Explaining public preferences for high voltage pylon designs: An empirical study of perceived fit in a rural landscape

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***Highlights (for review)**

- The UK Government held a design competition for high voltage powerlines in 2011
- We examine public preferences for conventional and alternative pylon designs
- The winning design in the competition was the most preferred
- But undergrounding is a more acceptable mitigation measure than alternative designs
- This highlights the need for public discussion of different models of power supply

ABSTRACT

In many countries, electricity transmission networks are being upgraded and developed arising from policies aiming to decarbonise energy systems. However, new power lines are often controversial, due to their perceived negative impacts on rural landscapes. Despite the fact that visual impacts are an important element of public objections, to date, little research has analysed public preferences for alternative pylon designs, as well as investigating the social and psychological factors that might explain such preferences. This paper sought to address this gap, informed by research on public acceptance of renewable energy technologies, using a survey conducted with a representative sample of UK adults (n = 1519). The findings indicate that the 'T-pylon' design, winner of a recent competition, was most strongly preferred and the one most perceived to fit with a rural landscape, by comparison to the conventional 'A frame' design and a 'Totem' design shortlisted in the competition. Linear regression analyses indicated three factors that explained perceived fit, regardless of the designs: lower levels of educational attainment, positive general attitudes towards transmission lines and higher levels of trust in National Grid were associated with positive perceptions of fit of the pylons in a rural landscape. Finally, findings concerning public support for diverse mitigation measures indicated that the use of alternative designs was less supported than burying new powerlines underground and routing pylons away from homes and schools. The implications of these results for more sustainable grid networks are discussed.

KEYWORDS: Electricity pylon designs; public preferences; mitigation measures; socio-psychological approach

MAIN TEXT

1. Introduction

In most industrialised societies, electricity supply systems are centralised (Watson & Devine-Wright, 2011) and composed of two main sections. The transmission section ensures that electricity is distributed, at higher voltages, from the sites of energy generation (e.g., usually large-scale infrastructures, like coal fired power plants, wind farms) to substations, these being then responsible for transforming electricity to be provided by the distribution networks, at lower voltages, to industrial, commercial and residential areas (Butler, 2001). However, while the components of the distribution network are arguably those more visible and present in our daily lives, research suggests that 'A frame' high voltage pylons are iconic of electricity networks in the UK (Devine-Wright & Devine-Wright, 2009), often triggering opposition and contestation (Devine-Wright, Devine-Wright, & Sherry-Brennan, 2010). This is posing a challenge for current national and international agendas on climate change, which aim to streamline changes in power generation from fossil fuels (*e.g.*, gas and coal) to low carbon (*e.g.*, renewable) sources, deal with security of supply and ageing electricity infrastructures (Ellis, 2008; Parliamentary Office for Science and Technology, 2011; Renewables Directive, 2009).

There have been calls to simultaneously decarbonise *and* decentralise energy supply systems (*e.g.*, Greenpeace, 2005), amid claims that more localised generation, supply and use can lead to a more sustainable electricity system across economic, environmental and social dimensions (Watson & Devine-Wright, 2011). Nevertheless, at present in the UK, despite some debate at governmental and policy levels (Parliamentary Office of Science & Technology, 2011; Ofgem, 2008), the transition towards decarbonisation is mainly being pursued through a process of continuity with the centralised model and representation of electricity systems (Devine-Wright, 2006). Applying this model to the integration of more renewable energy in the electricity system implies that new large-scale sites of power generation, usually in remote rural

or coastal areas, will have to be connected with sites of demand, usually in distant urban and industrialised areas.

In the UK, the government aims to source 15% of electricity consumption from renewable energy sources by 2020 (Renewables Directive, 2009) by comparison to current levels of only 7% (RenewableUK, 2011). Within a centralised model of the electricity system, this makes it essential to upgrade and develop the current electricity transmission network. Large investments are forecast, estimated at over £100 billion (Department of Energy and Climate Change, 2011). However, recent cases of public opposition to the construction of new power lines (Cotton & Devine-Wright, 2011; Highlands before pylons, 2008; No Moor Pylons, 2011; Save Our Valley, 2012) suggest that efforts to develop electricity networks will be extremely difficult, unless public perceptions about these infrastructures are better understood and integrated in that process.

Research on the publics' opposition or support for other energy-related technologies, such as wind farms, has shown that one of the most important predictors of attitudes is the perceived visual impact they have in landscapes (Nadai & van der Horst, 2010; Sustainable Energy Ireland, 2003; Wolsink, 2000), and it is therefore suggested that "*if the perceived visual quality of a project is positive, people will probably support it*" (Wolsink, 2000; p.51). However, perception of landscape amenity is "complex and not yet fully understood" in the literature about facilities for renewable energy (Wustenhagen, Wolsink & Burer, 2007, p.2690; Nadai & van der Horst, 2010).

Regarding public acceptance of high voltage power lines, while the literature about this topic is relatively scarce (Devine-Wright, et al., 2010), it has already highlighted that one of the main reasons for public opposition is the visual impact they have in landscapes and their scenic quality (Cotton & Devine-Wright, 2011; Devine-Wright, in press; Soini et al., 2011). Such visual impacts may also come with other collateral impacts, such as reducing property values, harming fauna and flora and being perceived to threaten health due to electromagnetic fields, which in turn usually also shape negative perceptions

about these infrastructures (Elliott & Wadley, 2002; Soini et al., 2011). Recent cases of public opposition to high voltage power lines in the UK further corroborate those findings (e.g., Save Our Valley, 2012).

In the UK, opposition to technological interventions has been related with the cultural significance that rural landscapes occupy. Since the 1920's planning in the countryside – a term widely used in British culture to refer to rural areas (Woods, 2011) - has been essentially restrictive, trying to "preserve an ideal of rural life" (Cosgrove, 1984, p.264; Cowell, 2010). Landscapes have therefore been the basis of a 'rural idyll' and have become "inseparable from English culture and sense of identity" (Park & Selman, 1995, p.183), shaping attitudes towards countryside conservation (Woods, 2005). Changes to this landscape are, therefore, often not welcomed (Park & Selman, 1995).

To deal with some of these challenges, in 2011 the UK government launched a competition for new pylon designs, run by the Royal Institute for British Architects for the Department of Energy and Climate Change and National Grid Plc., the company responsible for transmission networks in England and Wales. Architects, designers, engineers and students of these disciplines were invited to "rethink one of the most crucial but controversial features of modern Britain: the electricity pylon" (Royal Institute for British Architects, 2011). Namely, they were asked to propose new pylon designs, set within a prescribed image of the rural countryside and taking into consideration the Holford rules[1] in the design of the pylons. Existing pylons in the UK are still based on the steel lattice tower A-shape design (Figure 1) which has remained unchanged since the 1920's (Department of Energy and Climate Change, 2011). The competition led to a new pylon design - the 'T-shape' (Figure 3)- being chosen by a jury panel consisting of UK government, electricity industry and architect representatives.

However, evidence is lacking about public perceptions of pylon designs, and also about other measures that could be taken to mitigate the rural impacts of new powerlines. On one hand, few studies have actually analysed people's

[1] These rules aim to preserve the amenity value of landscapes when new high voltage power lines are constructed, and have to be followed by the transmission network operator in England and Wales.

preferences between different pylon designs and, more importantly, the factors which may allow us to better understand those preferences and the perception of fit between pylons and landscapes. Moreover, the Pylon Design Competition did not formally take account of public perceptions of new designs, despite the fact that experts and citizens' evaluations of the aesthetic qualities of both infrastructures and landscapes are often contrasting (Bonnes et al., 2007; Vouligny, Domon, & Ruiz, 2009). On the other hand, the research conducted to date on this issue has been mainly focused on examining pylon design changes as a mitigation measure for the impacts of overhead lines in landscapes, therefore neglecting a broader perspective on mitigation measures: both public campaigns against new overhead high voltage lines and the findings of research suggest that the undergrounding of power lines may be perceived as the only solution to alleviate the perceived negative impacts of power lines (Devine-Wright, in press; No Moor Pylons, 2011).

The present research aims, first, to empirically examine UK residents' preferences between current and new pylon designs following the Pylon Design Competition. Then, to analyse, in an exploratory way, the socio-demographic and psychological factors which may explain the perception of visual compatibility between different pylons and rural landscapes and, finally, to examine how UK residents evaluate different mitigation measures for the impacts of new overhead power lines in landscapes, including design changes. The implications of these results for a sustainable electricity grid development in the UK will then be discussed.

1.1. Public perceptions of high-voltage power lines

Academic interest in socio-psychological aspects of public acceptance of overhead high-voltage powerlines is not new. In the 1980s, Furby and colleagues (1988) highlighted how opposition to electric power transmission lines began in the USA in the 1950s. After the electrification of most of the country, transmission lines were in many cases no longer synonymous with

progress and associated with materialist values (Inglehart, 1995), but instead perceived as a menace to quality of life, particularly issues of health and safety, the environment and the landscape (Furby et al., 1988). These authors proposed a conceptual framework to understand the factors explaining acceptance or opposition for new powerlines that includes the role of aesthetics as a predictor of attitudes towards transmission lines and, through this, of acceptance or opposition. However, despite the fact that public opposition to high voltage power lines continues to exist and to have high visibility (Devine-Wright et al., 2010), the social and psychological aspects related with electricity networks in general have received little attention (see Devine-Wright et al., 2010; Soini et al., 2011) and, particularly, the visual impacts of pylons (Elliott & Wadley, 2002).

Existing research has been concerned with how people represent electricity networks and associated meanings. This line of inquiry has highlighted how A-shape steel lattice pylons are used by the public as an image for electricity networks, and are associated with both positive and negative meanings (Qualter, 1995; Devine-Wright & Devine-Wright, 2009). For instance, Qualter (1995) used visual research methods to understand how children represented electricity networks. Results show that while children generally do not have a sense of how the distinct parts of the network interrelate, they would typically draw pylons to visually represent it. Following this study, Devine-Wright and Devine-Wright (2009) made use of visual methods in a study about everyday understandings of electricity networks with adult participants from two locations in the UK, one where new power lines were being proposed, and one where such proposals were not made. They asked participants to draw the components of the electricity network and revealed that, across the groups, "the single, HV electricity pylon was iconic of what was commonly described as a 'network of distribution' rather than a network of transmission" (Devine-Wright & Devine-Wright, 2009, p.363), something that further corroborates the importance of the pylon as an image of electricity networks. Moreover, this

study also showed that A-frame pylons were described as big or huge, monstrous, ugly and as eyesores[2].

In a similar vein, Cotton and Devine-Wright (2010) used Q-methodology to research discourses of powerline siting with stakeholders and community members from Somerset, UK, in the context of proposals for a new power line. They demonstrate that statements positing pylons as symbols of progress, as a part of contemporary landscapes and as having positive aesthetic characteristics were strongly rejected by the participants of the affected communities. This is corroborated by a recent survey conducted in southern Finland in an area with diverse characteristics regarding its population, the density of power lines and the surrounding landscapes (Soini et al., 2011). The authors show that power lines are the most negatively evaluated of several human elements considered in the survey, such as telemasts and main roads, and strongly perceived as defacing the landscape and making the living environment more unpleasant (Soini et al., 2011).

This body of research highlights then that pylons – namely steel lattice ones in the UK – are a visual symbol of electricity networks and are often seen in negative ways. Would then a change in pylon design transform these perspectives and dissociate power lines from some of the negative impacts usually associated with them? Another line of inquiry concerned with public perceptions of transmission lines has focused on the influence of the visual impacts of transmission lines on their acceptance. Specifically, the effect of pylon designs on those perceptions has been analysed through the examination of peoples' preferences between different types of pylon designs and perception of compatibility between pylons and landscapes.

For instance, Priestley & Evans (1996) surveyed residents living close to a high voltage transmission line in a suburban area in San Francisco, USA, and examined their preferences between two different pylon designs, the old/current one – steel lattice pylon - and a new, alternative, design – tubular steel towers (see Appendix – Figure A.1). This new design was preferred by

[2] It is however noteworthy that participants living in the location where no new transmission lines would be constructed also symbolized pylons positively.

47% of the respondents, while 21% preferred the old one. Atkinson, Day & Mourato (2006) also revealed that alternative pylon designs (see Appendix – Figure A.2) are preferred over current ones – A-shape steel lattice pylons- through a study conducted with residents from urban and rural locations in England and Wales living near to existent high voltage transmission lines: 69% of respondents preferred at least one of the new pylon designs presented over the current pylon design. The authors also explored preferences for the undergrounding of new power lines, as well as their willingness to pay both for replacing pylon designs and for undergrounding – or maintaining the *status quo*. Results show that in general people are not very willing to pay for either of the two measures, even if willingness to pay for undergrounding is higher than for the most preferred alternative pylon design, especially by residents in rural locations. Since respondents were not very willing to pay for changes to pylon designs, the authors concluded that despite people preferring new designs to the old one, "people can be thought of as being 'indifferent' between maintaining and replacing the old design" (Atkinson, Day & Mourato, 2006, p.236). However, this study did not draw upon a representative sample of UK residents and it did not explore which factors can be associated with preferences for different pylon designs. It also relied only on 'willingness to pay' measures to compare people's preferences between pylon design changes and undergrounding as mitigation measures, when people can assume that it is not their responsibility to pay for those changes (e.g. People Against Pylons, 2012), as they are mitigation measures for the construction of nationally significant infrastructures which are not decided at a local or even at a regional level in the UK (Ellis, 2008; Guide for Localism Act, 2011).

In sum, research has shown that the visual impact of pylons is one of the main dimensions influencing negative perceptions of high voltage power lines and that people tend to prefer alternative designs to the conventional one. However, it is not still clear whether changing pylon designs is perceived to be a significant mitigation measure of the impacts of overhead transmission lines in landscapes. In addition, it is unclear whether public attitudes towards high voltage power lines would change if new pylon designs were used. In other

words, it has not yet been explored which factors can help us understand perception of fit between pylons and landscapes and their differential or similar impact for distinct pylon designs.

For that task, an important contribution can be taken from recent research that has examined public attitudes towards high voltage power lines. Devine-Wright (in press) argues that literature on public acceptance of renewable energy technologies has followed two explanatory pathways: first, focusing on personal and place related factors (e.g. age, education, feelings of rootedness or place attachments, e.g. Vorkinn & Riese, 2001) and second, project related factors, including trust (Midden & Huijts, 2009), degree of information about the infrastructure (Furby et al., 1988), perceived proximity to the development (Priestley & Evans, 1996), or perceived local impacts (Upham & Shackley, 2006). The analysis integrated these two sets of factors to explain attitudes towards a high voltage power line to be built in South West England. Results show that personal and place related factors were each able to explain 4% of the variance of the attitude towards the power line, while project-related factors (perceived impacts, trust and procedural justice) explained an additional 31% variance in power line acceptance (Devine-Wright, in press).

In this sense, it could be expected that these factors - personal, place and project related – may also be able to help us understand perception of fit of pylons with landscapes. Their comparative impact on the acceptance of different pylon designs may help to uncover if and why different pylon designs are perceived as fitting differently in landscapes and, more specifically if factors such as negative beliefs and expected impacts of pylons, for instance, would only be associated with the perception of compatibility for the traditional pylon design or with new ones as well. Moreover, other factors, such as more general values like materialism (Kilbourne & Pickett, 2008) and environmental concern (Milfont & Duckitt, 2004), which have been related with attitudes and beliefs regarding other issues with environmental impact (Stern, 2000) and also with different landscape preferences (Kaltenborn & Bjerke, 2002), may also be expected to contribute.

Arising from this review, our study had three aims. First, to examine public preferences for both conventional and new pylon designs, as selected or shortlisted in the recent competition in the UK. Second, to analyse the factors that may explain the perception of fit between different types of pylon designs and a rural landscape. Third, to investigate the potential impact of diverse mitigation measures, including undergrounding and new pylon designs, upon levels of acceptance of new powerlines.

2. Methodology

2.1. Procedure and sample

A survey tool was used to examine preferences for different 400 kV pylon designs, their perception of fit with a rural landscape and acceptability of different mitigation measures. These questions were part of a larger survey, conducted online by YouGov in January 2012, with a representative sample of UK residents to understand their perceptions about high voltage power lines. Thus, the survey included questions aiming to tap other socio-psychological and demographic factors, which could be associated with those perceptions. The survey was completed by 1519 participants, representative of all UK adults (aged 18+) by age, gender, socio-economic classification and region, according with the 2001 Census. The characteristics of the sample are summarised in Table 1.

---------- Table 1----------

2.2 Measures

To enable comparisons, standardised images were used that situated three pylon designs in a rural landscape that was devoid of buildings and people (See Figures 1-3) and that satisfied the Holford rules (National Grid, 2011). The pylon images consisted of the traditional A-shape pylon; the new 'T-shape' design which won the design competition, proposed by Bystrup; and another design shortlisted in the competition – the Totem pylon - proposed by New Town Studio Structure Workshop. These were sourced from National Grid and the respective designers (Bystrup and New Town Studios) and the order in which they were presented to participants was randomised.

---------- Figure 1 ----------

---------- Figure 2 ----------

---------- Figure 3 ----------

A ranking question was used to examine preferences for each of three pylon designs in which participants chose their first, second and third preferences. This method has already been used to measure preferences for different pylons designs (see Atkinson, Day & Mourato, 2006).

To capture the perceived fit or compatibility between the three pylon designs and the rural landscape, a single question was used: "To what extent do you agree or disagree that this pylon fits well with this place or landscape?". This was answered for each pylon considered via a 5-point Likert-type scale of responses, from 1 (strongly disagree) to 5 (strongly agree). To capture beliefs about different mitigation measures, participants were asked: "*If a new high voltage powerline was proposed in the area where you live, would it be more acceptable to you, if…*". Following this, nine mitigation measures were presented, including "*The powerline was completely buried under*ground";

"*Routed away from homes and schools*" and "*New pylon designs were used instead of the typical ones for overhead power lines*". Answers to these statements were given via a similar Likert-scale to the previous question, with responses ranging from 1 (strongly disagree) to 5 (strongly agree).

Regarding personal factors[3], questions captured participants' gender, age, educational qualifications, socio-economic grade, voting intention and length of residence. Regarding socio-psychological factors, trust in National Grid plc., the developer responsible for constructing new high voltage power lines, was measured through a single item (cf. Devine-Wright, in press): "*How much trust do you have in National Grid Plc. (i.e., their arguments for new powerlines)?*", with response options comprising a 5 point Likert-type scale from 1 (Do not trust at all) to 5 (Trust completely). Degree of familiarity with high voltage power lines was measured through a single item: "*Overall, how familiar are you with the electricity powerline system in the UK?*", with options from 1 (Not at all familiar) to 5 (Very familiar). Perceived proximity to existing powerlines was measured through the question "*How close do you live to the nearest section of an existing high-voltage powerline*?" and answered through a 5-point Likert-type scale from 1=Not at all close to 5=Very close. Expected local impacts of powerlines were measured through a set of 13 items based on previous studies (e.g., Cotton & Devine-Wright, 2010; Devine-Wright, in press); these consisted of negative (9 items - Alpha=.92[4]) and positive (4 items - Alpha=.67) local impacts (e.g. *High voltage power lines will reduce the quality of the landscape; High voltage power lines will safeguard the delivery of electricity*).

Two measures of attitudes towards high voltage power lines were included. General attitude towards transmission lines was measured through three items (e.g. *In general, I accept overhead power lines*) and all items were answered through a 5 point Likert scale from 1 (strongly disagree) to 5 (strongly agree) (Alpha=.86). Attitude to a local powerline was measured through two items (e.g. *To what extent would you accept the construction of a*

[3] A measure of place attachment was not included because we did not asked participants about perception of fit between pylons and the place where they live.
[4] All items accessing the same concept (e.g. negative local impacts of powerlines) were analysed for the purpose of composing scale measures. Cronbach's alpha indicates the internal reliability of the scales composed by those items. Values from 0.7 to 1 indicate good levels of reliability.

new high voltage power line near your community (for example, within 3 miles)?" with response options from 1 (Not at all accept) to 5 (strongly accept). The two items were highly and significantly correlated (r=.86; p<.001) thus allowing for their combination to compose a scale capturing attitudes towards local power lines. Finally, concern for the environment was measured through the abbreviated version of the New Environmental Paradigm Scale (Milfont & Duckitt, 2004), composed by 4 items (e.g. *The balance of nature is very delicate and easily upset*) (Alpha=.88). Beliefs about materialism were measured using 3 items (e.g. *I admire people who own expensive homes, cars and clothes*) from the Materialism scale (Kilbourne & Pickett, 2008) (Alpha=.67). Both of these scales consisted of statements answered via 5-point Likert-type scales, from 1 (strongly disagree) to 5 (strongly agree).

3. Results

3.1. Preference for pylon designs

Descriptive data for the ranking question indicated that the most preferred design (i.e. ranked most frequently - 77%) was the T-shape (see Figure 4). This design won the competition launched by the UK Government. The traditional A-shape pylon, currently in use in the UK, was least often chosen as the most preferred design by only 10% of the respondents.

---------- Figure 4 ----------

Nevertheless, the other new design – the 'Totem pylon' – was chosen as a first option by only 13% of respondents, which, taken together with the results for second and third ranks, suggests that while there is a clear preference for

the T-shape design compared with the other two, there is no clear preference between the traditional and the Totem designs. To better understand what could be associated with these preferences, we then analysed how the personal and socio-psychological factors correlated with the questions about the perception of fit between the different pylons in a rural landscape.

3.2. Perceived fit of the pylon designs in a rural landscape context

The T-shape pylon design was perceived to be a better fit in a rural landscape context in comparison to the other two designs. The traditional and Totem designs hold similar results: people tend to disagree that either design fits well in a rural landscape. In fact, there is no statistically significant difference ($t(1457)=.812$; non-significant.) between the mean perception of fit of the traditional pylon ($M=2.4$) and the mean perception of fit of the Totem pylon ($M=2.4$). The T-shape pylon is perceived to fit significantly better ($M=3.5$) than both the traditional pylon ($t(1460)=-34.13$; $p<.001$) and the Totem pylon ($t(1458)=-32.29$;$p<.001$).

3.3. Factors associated with the perceptions of fit of the pylons with a rural landscape

Correlations between the measures on perceptions of fit and other personal and socio-psychological variables were inspected, in order to see which ones should be included as independent variables in a prediction model[5] (see Table 2).

---------- Table 2 ----------

[5] The variables gender and political intention of vote were transformed into dummy variables. For gender, female respondents were compared with male respondents. For voting intention, participants voting for Labour, Liberal Democrats, Scottish National Party, another party or not voting were compared with those voting for the Conservatives.

Inspection of the correlations reveals three aspects. First, some factors do not relate significantly with any of the pylon's perceived fit, including gender, voting intentions (including for the Liberal Democrat party, the Scottish National Party, another party or not voting), familiarity with electricity networks and perceived proximity to a high voltage power line. Second, some significant factors consistently correlated with the perceived fit for each pylon, such as socio-economic group, trust in National Grid Plc., general attitude towards high voltage power lines, perceived local positive and negative impacts of high voltage power lines, and attitudes towards local power lines. Thirdly, there are several factors that reveal a significant correlation, but only for some designs (e.g. environmental concern and materialism). Regression analyses were then conducted inputting only factors into the models that were significantly correlated with at least one of the dependent variables (see Table 3). The aim of the regression was to examine the impact of socio-psychological and personal factors on pylon' designs perception of fit with a rural landscape when all the significant factors are considered together. Therefore, separate regression analyses were conducted for each pylon design. For all three regressions, inspection of VIF and Tolerance values[6] showed that those were far from threshold values that would signal problems of multicollinearity (Field, 2005).

---------- Table 3 ----------

Results show that the models explained 15-19% of the overall variance in perceptions of fit of the different pylons. Although this is not particularly high for any of the dependent variables, nevertheless, the results indicate that personal and social-psychological factors do play a role in explaining public

[6] The Variance Inflation Factor (VIF) and Tolerance values indicate if a predictor has strong linear relationships with other predictor(s), in which case it would not be possible to obtain unique estimates of the regression coefficients (Field, 2005).

perception of fit of pylon designs in a rural landscape. Results also show that three factors are transversally important predictors: education, trust in National Grid Plc. and general attitude towards high voltage power lines. Regardless of the specific design, the less educational qualifications participants have, the more they trust National Grid Plc., and the more positive their attitude towards high voltage power lines generally, the more they perceive pylons to fit well with a rural landscape.

The results also reveal some differences between the regressions. First, the explained variance for the traditional pylon design was highest (19%), perhaps due to the fact that this design was most familiar to participants. Second, the findings indicate a different pattern of significant explanatory factors for each pylon design. For example, in terms of personal factors, the perceived fit of the traditional pylon design was explained by education and intention to vote for the Labour party, while the perceived fit of the T-shape pylon was influenced by education and socio-economic status. Age was a significant factor explaining the perceived fit of the Totem design, but was not significant for either of the other two designs.

In terms of social-psychological factors, the regressions indicate that materialism influences the perception of fit of the traditional and T-shape pylons, but not of the Totem pylon. This suggests that the more people endorse materialist values, the more they perceive the traditional and T-shape pylons to be compatible with a rural landscape. Local negative impacts is also an important predictor of both the perception of fit of the traditional pylon and the T-shape pylon, namely, the more people perceive new power lines to have negative local impacts, the less they perceive the traditional and T-shape pylons to be compatible with a rural landscape. In contrast, positive local impacts is not a predictor of the perception of fit of the traditional pylon, but is a positive predictor for both the Totem and T-shape pylons, showing that the more power lines are perceived as having local positive impacts the more these two designs are perceived as fitting well with the rural landscape. Attitude towards a local powerline is only significant for predicting the perceived fit of the traditional pylon design: the more positive the attitude towards power lines being built

near where participants' live, the more they perceive traditional pylons to be compatible with a rural landscape. Finally, concern for the environment, against expectation, did not emerge as a significant predictor. It might be expected that willingness to conserve the environment from human influence would be associated with low perceived fit of high voltage pylons in a rural landscape, yet this was not found.

3.4. The impacts of different mitigation measures on local powerline acceptability

Nine mitigation measures referring to issues of undergrounding, routing, design, participation and compensation were evaluated to identify whether they might impact upon the acceptability of local powerlines (see Figure 5 for the descriptive data).

---------- Figure 5 ----------

The findings indicate that using new pylon designs was one of the least significant mitigation measures (*M*=3,34; *SD*=1,09) while burying powerlines underground (*M*=4,25; *SD*=1,04) and routing them away from homes and schools received highest levels of support (*M*=4,18; *SD*=1,02). The least supported mitigation measures, along with new pylon designs, are the transportation of electricity generated from renewable sources (*M*=3,35; *SD*=1,21) and providing financial compensation to those living within sight of the lines (*M*=3,29; *SD*=1,19). There were no statistically significant differences between the means for these three mitigation measures. The means of all other measures are significantly different from each other, with the exception of "Routed close to roads and railways", "Routed away from scenic landscapes" and "Local residents involved from an early stage", which are equally endorsed ($F(8,9848)=169.29$; $p<.001$; $n2=.121$).

4. Discussion

In the context of climate change concerns and related energy policies, new electricity grid developments are being proposed to connect contexts of renewable and nuclear energy generation to contexts of consumption, maintaining a centralised approach to the electricity system (Watson and Devine-Wright, 2011). Public opposition stems, at least in part, due to concerns about the visual impacts of large scale structures such as high voltage electricity pylons or wind turbines in rural landscapes (Cotton & Devine-Wright, 2011; Save Our Valley, 2012). It is therefore important to fully understand public perceptions of high voltage power lines generally and, specifically, about the pylon designs used for overhead transmission lines and their impact in rural landscapes, if new grid developments are to be conducted in a sustainable way. The present paper aimed to address this issue by drawing on a representative sample of UK adults to explore preferences for different pylon designs following the competition launched by the UK Government (RIBA, 2011). Taken together, the results can inform decision-making processes regarding new power lines, while also revealing which pylon designs are preferred by UK residents and why, by indicating some of the factors that explain those preferences and the perceived impacts of different mitigation measures, including using new designs.

The findings indicate that the T-shape design was by far the most preferred by UK residents and the one that was perceived to fit better in a rural landscape, by comparison to two alternatives: the traditional A frame lattice design and one of the designs shortlisted in the competition, the Totem design. The results suggest that new designs are not more preferred than conventional designs in all cases (Atkinson, Day & Mourato, 2006), but that the public has specific preferences regarding the design of pylons: while the T-shape pylon was the most preferred, there was no significant difference between the Totem and traditional pylon designs. One issue arising from the study is whether the

preferences for the T design were influenced by the design competition itself and associated media reporting (e.g. BBC News, 14th October 2011). It may be that the results of the competition and associated media reporting served to legitimise the choice of that design and its role in replacing traditional pylons. To investigate this, future research could investigate levels of public awareness of the competition itself and the winning design, in addition to public preferences.

According to the literature, pylons are iconic of electricity networks (Devine-Wright & Devine-Wright, 2009), with their visual impacts being one key element of public objections to new overhead power lines (Furby et al., 1988; Priestley & Evans, 1996; Soini et al., 2011; Devine-Wright, in press). It could thus be expected that perception of compatibility between pylons and rural landscapes would not only be dependent on the evaluation of their aesthetic characteristics *per se*, but also on more general beliefs, attitudes and meanings about the impact that pylons and the associated high voltage power lines can have in landscapes and other related dimensions. However, it could also be expected that these factors would impact differently upon the perception of fit of each pylon design, as negative meanings, beliefs and attitudes towards pylons may be most strongly associated with the conventional and familiar A frame design.

Building from this literature in order to explain the preference findings, regression analyses were conducted using a diverse set of personal and social-psychological variables as potential predictors of the perceived fit of pylons in a rural landscape, following previous research (Devine-Wright, in press). The results indicated modest amounts of variance explained (15-19%) and three factors that were significant in explaining preferences for all three designs: educational attainment, trust in National Grid and general attitudes towards high voltage powerlines. This suggests that evaluations of the designs are at least in part influenced by broader beliefs and attitudes about pylons and power lines, as well as specific beliefs about the characteristics of a particular design in a particular rural context.

A first conclusion that can be taken from these findings then is that some of the results here presented should be read with caution: if it is incontestable that the large majority of UK residents prefers the T-shape design and perceive it as fitting better with a rural landscape than the other two, this does not necessarily mean that opposition to new high voltage power lines will cease to happen if the T-shape design starts to be used: people's beliefs, attitudes and expectations regarding the overall impact of pylons and power lines will continue to shape their perceptions about the compatibility between pylons and landscapes, independently of the designs used for grid development. This is further corroborated by the results presented about the acceptability of new transmission lines if different mitigation measures were to be taken: changing pylon designs is actually one of the least supported measures. Fully undergrounding a line and routing it away from homes and schools are the measures that are suggested to be most likely to lessen public objections. Interestingly, involving local residents in the decision-making process from an early stage was also strongly supported as a mitigation measure that would lead to greater levels of acceptability. This supports recent calls for more upstream engagement with communities directly affected by powerline proposals (Cotton and Devine-Wright, 2011).

Nevertheless, the results of the regressions also reveal some differences between the perceived fit of each pylon design. The traditional pylon is best explained by the sets of factors considered as independent variables in the regression models, although even in this case, barely 20% of the variance was explained, suggesting that future research is required to explore additional factors, not considered here, that may also play a role in explaining pylon perceptions. The fact that the traditional pylon was best explained by the analyses may be interpreted as arising from higher levels of familiarity with this particular design in comparison to the two new designs arising from the recent competition, which is supported by research indicating the iconic association of this particular design with grid networks generally (Devine-Wright & Devine-Wright, 2009). The analyses also revealed patterns of explanatory factors unique to each design. Beginning with personal factors, which are shaped by

belonging to specific groups, norms and values (Kaltenborn & Bjerke, 2002), it is interesting to see for instance that voting intentions were significant factors predicting perceived fit. Specifically, intention to vote for the Labour party, as compared with the Conservative party, in a forthcoming general election, emerged as a significant predictor only for the Traditional and Totem designs' perception of fit in a rural landscape. This may be related to the fact that the Pylon Design Competition, which chose the T-shape pylon design, was part of the agenda of the Coalition Government formed by the Conservative and Liberal-Democrat parties.

Regarding other socio-psychological factors considered, it is notable that materialism is a stronger predictor of the T-shape pylon perception of fit, something which suggests its relation not only with perceiving (or not) electricity as an asset of modern societies and with more traditional values (Inglehart, 1995; Furby et al., 1988) – as in the case of its relation with the traditional pylon perception of fit – but also with technological and aesthetic innovation and progress. It is also notable that environmental concern did not emerge as a significant predictor of perceived fit, against expectation. This might stem from the fact that the statement used did not refer to issues of rural or countryside conservation specifically, instead referring to 'environmental' or 'nature' issues more generally.

Another important finding concerns the diverse ways that perceived positive and negative impacts of powerlines emerged as significant factors for the different designs. Negative impacts (e.g. to affect local birdlife negatively) was only a significant predictor for the traditional and T-shape pylon designs' perception of fit. However, positive impacts were significant for the Totem and T-shape pylon designs' perceived fit. Positive impacts were measured by statements concerning the importance of power lines for guaranteeing security of supply and for generating jobs in their construction and maintenance. Expectations regarding these positive impacts are important only for the new designs, not the old one, suggesting then that when it comes to evaluating the compatibility between the traditional pylon design and landscapes, beliefs about positive impacts of power lines are not relevant. Inversely, the traditional

pylon design perception of fit is explained by local negative impacts, which is likely to stem from its historical associations as being big or huge, monstrous, ugly and as eyesores (Devine-Wright and Devine-Wright, 2009).

However, local negative impacts also influence the perception of fit of the T-shape design, suggesting then that, independently of the design of the pylons being traditional or T-shape, the more people expect power lines to bring with them local negative impacts, the more they perceive pylons as not being compatible with a rural landscape. This is, again, a very relevant finding in line with the ones regarding the consensual predictors of perception of fit for all the pylon designs, since it highlights that while people may have preferences for some designs over others, this does not mean that they will accept the designs they prefer in specific scenarios, namely, in a rural landscape, in all cases. As with wind power facilities, it seems that the perceived quality of the landscape or place in which infrastructure is proposed is an important determinant of public responses to new overhead powerlines, and not the designs of the pylons themselves (Nadai & van der Horst, 2010; Sustainability Energy Ireland, 2003). Finally, it is also interesting to see that while attitudes towards a local high voltage power line is a significant positive predictor of the perception of fit of the traditional pylon design, the perception of fit of the Totem and T-shape designs are evaluated regardless of the attitude people have about the construction of new power lines in the place where they live.

This research has several limitations. First, it would have been useful to compare a greater number of alternative designs and landscape backdrops to reveal people's preferences in more detail. Future research can adopt similar visual methods to research on wind farms in multiple rural and semi-urban contexts such as upland areas, coastal zones and industrial areas (cf. Sustainable Energy Ireland, 2003). The findings concerning mitigation measures from this study suggest the likelihood of public opposition to powerlines that are sited close to homes, schools and scenic landscapes, regardless of pylon designs used. The findings also suggest public acceptance of siting close to existing infrastructure such as roads and railways. Future research can build on these findings to systematically examine diverse pylon

designs in specific rural and non-rural contexts, and even to provide information regarding each pylon design's characteristics, such as their size and materials (Atkinson, Day & Mourato, 2006). This can then help to reveal distinctions between the preferences for specific pylon designs and the specific contexts in which they are situated. Also, the study is limited by its exploratory correlational design that is limited in making inferences regarding causality. For example, it might be expected that the perception of fit of the different pylons with rural landscapes influences perceived negative and positive impacts of power lines, rather than vice-versa. Future research can adopt different designs and methods, for example experimental designs and qualitative methods that can reveal causal relations more systematically and reveal underlying beliefs and values with more richness than a survey method can achieve. Finally, the results should be taken with caution, not only due to the above mentioned exploratory nature of this study and the not very large effects obtained (the explained variance of pylons' perception of fit in landscapes was in all cases below 20%), but also because as already highlighted changing pylon designs may not be the most significant mitigation measure of the effects of overhead powerlines in landscapes.

Nevertheless, there are also several important contributions of this research to the literature about perceptions of high voltage power lines and, specifically, of pylon designs. This research made use of images of pylon designs that actually exist and are being considered to replace the old pylons. It also provided a first examination of the possible personal and social-psychological factors explaining perception of the compatibility between pylon designs and rural landscapes, as well as evidence of the acceptability of new transmission lines in the places where they live in the presence of several mitigation measures.

Therefore, the findings can have important implications. First, they highlight that even if there are some pylon designs that are preferred over others, perceiving pylon designs as being compatible with landscapes depends also on several personal and psychological factors related to broader beliefs and attitudes regarding high voltage power lines. In this vein, they emphasise that

even "*if the perceived visual quality of a project is positive, people will probably support it*" (Wolsink, 2000; p.51), visual quality here has to be defined not only through the presence of certain aesthetic 'qualities' in technological structures, but also through the absence of such structures at all, as the results for the undergrounding of new lines suggests. In many cases of controversy (e.g. Save Our Valley, 2012), objectors argue for not having pylons in rural landscapes at all, independently of their design. Thus, research on pylon designs should go beyond the single analysis of people's preferences between different – old and new – pylon designs and focus more on understanding the real acceptance of new pylon designs as a relevant mitigation measure, among others, of the visual impacts of new overhead power lines.

In this way, these findings also provide some suggestions that can be integrated into decision-making processes regarding policies on new grid developments. First, the fact that general attitudes towards power lines and trust in National Grid Plc. showed up as transversal predictors of perception of fit for all the designs considered in this research, further suggests that independently of the pylon design used, engaging with stakeholders, citizens and communities about why new power lines are needed and trying to understand their concerns about power lines is crucial if overhead power lines are to be constructed in a sustainable way. As further discussed below, this engagement should arguably also involve some debate about whether new transmission lines are needed at all, when more decentralised and localised approaches to renewable energy generation could be fostered (Devine-Wright, 2006). This is also highlighted by the data that shows strong public support for the involvement of local residents at an early stage in decision-making processes about power lines. This data also emphasizes the importance of taking a more local and contextual approach to decision-making that takes into account the characteristics, concerns, needs and expectations of the specific communities to be affected. Second, public engagement processes when constructing new overhead power lines and even when devising new designs for electricity pylons should take into account how different personal and social-psychological factors are significant in explaining their perceived fit,

depending on the designs proposed. In this regard, it could be relevant to further explore similarities and differences between distinct communities and contexts concerning preferences for pylon designs and other mitigation measures (Nadai & van der Horst, 2010; Cowell, 2010) and to include those in the decision-making processes about new high voltage powerlines.

Finally, the results make the case for enlarging the scope of public discussion and debate around the acceptance of renewable energy and associated infrastructures (Wustehagen et al., 2007), to encompass not only the value of maintaining a centralised approach to electricity systems, but also the value of adopting a contrasting more decentralised and localised approach (Watson & Devine-Wright, 2011). The fact that the most chosen mitigation measure of the impacts of transmission lines by UK residents is the undergrounding of the lines might implicitly suggest that, for them, fostering renewable energy generation might be perceived as a positive agenda (Wustenhagen et al., 2007), but not if it is pursued within the current centralised approach that will require the construction of more transmission lines.

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APPENDIX

---------- Figure A.1 ----------

---------- Figure A.2 ----------

Table 1 – Sample characteristics

	Category	%
Gender	Female	48,1
	Male	51,9
Age	18-29	23,2
	30-39	14,1
	40-49	19,6
	50-59	16,3
	60-69	13,3
	> 70	13,5
Educational qualifications	None	10,8
	GCSE/O level	23,7
	A level	27,5
	Undergraduate degree	23,7
	Postgraduate degree	12,6
Socio-economic grade[1]	DE	32,6
	C2	14,4
	C1	31,6
	AB	21,4
Area of residence[2]	Urban	79,4
	Town/Fringe	8,9
	Rural	9,2
Length of residence	Mean	3,72 years (*SD*=1,3)

[1] The socio-economic grade is calculated based on the occupation of the chief income earner in the household.
[2] According with the Office for National Statistics Classifications. Responses from people living in Northern Ireland were not classified under this criterion.

Voting intention in a future election	Conservative party	27,8
	Labour party	27
	Liberal Democrats	5,8
	Scottish National Party	3,7
	Another party	8,4
	Not vote	9,8

Table 2 - Correlations between personal and social-psychological factors and the perceptions of fit of the pylons with a rural landscape

	Traditional pylon perception of fit	Totem pylon perception of fit	T-shape pylon perception of fit
1. Gender(Women)	.048	-.004	-.016
2. Age	-.077**	.060*	.004
3. Education	-.062*	-.087**	-.049
4. Socio-economic status	-.060*	-.124**	-.096**
5a.Town/fringe area of dwelling	-.018	.021	-.088**
5b. Rural area of dwelling	-.049	-.059*	-.005
6. Length of residence	.007	.020	.055*
7a. Labour voting	.096**	.156**	.034
7b. Liberal Democrat voting	-.017	-.049	-.005
7c. Scottish National Party voting	.000	.025	.022
7d. Another party voting	-.050	-.050	-.035
7e. No intention to vote	-.031	-.033	-.007
8. Materialism	.103**	.008	.116**
9. Environmental concern (NEP)	-.085**	.035	-.088**
10. Familiarity with powerlines	.043	.016	.051
11.Trust in National Grid	.257**	.169**	.251**
12. General attitude to powerlines	.304**	.171**	.267**
13. Proximity to existing lines	-.047	.075	-.004
14. Local positive impacts	.222**	.196**	.186**
15. Local negative impacts	-.358**	-.130**	-.281**

16. Attitude to a new local line	.358**	.221**	.255**

**p<.01; *p<.05

Table 3 - Regression analyses of the factors influencing the perception of fit of the three pylon designs in a rural landscape

	Traditional pylon		Totem pylon		T-shape pylon	
Factors	ß	*t*	ß	*t*	ß	*t*
Age	-.012	-.333	**.089***	2.480	.034	.951
Education	**-.067***	-2.104	**-.086****	-2.615	**-.069***	-2.133
Socio-economic grade	.026	-.820	**-.081***	-2.477	**-.090****	-2.774
Labour party voting	**.076***	2.439	**.130*****	4.058	-.008	-.237
Materialism	**.087****	2.679	.024	.709	**.125*****	3.759
Trust in National Grid	**.073***	2.141	**.094****	2.684	**.154*****	4.403
General attitude to powerlines	**.141*****	.3668	**.122****	3.089	**.107****	2.735
Local positive impacts	.043	1.207	**.139*****	3.819	**.078***	2.151
Local negative impacts	**-.169*****	-4.112	-.031	-.732	**-.218*****	-5.221
Attitude to local power lines	**.129****	2.907	.068	1.495	-.063	-1.387
	***Adj. R^2*=.193** F(14,871)=16.078; p<.001		***Adj. R^2*=.148** F(14,871)=11.961; p<.001		***Adj. R^2*=.160** F(14,872)=13.053; p<.001	

***p<.001**p<.01; *p<.05

MAIN TEXT

Figure 1 – The traditional pylon designs

Figure 2 – The Totem pylon design