefits of Y by at least £5 million. It might then be asked whether the benefits of Y are likely to be at least this large. Moreover, if we also know the number of households which are affected by project Y then we can estimate what per household WTP needs to be to tip the balance in favour of choosing project Y rather than project X. Clearly, this is no substitute for methods which measure these benefits explicitly (either through primary studies or benefits transfer). Nevertheless, it may offer some preliminary insight if some credible benchmark exists for judging whether the implied 'threshold' WTP value seems reasonable or whether it is so large that it would not pass a 'laugh-test', i.e. is highly unlikely compared to previous evidence.

One key element in answering the question over whether constructing electricity pylons or undergrounding is likely to yield higher net benefits is an assessment of the likely cost magnitudes of these options. Cowell (2002) provides a detailed discussion of the capital and operating costs of erecting new overhead lines compared to the costs of burying transmission lines underground. For example, Cowell reports NGC estimates that erecting a 1km stretch of pylons supporting HVTLs costs £500,000 while 1km of underground high voltage cables costs £10 million. While it is not clear whether such cost estimates are present values, these data (taken at face value) are at least crudely indicative of the differences in costs between (current) pylons and undergrounding options, although elsewhere Cowell indicates the cost ratio tends to decline with the voltage of the transmission lines.

From the cost-benefit perspective, estimating the costs of different options that enhance visual amenity depends on whether the project is replacing current pylons or is a wholly new transmission line project. For example, if the project is in a location where towers or overhead lines currently exist, the relevant baseline is the current Lattice design. That is, 'costs' refer to the economic resources needed to remove the current pylons and replace them with some transmission alternative[5]. Alternatively, if the project is in a location where *no* towers or overhead lines currently exist, the relevant baseline could still be the current design when there is a statutory obligation to transmit electricity and hence incur at least the minimum cost, say, that of the current design. In this case, costs can be defined as the costs of undergrounding *minus* the cost incurred if HVTLs supported by a stretch of transmission towers were erected. In other words, compared to the baseline, burying HVTLs would entail a cost-saving in the form of towers that would no longer need to be erected and maintained.

Similarly, as regards the CBA of proposals to construct pylons based on some new design then the costs of any such project are the following. If the baseline is that pylons of the current design would otherwise be constructed at the location of the project, the net cost of the new design is the *additional* cost of that design. That is, the costs of constructing pylons of a new design minus the costs of constructing pylons of the current design.

2.5 The institutional context for economic appraisal

At present, formal cost-benefit analysis plays little part (if any) in decisions regarding where to locate pylons in England and Wales. Rather this process is dealt with as part of the planning process which observes the statutory obligation to supply electricity to households (otherwise known as Class G: Electricity undertakings – see, for example, Lichfield, 2003). This planning process entails rounds of discussion with stakeholders and local authorities and the avoidance (in general) of constructing HVTLs across certain designations of land (e.g. National Parks).

It is tempting to think that, as this process entails rounds of discussion and deliberation between decision-maker and stakeholders, the planning outcome reflects a revealed willingness to pay for less visually intrusive options relative to its alternatives. Unfortunately, this conclusion would be quite wrong for at least two reasons. First, benefit assessment must be understood as the benefits of all members of society (with standing) that are affected by the project and it may be that, within the planning process, the preferences of particular sectional interests are, for various reasons, disproportionately reflected in the outcome. Second, this reasoning seems to imply that whatever emerges from the planning process is the right decision from the cost-benefit perspective. If so, this would be a strong claim.

Rather the correct context is to argue that benefit assessment (e.g. estimating willingness for pay for less visually intrusive transmission options) or cost-benefit appraisals are one additional input that could be usefully brought to bear in the planning process. Indeed, an authoritative review of development rights by Lichfield (2003) discusses the finding that nearly a quarter of local authorities were dissatisfied with development outcomes with at least some of this dissatisfaction arising from concern about the visual impact of overhead lines in rural and urban areas. It is exactly for this sort of problem that some assessment of the monetary benefits of, say, lessening these visual impacts could offer an additional input to evidence-based decision-making.

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[5] Of course, to the extent that currently erected pylons have a scrap value this item should also be included in the assessment of costs and benefits.

3. Literature Review

This Section reviews the currently available literature on the definition of the good (landscape) (Section 3.1) and the relevant economic valuation studies (Section 3.2).

Landscape research can be used to define different landscapes and assess their relative importance judged against different parameters. This information, in turn, can be used on its own during the planning of a project (e.g. by avoiding landscapes when designing new transmission routes or by prioritizing certain areas for undergrounding). The fact that data about landscape is generally in a GIS compatible format makes it more feasible to overlay landscape data with grid route data and hence contribute to planning. This is further discussed in Research Option 1 in Section 4.

Information about landscape can also be used in conjunction with economic valuation in that technical knowledge and data are necessary to define 'the good' that will be affected, i.e. landscape, and the changes, i.e. visual impact, both when interpreting the existing evidence (perhaps through benefits transfer) and when designing a new valuation study. This is further discussed in Research Options 2 and 3 in Section 4.

3.1 Landscape research

Relevant landscape research here could be grouped as (i) digital landscape data: the Land Cover Map 2000 (LCM2000) by the Centre for Ecology and Hydrology[6] and NEXTmap by Bluesky; and (ii) information on landscape characteristics: Countryside Quality Counts (CQC), the Quality of Life Assessments (QoLA), and Landscape Character Assessment (LCA) by the Countryside Agency.

3.1.1 Land Cover Map 2000

The Countryside Survey 2000 (CS2000), with components covering Great Britain and Northern Ireland, was designed to provide detailed information about the habitats and landscape features of the UK countryside. The Land Cover Map 2000 (LCM2000) is a key part of the CS2000. It complements the detailed, sample-based, field surveys of CS2000 by providing comprehensive information on the UK landscape and its mosaic of habitats by analysing the data from Earth observation satellites (e.g. Landsat 7)[7].

LCM2000 is a vector database, for use within a GIS system. It is registered to the British National Grid (also known as Ordnance Survey grid references). It shows areas of land as 'parcels' or polygons. Each parcel has attached to it a list of values or attributes, covering such topics as land cover class, parcel area, length of boundary, processing history, knowledge-based correction and identification of the original satellite scene. Land Cover Map 2000 (LCM2000) is provided in several different Product Versions including vector database and raster dataset[8].

1. **The Vector database**. This is the Core dataset. Data is provided as polygons or land parcels, and each parcel has a list of attributes attached to it. The standard output format is as Arc View shape files. Other export formats are available, for Arc Info and Map Info systems.

[6] ADAS also has an adapted version, ADAS Land Cover Map, which expands on LCM2000 with regards to agricultural land.
[7] For further details, see http://science.ceh.ac.uk/data/lcm/lcmleaflet2000/leaflet1.pdf
[8] http://science.ceh.ac.uk/data/lcm/productversionsandformats.pdf

- The standard level of detail is LEVEL 2, which provides 26 target/subclasses.
- LEVEL 3 data is available, giving a higher level of detail, but quality of detail may vary in different areas of the country, requiring expert interpretation. LEVEL 3 data is only provided by special arrangement with CEH staff, as more user support is required.

2. **The Raster dataset** has been derived from the Core Vector database, and provides data as pixels. This does not have the attribute lists attached to each parcel, only the Broad Habitat classification/class list. If using this data within Arc View, the spatial analyst extension will be required. There are two resolutions: 25 metres, and 1 kilometre. The 1km version is available in two forms:

- 1km dominant values - freely downloadable from the LCM2000 web site.
- 1km CIS (Countryside Information System) format. This is provided to licensed users.

There is also a range of data on administrative areas and landscape. The system operates through familiar Microsoft Windows software; it allows users to tailor enquiries to generate maps and statistics for regions of interest, and for combinations of environmental conditions (www.cis-web.org.uk).

The database shows 25 Broad Habitat types including: broad-leaved, mixed and yew woodland; coniferous woodland; boundaries and linear features (larger linear features such as motorways – smaller ones such as hedges, walls and smaller roads are only recorded by the field survey); arable and horticulture; improved grassland; neutral grassland; calcareous grassland; acid grassland; bracken; dwarf shrub heath; fen, marsh and swamp; bog bogus; standing open water and canals; rivers and streams; montane habitats; inland rock; built-up areas and gardens; supra-littoral rock, supra-littoral sediment; littoral rock; and littoral sediment.

A sample of map products from the database can be viewed at http://science.ceh.ac.uk/data/lcm/lcmleaflet2000/leaflet4a.pdf. As well as pictorial examples, this website also makes the following comments which are relevant in the context of this study:

- Once data are accessed in a GIS, the full scope of LCM2000 becomes clear.
- Each parcel carries a range of attribute data that describe its shape, size and location; the source images and their dates are referenced.
- Thematic details include the Broad Habitat, subclasses and, where known, class-variants (spanning 71 cover types); class probabilities are recorded.
- Other details include pixel-based scores of within-parcel heterogeneity and LCMGB and CORINE 1990 classes.
- A range of ancillary data can be included, for example, terrain, soils and geology.
- Analyses produce a detailed picture of the UK Broad Habitats, their patterns, inter-relations and environmental contexts, at a range of scales.
- Users can take stock, investigate environmental processes, model and predict environmental impacts, plan responses, devise management strategies and monitor their success in operation.

While the database does not show designations such as National Parks and Areas of Outstanding Natural Beauty, these should be possible to overlay within GIS.

3.1.2 NEXTmap

NEXTMap Britain[9] consists of a family of Digital Elevation Models (DEMs), captured and processed using the latest airborne radar technology that models the ground surface in great detail. The minimum tile size is half a square kilometre.

There are two basic DEMs. The Digital Surface Model (DSM), which is derived from radar signals bounced off the first surface encountered. This will include forestry and other vegetation, buildings, roads and other surface structures. The Digital Terrain Model (DTM) is a representation of the earth's surface with vegetation buildings and other cultural features removed revealing terrain characteristics that might otherwise be masked in the DSM.

The elevation calculation is made every 5 metres (known as post spacing) but it has been resampled to be available at 10 and 50 metres too. From the South East up to the Midlands covering many urban areas including the Thames basin, the data was captured as a Digital Surface Model (DSM) with an accuracy of 50cm. The DSM for the rest of England, Wales and Scotland was collected with a vertical accuracy of 1m.

A digital orthorectified radar image (ORI) dataset is also available providing a highly detailed greyscale image of the earth's surface. NEXTMap Britain shows elevation of the land but needs to be overlaid with aerial maps to give a better idea of the landscape.

3.1.3 Countryside Quality Counts

The Countryside Character Initiative is a programme of information and advice developed by the Countryside Agency on the character of the English countryside[10]. It includes systematic descriptions of the features and characteristics that make the landscape and guidance documents on how to undertake Landscape Character Assessment.

The Initiative came about because it was recognised that there was a need for a new approach to landscape assessment that would look at the whole of England's countryside - rather than just specific designated areas. It resulted in mapping the country into 159 separate, distinctive character areas.

The features that define the landscape of each area are recorded in individual descriptions that explain what makes one area different from another and shows how that character has arisen and how it is changing. Separate characterisation documents are available from the programme website for England for: North East, North West, Yorkshire and Humber, East Midlands, West Midlands, East of England, South East and London, and South West. These documents list each region's underlying features, cultural elements, changing elements, designations and 'Countryside Quality Counts' assessment[11].

While the programme contains valuable information, it does not contain data that are ready to be overlaid onto the LCM2000. However, the information can still be useful in future research as discussed in Section 4.1. Moreover, the 159 character areas are being grouped within a 'richness scale' in an ongoing project by Eftec, ADAS and TRL for the Department for Transport. This scaling, which should be publicly available later in 2006, could also be used in identifying areas that should avoided when planning transmission lines or given priority for undergrounding (e.g. 'richer' areas to be avoided etc.).

[9] http://www.bluesky-world.com/nextmap.html
[10] http://www.countryside-quality-counts.org.uk
[11] An example document for the North Pennines can be viewed here: (http://www.countryside-quality-counts.org.uk/cap/northeast/CA010.htm).

3.1.4 The Quality of Life Assessment

The Quality of Life Assessment[12] is a tool for maximising environmental, economic and social benefits as part of any land-use planning or management decision. It is promoted by four agencies: the Countryside Agency, English Heritage, English Nature and the Environment Agency. The Approach:

- stands back from areas or features and considers the benefits that they provide for human well-being ("what matters and why?");
- provides a systematic and transparent evaluation framework for all scales of decision-making;
- integrates environmental, social and economic issues;
- emphasises improvement of quality of life rather than acceptance of the status quo;
- values the common place as well as the unusual and rare;
- puts professional/expert judgements alongside the concerns of local people; and
- works with other tools and processes including Environmental Impact Assessment, Sustainability Appraisal, Community Planning and Best Value.

All applications of the approach involve the same six basic steps, which are reproduced in Box 3.1. This section introduces them and subsequent sections discuss them in more detail.

Box 3.1: Application of Quality of Life Assessment Approach

Step A: purpose The same basic approach can help with a wide range of different decisions and planning processes, from site briefs to regional planning guidance. But the details of what you need to do vary greatly with the purpose. So the essential first step is to be clear about the purpose of the study. This guide concentrates on examples from planning and environmental management.

Step B: identifying what is there The purpose of the exercise (step A) will imply which sources of social, economic and environmental benefits need to be studied. A variety of techniques including traditional survey methods and character assessment may be useful for identifying environmental features depending on scale and circumstances. For example, regional planning guidance will need to look at what is special or important at the level of the region. At the other extreme, a development control application can look solely at the ways the proposed development would affect the local area. For comparing potential development sites already identified, QoL Assessment could concentrate on the *differences* between them, whereas an exercise carried out to identify possible sites would need to consider the whole area.

Step C: benefits and services The key to the method is to ask: what are the benefits and services which are potentially affected by the planning process or the decision at issue? Many places or environmental features provide a wide range of different services, and being clear about the purpose of the study enables the work to concentrate on the issues that matter and can be influenced.

Step D: evaluation This examines the benefits and services systematically, using a series of questions:

who the services matter to, why, and at what spatial scale: for example habitat quality may matter for biodiversity at a regional or national scale, while recreational access may matter for quite specific groups of people from a small local area;

how important are they: which is a distinct question from the previous one: a service that matters at national level is not necessarily more important than one that matters only locally;

[12] http://www.countryside.gov.uk/LAR/Landscape/Quality/overview/index.asp

whether we have enough of them: it is more important to maintain services which are in short supply (or in danger of becoming so) than ones that are plentiful (though obviously there are degrees of scarcity, and the method should not be used as an excuse to let things decline to the minimum acceptable level). Where we currently do not have enough, the aim should be increase;

what (if anything) could make up for any loss or damage to the service: for example other places local people could go equally readily for the same types of recreation, or other areas that could be managed to support displaced communities of bird species. (Many services - notably historical and cultural significance - cannot be substituted.)

Expert judgement and community views both need to be reflected, so QoL Assessment draws on both public consultation and involvement processes and technical appraisal methods including (for environmental benefits and services) environmental impact assessment, landscape, ecological, archaeological and characterisation studies.

Step E: policy / management implications From the evaluation, this step draws clear messages about the aims or policies which would be needed to ensure that social, economic and environmental benefits were maintained or enhanced rather than damaged. The form these take will depend on what decision or process the exercise is feeding in to. For example structure plan policies need to be framed very differently to planning obligations for a particular site – another reason why it is so important to be clear about the purpose for the study in advance.

Step F: monitoring The benefits and services identified as important in the process are, for this very reason, the aspects of the environment which should be monitored. QoL Assessment thus provides its own performance indicators.

Source: http://www.countryside.gov.uk/LAR/Landscape/Quality/overview/index.asp

Steps A-E above are, in fact, very similar to what would need to be done in an economic valuation exercise. The difference lies in the way the benefits are measured where economic techniques use money as the measure and QoL assessment could use a variety of units. Nevertheless, the information generated by QoL can be an input to economic valuation.

3.1.5 Landscape Character Assessment

Landscape Character Assessment (Countryside Agency and Scottish Natural Heritage, 2002)[13] is a guidance document prepared for all those involved in influencing the landscape. Landscape Character Assessment recognises the fundamental role played by farming and forestry and by different forms of development in fashioning the landscape. It could be used for planning, and landscape conservation, management and enhancement. Box 3.2 provides the steps of the guidance.

Box 3.2: Landscape Character Assessment Guidance

STAGE 1: CHARACTERISATION

[13] http://www.countryside.gov.uk/lar/landscape/cc/landscape/publication/

These are the practical steps involved in initiating a study, identifying areas of distinctive character, classifying and mapping them and describing their character:

• **Step 1**: **Defining the scope.** All Landscape Character Assessments need a clearly defined purpose. This will critically influence the scale and level of detail of the assessment, the resources required, those who should be involved in its preparation, and the types of judgement that are needed to inform decisions. As part of defining the scope, it is normally essential that a familiarisation visit is undertaken to allow those involved in commissioning or carrying out the assessment to learn more about the character of the location's landscape.

• **Step 2**: **Desk study.** This involves review of relevant background reports, other data and mapped information, and use of this information to develop a series of map overlays to assist in the identification of areas of common character (usually draft landscape character types and/or areas).

• **Step 3**: **Field survey.** Field data is collected in a rigorous way to test and refine the draft landscape character types/areas, to inform written descriptions of their character, to identify aesthetic and perceptual qualities which are unlikely to be evident from desk information, and to identify the current condition of landscape elements.

• **Step 4**: **Classification and description**. This step then refines and finalises the output of the characterisation process by classifying the landscape into landscape character types and/or areas and mapping their extent, based on all the information collected, followed by preparation of clear descriptions of their character. These descriptions will often recognise 'forces for change', such as key development pressures and trends in land management.

STAGE 2: MAKING JUDGEMENTS

• **Step 5**: **Deciding the approach to judgements**. Further work is usually needed to decide on the approach to making the judgements that will be needed to meet the objectives of the assessment. This will require thought to be given to the overall approach, the criteria to be used and the information needed to support the judgements to be made. Decisions will be needed on the role to be played by the stakeholders.

Sometimes, especially if judgements are needed about landscape value, it may be necessary to look for evidence about how others, such as artists and writers for example, have perceived the area. Additional field work may be necessary, especially when additional applications of the assessment only emerge after the original characterisation has been completed. Information from the field survey will need to be reviewed on topics such as the condition of landscape elements and features and the sensitivity of the landscape to change.

• **Step 6: Making judgements**. The nature of the judgements and the outputs that may result from the process will vary according to the purpose of the assessment. The main approaches to making judgements within the landscape assessment process are: landscape strategies; landscape guidelines; attaching status to landscapes; landscape capacity.

Source: http://www.countryside.gov.uk/lar/landscape/cc/landscape/publication/

3.2 Economic valuation research

In what follows, we review a small selection of studies that have sought directly to measure the disamenity of living close to electricity transmission lines and pylons. To our knowledge there are no studies specifically of gas transmission options and those studies of electricity transmission have all examined high voltage transmission lines (HVTLs) and pylons. In addition, existing studies all measure use values; that is, the values that local householders or recreational users place on visual amenity. For transmission projects in some (but certainly not all) locations it may be that non-use values are relevant. Examples might include national parks and Areas of Outstanding Natural Beauty. Again, we are unaware of studies that have looked at this particular issue; there may be studies that are not in the public domain. As a result, we can make no claims to have been exhaustive as regards the literature we discuss here.

There appear (to our knowledge) to be no empirical studies in the public domain that have sought to value the potential costs of undergrounding HVTLs in terms of increased risk of outage etc. A report by SAIIR (2000) does outline a number of studies of the value of outage events or changes in these risks in Canada, Australia and the UK. Both UK studies appear though to be market research rather than examples of stated preference methods designed according to the principles of welfare economics, and so their findings arguably are of indicative value only. One of these studies[14] by BMR (1999) on behalf of Norweb reckoned that household willingness to pay and the value that commercial electricity users placed on a reduction in (current) outages by just under 20 per cent was about £6 and £12 per annum, respectively.

3.2.1 Revealed preference studies

There is a small number of studies of landscape which used revealed preference methods (travel cost and hedonic property pricing). These are reported in Eftec and Entec (2002) and not repeated here. Here the focus is on the visual impacts of transmission lines.

A recent paper by Sims and Dent (2005) has provided a detailed picture of the way in which house prices might be affected by proximity to pylons and HVTLs. The authors employ two specific methods. Firstly, a hedonic price model which seeks to 'tease out' the degree to which proximity affects the prices at which residential properties change hands. As with all hedonic studies this was a case-specific application to a particular housing market in the UK, in this instance near Glasgow. The second method was a survey to elicit the expert views of property valuers and agents as regards changes in house prices due to proximity to pylons and HVTLs. Mail questionnaires were administered to a random sample of members of both the Royal Institute of Chartered Surveyors and the National Association of Estate Agents.

The main findings of both elements of this study are outlined below:

- The hedonic study revealed that there was a negative and significant reduction of about 12% (in the range of about 6 to 17%) for houses which were within 100 metres of a HVTL.
- For houses within 100 metres of a pylon the drop in property price was steeper at just under 21%.
- These property price changes are described relative to similar properties sited 250 metres away from the visual amenity. At this distance and beyond, the impact on house prices appears to become insignificant.
- In the case of proximity to pylons, the negative impact on property prices varies depending on whether this disamenity is to the front or rear of the property. The largest negative impact occurs when the pylon interrupts the view of the front of the house.

[14] The other study was carried out by MORI (1999) on behalf of the (then) Office of Electricity Regulation.

- In the case of proximity to HVTLs, if these lines are at the rear of a property, the impact on price can be positive. Sims and Dent report that similar findings have been uncovered elsewhere in the literature. The authors argue that the likely explanation for this 'anomaly' is that further development is typically prohibited on the land across which these HVTLs stretch.

- The findings of the survey of property valuers and agents are broadly in line with the hedonic study. Taken at face value, this is useful information. While the survey was an expert assessment and so does not tell us about householders' preferences either directly or by uncovering information from householders' revealed behaviour, it might be considered, in principle, to give 'generalisable' results.

- The survey revealed that any reduction in property values because of proximity to pylons and HVTLs is by no means solely determined by visual impacts on the surrounding landscapes. Perceptions of health risks as well as other safety concerns and noise/buzzing were also said, by these expert respondents, to be of parallel importance.

3.2.2 Stated preference studies

There are a plethora of stated preference studies that have looked at the value that individuals or households place on the visual amenity provided by a variety of landscapes. These are reported in Eftec and Entec (2002) and hence are not repeated here. Here our focus is on the visual impact of transmission lines. Very few studies, in the public domain, appear to have tackled the specific issue of valuing the visual impacts of electricity (and gas) transmission options. Two studies are, however, worth discussing.

The first of these is Willis and Garrod (1998) which used stated preference methods to examine the extent to which public service networks create visual disamenity, with the focus on canal users. A survey of 1,000 people at canal sites across England found that WTP values to avoid encountering electricity pylons and other cable and pipeline crossings amounted to £0.09p, £0.10p and £0.05p, respectively, for a 1% reduction in each of these utility service crossings over canals. Aggregating these values over the three million households that visit canals each year suggests a loss of well-being in the region of £35 million per year. These data in cost-benefit analysis can be used to assess the net benefits of removing these structures and burying them underground to eliminate the visual disamenity.

The second study, which is by Day *et al.* (2001) (the results of which are also discussed in Atkinson *et al.* 2004, 2006), had two primary objectives. Firstly, the authors examined how rural and urban households rank a series of five new tower designs relative to the current ('Lattice') design for the pylons that support HVTLs. Secondly, the authors sought to elicit, using contingent valuation, how much rural and urban households were willing to pay for new tower designs and an option that would replace overhead transmission lines (and towers) with underground lines. These WTP estimates can be interpreted as reflecting preferences for visual amenity *only* and refer to removing a specified 2km stretch of pylons and HVTL.

In total, 799 interviews were undertaken in England and Wales during August and September 2001 in 17 urban locations and 17 rural locations. Respondents were sampled from an area of up to 5km from an existing stretch of transmission towers. Specifically, respondents lived in households within one of four geographical bands: (i) within 500m of the HVTL; (ii) between 500m and 1km from the HVTL; (iii) between 1km and 2km from the HVTL; (iv) between 2km and 5km from the HVTL. This geographical distinction permitted an evaluation of how preferences towards tower design change according to the distance that a household is from the specified stretch of towers.

Table 3.1 provides a summary of the main findings of this study. Respondents were given the option of spreading their payments over three years so it should be noted that the WTP estimates in the table are present values. For the whole sample, mean WTP was £66 (in the range of £55 to £76). While mean WTP was higher in the rural sample than in the urban sample this was not significantly so.

Table 3.1: Mean and Median WTP for Undergrounding of Existing HVTLs

	Whole Sample		**Urban Sample**	**Rural Sample**
	Mean **(95% confidence interval)**	**Median**	**Mean** **(95% confidence interval)**	**Mean** **(95% confidence interval)**
WTP for Undergrounding of HVTLs	£66 (£55 - £76)	£9	£58 (£44 - £73)	£72 (£57 - £88)
Households living within **500m** of a HVTL	£81 (£55- £106)	...	£76 (£43- £114)	£85 (£53- £125)
Households living between **500m to 1km** from a HVTL	£70 (£51- £89)	...	£61 (£41- £82)	£80 (£48- £119)
Households living between **1km to 2km** from a HVTL	£55 (£38- £78)	...	£41 (£17- £78)	£66 (£45- £91)
Households living between **2km to 5km** from a HVTL	£46 (£33- £62)	...	£40 (£25- £56)	£51 (£32- £72)

Source: adapted from Day *et al.* (2001)

It is worth noting that the distribution of WTP values was wide. This indicates that a relatively small number of people were willing to pay relatively high amounts, while a larger number of people were willing to pay relatively small amounts. The result of this wide distribution is a disparity between mean willingness to pay (what the 'average' person would pay) and median willingness to pay (what the majority of people would pay). As mentioned in Section 2.4.3, this raises interesting issues especially when what is sought is some means of capturing WTP. The findings in Table 3.1 are broadly indicative of 'distance-decay' (See Section 2.4.4), i.e. WTP declines the further away households are located from the disamenity. For the whole sample, mean WTP for households living within 500m of a stretch of pylons was £81 while the mean value for households living between 2km to 5km away was £46. However, it is also interesting to note that even at these larger distances, WTP remains significantly positive which means that households living beyond 5km away from the disamenity might be willing to pay something (on average) for its removal.

3.2.3 Summary comments

How can the findings of the Sims and Dent (2005) and Day *et al.* (2001) studies be reconciled? The important thing to note is that these estimates are measuring somewhat different non-market goods. In the latter study, the researchers sought to elicit WTP measures which did not include increases in property values that householders might enjoy if existing pylons were removed and HVTLs were buried under the ground. As a consequence, questions were included to identify those considering the change in value of their property. Only about 7% of respondents were motivated by the impact that removing the towers will have on the market value of their property. Of those respondents, the expected changes in property values quoted cover a broad range from under £100 to over £10,000. All those quoting property value changes greater than £3,000 lived within 500m of the towers. Those identified through this question were asked to re-estimate their WTP under the assumption that their property would not change in value. Put another way, WTP estimates corresponded to the value that a household placed on visual amenity over-and-above any change in property value that might occur. In this sense, the findings of the two studies are complementary rather than alternative.

3.2.4 Willingness To Pay for new designs

Might a new design for transmission towers be viewed as a less visually intrusive option? This issue was explored in Atkinson *et al.* (2004). Options investigated included five new pylon designs as well as the current (Lattice) design. Each new pylon design satisfied a set of engineering and design parameters determined by NGC. Visual representations of pylons in a ‘typical’ urban setting were also prepared and survey respondents were either shown pictures of the rural setting or of the urban setting, depending on their area of residence.

Respondents initially were presented with visual representations of each of the six tower designs and asked to rank these designs according to their visual appearance within a (specified) landscape. The findings suggest that many people think positively about new designs in that a majority of respondents chose *at least one* new design in preference to the current design. That said, preferring a new design (to the current one) does not necessarily translate into being willing to pay to see that new design replace the old. Thus, to the extent that a respondent ranked any new design as being preferable to the current one, he or she was asked to express his or her WTP to see a specified (2km) stretch of towers in their local area changed to this new design. A majority of respondents were not actually willing to pay anything for new designs. Put another way, these people can be thought of as being indifferent between maintaining and replacing the current design. For certain designs a notable number of respondents did actually state that they would actually suffer a loss in their wellbeing if the current design was replaced by this new (less preferred) design, i.e. they did not like the new design. To the extent that these respondents would pay to maintain the status quo, this can be characterised as a negative WTP for the proposed change. These (negative) values were elicited through indicators of how inconvenienced respondents would feel if a less preferred option were to replace the status quo; that is, the time and cost respondents were prepared to commit to opposing the change.

Taking into account both this apparent indifference (zero WTP) and negative WTP, the results indicate that mean WTP for two of the new designs were not significantly different from zero (see Table 3.2 for the statistically significant results). For those three designs where mean WTP was significantly positive these mean values were still low, i.e. a one-off payment of a few pounds per household on average. In addition, for all five new designs, median WTP was zero. That is, if it was put to a vote, a majority of respondents would choose *not* to have the current design replaced by any of the new ones at any (positive) price.

Table 3.2: WTP for New Tower Designs

	Mean WTP for new design (95 per cent confidence interval)
Single Pole with Arms	£6.60 (£5.11 - £8.42)
One Pole	£4.86 (£3.32 - £6.54)
Double Pole with Arms	£4.67 (£3.40 - £6.06)
V Pole	£0.45 (-£0.69 - £1.61)
Windmill	-£0.40 (-£1.31 - £0.35)

Source: Atkinson *et al*. (2004)

4. Research Options

This section reviews three research options:

- *Option 1: Environmental constraints mapping* – this involves overlaying landscape characterisation maps with the current and planned HVTLs (from company capex plans). It can be an option in its own right in terms of showing higher priority landscapes that should be avoided (or may warrant undergrounding), however, would not generate economic value estimates that could be used in an economic appraisal. It could also be an input to the other two options as it will help with defining the type and magnitude of environmental change. This option is discussed in Section 4.1.

- *Option 2: Benefits transfer* – this option will involve making use of the currently available economic value evidence. Therefore, it requires less time and fewer resources than the next economic valuation option and could generate economic value estimates of the visual disamenity of current HVTLs and hence benefits of alternatives. But the option is limited by the available literature. This option is discussed in Section 4.2.

- *Option 3: New valuation work* – this option involves study(ies) that build on and expand the available information. While there is unlikely to be sufficient time within the TPCR framework to undertake such a study, we briefly discuss the likely form this option may take in Section 4.3.

4.1 Environmental constraints mapping

This is an impact assessment option that can be undertaken at two levels:

1. at the national level
2. at the site-specific level

Both levels are discussed below. This option is most relevant for re-routing or undergrounding options.

4.1.1 Environmental constraints mapping at the national level

Here the usefulness of the LCM2000 database on its own and its combination with the information contained in the Countryside Quality Counts (CQC) should be investigated. LCM2000 shows landscape types but does not help with prioritisation, i.e. in assessing where new HVTLs should be built or where they should be buried underground etc. This is why the database should be combined with a landscape assessment methodology and among those reviewed in Section 3, CQC seems to be the most relevant. This will allow a GIS mapping of broad habitat types and their prioritisation and can tell us which areas new HVTLs should avoid or where undergrounding is justified. The exercise can be tailored so that mapping can exclude urban areas or focus only on 'honey pot' sites.

This is likely to be a rather involved exercise since while the data are available, it will require effort to adapt it to the needs of this research option. In addition, the combined LCM2000 and CQC mapping will need to be overlaid with the company business plans.

The CQC information is freely available. Some of the LCM2000 data are provided free of charge, while others are charged different levels of fees depending on the type of use – commercial, non-commercial or academic. We have not been able to look at this option in sufficient detail to assess its time and resource requirements to combine LCM2000 and CQC and overlay this with business plans. However, we could arrange for a more technical specification to be prepared (under separate contract) by a landscape assessment and GIS expert.

4.1.2 Environmental constraints mapping at the site-specific level

At a particular site, the visual impact of HVTLs is determined by the view from various points, other elements in the surrounding landscape, who sees the view, and so on, as well as the type of landscape. This is why at this level a more involved approach may be warranted and NEXTMap may be more suitable than LCM2000 as it shows elevation. However, this need not apply to all sites across the country but a sample of the types of sites. In fact, this option is most relevant for protected areas and would, in principle, involve a three staged approach.

- Stage 1: preparation of a constraints and opportunities map, identifying all relevant designated areas, which have a direct influence on the choice of routes;

GIS analysis would be conducted to bring together a number of key datasets of all relevant designated areas within the AONB/ National Park. As well as NEXTMap, Ordnance Survey (OS) 1:50,000 TIFF rasters covering the whole of the protected area and their associated TFW world files would be used.

These would bring together all the datasets such as landscape character, Sites of Special Scientific Interest, Scheduled Monuments, Nature Reserves, Special Conservation Areas and Special Protection Areas etc. and would be used as backgrounds to the project within the GIS and in the final map production.

All viewpoints would also be added as this is considered to be particularly important in relation to weighing up the benefits to the general public.

- Stage 2: overlay the opportunities map with the network of overhead lines supplied by the electricity companies.

For strategic mapping of the whole country, selective identification of overhead lines would be required in order to keep the mapping manageable. The information would need to be focused on a particular network and a filter applied.

Once all the data has been compiled, GIS would allow analysis and interrogation of all the information and a series of indexed printed maps at A3 size covering the National Park area showing all designated areas.

If the information on the site is in the correct vector format it would allow for a smooth incorporation into the GIS. However, if it can only be supplied in a raster format, it would mean that the data would need to be converted into a format that can be read by a GIS system, and it will have to be digitised to create vector data.

- Stage 3: targeted field visits, consultations with relevant Parish Councils/stakeholders and preparation of a summary report.

Field visits would be made to any target routes identified as having particular potential for undergrounding; these would include any areas specifically selected by the Protected Area Authority. Field assessments would include:

- Local conditions which will impact on engineering work e.g. rivers/ topography/ geology;
- The degree to which the overhead line is a discordant feature in the landscape;
- Where and how the line crosses the landscape;
- The density of the wires, stays, services, outriggers, terminal poles and pole mounted transformers; and
- The level of visual impact when viewed from different locations; open access/ Public Rights of Way/ viewpoints and 'honeypot' sites/ local communities.

Meetings could be held with relevant Parish Councils/ stakeholders, so that their views and all routes selected by them are properly considered. This would be an opportunity to discuss their priorities, explain to them how the routes are being selected, so that they would appreciate that it is being done objectively.

As with the national level option, we have not been able to assess the exact time and resource requirements of this option. But we are happy to arrange a landscape assessment and GIS expert to provide this information under separate contract.

4.2 Benefits transfer

The key to the routine policy use of non-market values is a greater reliance on *benefits transfer*: that is, taking a unit value of a non-market good estimated in an original or primary study ('study site') and using this estimate (perhaps after some adjustment) to value benefits that arise when a new action is implemented ('policy site'). Benefits transfer is the subject of a rapidly growing literature (see, for reviews, Champ *et al*. 2003, Pearce *et al*. 2006).

The reason for the growing literature on benefits transfer and increasing use of it in cost-benefit analysis is obvious as the need for costly and time-consuming original studies of non-market values would be vastly reduced. This is just as true in the case of incorporating environmental values – such as improvements in visual amenity – in either cost-benefit appraisals of electricity and gas transmission options or 'capturing' these values in price control arrangements.

The most crucial stage of a transfer exercise is selecting the estimates from the existing literature that are most relevant for the policy site (e.g. per household benefits). This also implies choosing a particular transfer approach. The approach might range from transfers based on extremely simple rules of thumb to relatively complicated computations.

An example of a simplistic approach would be to 'borrow' an estimate of WTP from an original study carried out at some location (or locations) and apply it – unadjusted – to some new location where we wish to evaluate a new project. The virtue of this approach is clearly its simplicity and the ease with which it can be applied once suitable original studies have been identified. Of course, the flipside of this relative straightforwardness is that it is likely to fail to reflect important differences between, for example, the characteristics of the study site (or sites) and the policy site. Moreover, if these differences are significant determinants of WTP, then this transfer approach ignores likely divergences in WTP at the original and policy locations.

Determinants of WTP that differ across locations might include for example:

- The socio-economic and demographic characteristics of the relevant populations – this could consist of income, educational attainment and age.

- The physical characteristics of the study and policy sites – this might consist of the type of landscape (e.g. its features and its relative importance) that is affected by the change in the case of gas or electricity transmission options.

As a general rule, there is little evidence that the conditions for accepting unadjusted value transfer hold in practice. These conditions would either amount to locations being effectively 'identical' in all these characteristics, or such characteristics not being significant determinants of WTP, a conclusion which sits at odds with intuition.

Many commentators have concluded that, at least in theory, the more sophisticated the approach the better, in terms of accuracy of the transfer. The rationale for this conclusion presumably being that there is little to commend benefit transfer if it is inaccurate and misleading. While it may be that intermediate approaches – such as taking account of income differences only – could be used, what this means in practice is that transfer exercises are based on models that account for as many differences as possible between sites. Greater sophistication, however, comes at a cost if it means that benefit transfer becomes the preserve of the highly trained specialist. This conflict will only be resolved once analysts have learned more about when and where simple approaches are justified and when they are not. Unfortunately, in general, the literature on benefits transfer currently seems to be far from this resolution. Moreover, more recent / ongoing research is also finding results that argue the opposite, i.e., simpler benefits transfer approaches could in fact be more accurate.

In the case of evaluating new electricity and gas transmission options using benefits transfers, a key problem remains the lack of original studies that are the bedrock of a good transfer exercise. The revealed preference study, by Sims and Dent (2005) based on a hedonic model of house price determinants was site-specific but this does not mean that its results cannot be transferred. The stated preference study by Day *et al.* (2001) drew respondents from a number of different sites across England and Wales. In this sense then any of these results could be transferable[15]. However, analysts would need to be explicit in their analysis about important caveats and assumptions regarding any such transfer exercise as well as take account of the sensitivity of their recommendations to changes in assumptions about economic values based on these transfers.

Day et al. (2001) is also useful in presenting a distance-decay function as this would aid a more precise aggregation over 'affected populations' than a single WTP estimate would. However, even this cannot help if WTP to avoid disamenity of HVTLs is affected by the type of landscape

[15] Unfortunately, there were too few households sampled at each location to actually perform a benefits transfer test as this objective was beyond the scope of the study.

(especially 'honey pot' landscapes like national parks or Areas of Outstanding Beauty (see Section 4.3)) since these were not tested separately in that study.

The benefits transfer option for undergrounding options would involve:

- An assessment of where the current and alternative HVTLs options are will be needed, even though as detailed an analysis as in option 1 may not be necessary;
- Identification of the affected population in total and in different distance bands; and
- Aggregation of WTP estimates across the affected population by multiplying per individual or household values by the relevant population.

This assumes that the existing literature summarised in Section 3.2 is deemed to be sufficient.

The benefits transfer option for re-routing will follow the same steps to estimate the benefits to the area transmission lines are taken away from. However, on the other side of the cost-benefit equation, the cost of visual disamenity in the new location also needs to be estimated. But because the WTP estimates are not differentiated by landscape types this cost would also be estimated on the basis of the affected population as above. Since the relative aggregate benefit is determined by the relative size of the population, this could lead to perverse outcomes, i.e. re-routing HVTLs from more densely populated areas to less densely populated areas, which may also be designated areas. Therefore, landscape characterisation and economic value assessments should be thought through together.

The benefits transfer option for new pylon designs could use the results of Atkinson *et al.* (2004) following the same steps as above:

- An assessment of where the current pylons will be replaced with new designs will be needed, even though as detailed an analysis as in Option 1 may not be necessary;
- Identification of the affected population in total and in different distance bands; and
- Aggregation of WTP estimates across the affected population by multiplying per individual or household values by the relevant population.

Note that this option is only necessary for the designs for which mean WTP estimates were positive and significantly different than zero. Others, for which the mean WTP was found to be negative should not be considered on the basis of that study.

In all cases, the choice of how large the population that holds values for a given environmental improvement is or the degree to which there is 'distance-decay' needs a level of expert (landscape and economic) judgment.

How accurate would estimates need to be in order to inform actual price control arrangements? Or, to put it another way, what degree of accuracy would analysts have to demonstrate? For both of these questions it is difficult to escape a conclusion that more original studies of this policy problem are needed. It may be that evidence about transfer validity and exercise can be gleaned from 'similar' policy contexts such as changes in the visual appearance of landscape from other (non-transmission) causes. However, if greater specific knowledge about accuracy is desired, then this is the investment cost that is needed to realise this objective.

Assuming that the first stage of the benefits transfer approach, i.e. the determination of which type of alternative HVTL option is of concern and where these are placed, is ready, benefits transfer (using the simple approach) may take a matter of days per project. It is not possible to give a total cost and time estimate since the number of projects is not known.

4.3 A new economic valuation study

New valuation work could involve the following steps and research considerations:

- *Valuation method*: adopt and develop the contingent valuation (CV) questionnaire used in the study by Day *et al*. (2001), which sought WTP of local households for an improvement in visual amenity. Some number of considerations in developing this questionnaire include:

    - Is the valuation context one of electricity pylons and high voltage transmission lines? If yes, adapting the questionnaire would be relatively straightforward and would consist of:

        (a) Probable dropping of the valuation of new pylon designs (on the basis of the unlikely empirical significance of these options); and
        (b) Some reflection on updating the survey in the light of recent developments in the CV literature, i.e. since 2000/1.

- *Distance-decay*: in the Day *et al*. study it is was found that WTP for removing pylons remained positive up to 5km away from overhead lines. A better guide to distance-decay at greater distances would be gained if new work sampled well beyond this distance.

- *Benefits transfer*: test explicitly whether household WTP estimated at one (rural or urban) site is transferable to a different (rural or urban) site. This would need to ensure that sufficient numbers of respondents were sampled in the locations where the benefits transfer tests would be carried out.

- *Non-use values*: to date no studies have examined the loss of non-use value arising from new or existing transmission line proposals. If, however, these projects affect e.g. national parks, then economic appraisal is effectively giving no explicit weight to these impacts. The following considerations would be important:

    - Assessment of which areas might feasibly be characterised by non-use values;
    - Population to be sampled:

        (a) It could be that this could be done as part of the development of the Day *et al*. work. For example, a valuation scenario about “nationally important” landscape can be added to the original scenario about the local (and more typical) landscape; and
        (b) Distance-decay could apply to non-use values and so it would be useful to examine this.

- *Recreational use value*: for local landscape affected by transmission projects, recreation users can be thought of as coming mainly from local households. Their WTP responses presumably will reflect visual amenity enjoyed during recreational activities. For nationally important landscapes, recreational users will come from further afield. Surveys of non-use value might actually be capturing total value, i.e. including recreational use. However, some consideration might also be given to whether specific user groups such as the Ramblers’ Association (whose WTP might be relatively high) should be sampled in a more focussed way.

- *Other points*:

    - Hedonic property pricing studies indicate significant changes in house prices for those properties in close proximity to transmission lines and pylons and those properties which are further away. The study by Dent and Sims (2005) usefully employs an expert survey to get a generalisable picture for the UK. This does not unbundle the house price change so we do not know what specifically the change attributable to visual impacts is. Hence, this work could be usefully developed.

- The use of expert surveys (as previously discussed) raises the issue of whether similar methods could be used for stated preference research. For example, "Delphi" style methods have been used elsewhere. This would involve asking a sample of valuation experts for their assessments of household WTP for the provision of a particular environmental good. As a low-cost alternative to new valuation work that included household surveys this could be considered further. Other questions such as property rights could be addressed within this approach. For use in appraisal and/ or pricing however, a key consideration would be whether an expert approach is an adequate (e.g. robust and defensible) proxy for actual (but more costly and more time-consuming) fieldwork.

All of the above options would benefit from the environmental constraints mapping option presented in Section 4.1. Site-specific analysis may in fact be more useful in this case since it could provide more site-specific information for locally applicable questionnaires and help with developing visual aids to present landscapes with and without the HVTLs option.

The above options for new valuation work have different time and cost implications. And while they are interesting from a research agenda angle, our understanding is that these are unlikely to be possible within the framework of TPCR. Therefore, we have not developed these options further.

5. Research Options

We have discussed, in this report, a number of issues that are relevant to using estimates of the value of visual impacts arising from electricity and gas transmission options in the forthcoming Transmission Price Control Review (TPRC). In doing so, we have reviewed a number of existing valuation studies as well as explored methods and proposals for landscape classification more generally. Lastly, we have discussed possible future research needs.

We conclude by summarising a number of the main themes of this report from the perspective of the question of why it is important to understand the value of the visual impact of transmission options.

The first response to this question is that it is important to have this information in order to know whether a transmission project is justified by a social cost-benefit appraisal. This would entail an assessment of all the social benefits and social costs that arise as a result of the proposal (or proposals). Given that one such impact will be the change in visual amenity then it becomes important to know what value individuals and/ or households place on these changes. Otherwise, the impact in effect receives zero weight in the cost-benefit calculation.

Existing studies, as we have discussed, provided some interim guide to the economic importance of these impacts. These studies have sought to uncover or elicit values for households living in very close proximity to transmission lines, households living close to lines (but perhaps far enough away for any disamenity not to be reflected in house prices) and recreational users of particular areas where transmission lines are situated. There are no studies of the values that non-users might place on particularly unique and important landscapes although these too might be non-trivial in some cases.

A crucial issue here is the extent to which the results of these existing studies can be used to help in making decisions about the cost-benefit case for undergrounding or re-routing of electricity and gas transmission proposals. While this existing literature offers a proximate guide to the merits of new transmission options on grounds of visual impacts, it is arguable that using such data for the TPCR may impose a greater requirement for accuracy. If this is the case, it is difficult to escape the conclusion that more original valuation work is needed. If this work were to incorporate a benefit transfer test then a direct answer to the otherwise unknown problem of accuracy could be provided.

This leads us to a second response to the question of why do we need to know the value of visual impacts of transmission proposals. As well as providing useful information for cost-benefit analysis, this work is also important if what is required is an assessment of how such values can be 'captured' in order to help finance transmission proposals that are at the same time more costly proposals but entail less visual intrusion. That is, if a household is willing to pay some amount of money for an option that places transmission lines under-the-ground (rather than using transmission towers) then there is a prima facie case for passing on some of the costs of this project to this household in return for the benefits that it receives. In addition, to raising issues about the accuracy of the willingness to pay information on which these price increases are to be based, this also switches or, at least, adds emphasis to whether what should concern decision-makers is what the majority of people would be willing to pay (rather than what people would pay on average).

Whatever the ultimate conclusion, it remains the case that more generally social cost-benefit analysis could play a far more significant and meaningful role as an input to planning decisions about the merits of transmission proposals than is currently the case.

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