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Research Paper

The landscape benefits of the burial of high voltage power lines: A study in rural areas of Italy

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HIGHLIGHTS

- Interviewees believe that landscape is an economic resource for Italy.
- 39% of the sample is not willing to pay for the burial of power lines.
- More than 50% of the sample is in favour of a burial policy.
- The burial finds an economic justification only in areas of relevant environmental interest.

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ABSTRACT

High voltage overhead transmission lines are a type of infrastructure with a major impact on landscape quality. As studies have shown, it is sufficient that a pylon occupies even a modest fraction of a view to cause a marked decline in the aesthetic quality of the landscape. Few studies have tried to make a monetary quantification of the landscape damage caused by high voltage transmission power lines. Those few focused attention on urban areas. In this study, by means of a discrete choice experiment, the willingness to pay of the Italian population to eliminate the landscape impact of high voltage overhead transmission lines has been estimated for the entire national territory with reference to four different landscape contexts (protected mountain and hill areas, protected plain and coastal areas, other non-protected hill and mountain areas, non-protected plain areas). The results obtained have demonstrated that the willingness to pay per kilometre of power line eliminated is higher in the mountain and hill natural parks than in the other areas considered. Using a simulation with a two costs hypothesis, the research shows that the social benefit from burying high voltage power lines would exceed the costs only in limited areas of the country.

1. Introduction

The electricity system consists of three phases: generation, transmission and distribution. Transmitting electricity means transferring the power produced in the plants to consumer areas. To cover long distances, electricity is transmitted at high voltage in order to reduce losses. The elements that form the Transmission Grid are power lines and power transformation plants. The Italian National Transmission Grid has a total of over 63,500 km of lines with three tension levels (380 kV, 220 kV, 150 kV) at an average density of 0.21 km per km^2. In other words there is 1 km of high voltage overhead transmission lines (HVOTLs) for every 4.75 km^2 of land. The lines are owned and managed by a national Transmission System Operator (TSO), Terna Spa, which is also in charge of planning new lines and grid development. To this end, the TSO produces an Electricity Grid Development Plan (subject to Strategic Environmental Assessment). This plan is drafted each year based on the following: the trend in electricity demand and the forecast of the demand to be met; the need to upgrade the grid; the requests for connecting new generation plants (including those from renewable sources) to the grid.

After transmission, the electricity is delivered to end-users by the distribution network. This network carries a lower voltage (medium and low voltage) and is owned and managed by several Distribution System Operators (DSOs).

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The transmission of electricity therefore involves large areas and can produce many negative externalities (Bickel & Friedrich, 2005; Doukas, Karakosta, Flamos, & Psarras, 2011) including: visual impact, damage to wildlife, risk for health due to electric and magnetic fields (EMF), noise, farmers' income reduction, effects on property values (Furby, Gregory, Slovic, & Fischhoff, 1988), archaeological sites and sites of special scientific interest.

This probably contributes to the negative attitude of some citizens towards the construction of electricity grid infrastructure, with opposition to new HVOTLs becoming increasingly frequent (examples are the "NO A LA MAT" movement in Spain, the opposition to the new HVOTL in Crognaletto or Udine-Redipuglia in Italy, the cases of the line between Beauly and Denny in Scotland, or the "monster mast" in the Hardanger Fjord in Norway, to name just a few), or requests for the burial of those existing, causing delays in the provision of new power lines and an increase in their costs (Cotton & Devine-Wright, 2013; Devine-Wright, 2012; Jay, 2004).

The opposition of citizens to new HVOTLs originates from a plurality of factors (Cotton & Devine-Wright, 2013), but a common denominator is that the technical solutions used might not be desirable from a social viewpoint because they fail to take into account the negative externalities that are generated. Negative externalities are one of the causes of market failures, namely of the inability of the market to determine an efficient allocation of resources. In this respect, in order to limit market failures and pursue a socially efficient allocation of resources it is necessary to intervene in order to limit negative externalities. The costs and benefits of such interventions should be carefully weighed in order to avoid the introduction of new market inefficiencies. With reference to HVOTLs, a cost–benefit analysis of alternative solutions for transmission grid planning implies the valuation of their benefits and a comparison with their costs. In other words, to understand which is the best strategy for transmitting electricity, along with technical aspects, the externalities associated with each option should be valued in monetary terms. Landscape impacts are only a fraction of the negative externalities caused by HVOTLs and, during a cost–benefit analysis their value should be summed with those of the other impacts. Nevertheless, the reduction of the perceived aesthetic quality of the landscape should not be considered of little importance because it may have numerous negative interactions with the wellbeing of the population and the economy of areas that rely on tourism.

Many studies in the last decades have highlighted that landscape quality affects people's wellbeing. It has been shown that the landscape interacts with numerous physiological parameters of an individual and that more pleasant landscapes tend to improve overall personal health (Berto, 2005; Hartig, Evans, Jamner, Davis, & Garling, 2003; Muñoz, 2009; Ulrich, 1984; Ulrich et al., 1991; Velarde, Fry, & Tveit, 2007; Wells, 2000). Some studies pointed out that the more pleasant landscapes generally have a restorative effect on people (Kaplan, 1995; van den Berg, Koole, & van der Wulp, 2003).

Studies have shown that on the plain pylons have a major negative impact on the aesthetic quality of the landscape (Arriaza, Cañas-Ortega, Cañas-Madueño, & Ruiz-Aviles, 2004; Devine-Wright, 2012; Kaplan, TaskIn, & Önenç, 2006; Soini, Pouta, Salmiovirta, Uusitalo, & Kivinen, 2011; Tempesta, 2006; Tempesta & Thiene, 2007). These results are likely due to the fact that pylons are a highly incongruous element in both rural and urban areas.

To reduce the landscape impact of the HVOTLs it is possible to bury them or to modify the shape of the towers. While the effect of undergrounding the cables is clear and evident, only a few studies analysed the aesthetic impact of different tower shapes and the results are not univocal or conclusive (Atkinson, Day, Mourato, & Palmer, 2004). The results of a research carried out by Devine-Wright and Batel (2013) highlighted that despite the fact that people prefer some tower designs to others, the best method for reducing the landscape impact of power lines is to bury them. Similarly Atkinson, Day, and Mourato (2006) found that the willingness to pay to bury the lines is much higher than the willingness to pay to improve the pylon design. However undergrounding the lines is not always possible or technically feasible, especially for those of very high voltage and it is much more costly than building overhead cables (ICF Consulting, 2003). To estimate the loss of benefits caused by the presence of HVOTLs, monetary methods can be used based on revealed preferences like hedonic pricing, or based on stated preferences like contingent valuation and discrete choice models.

There have been quite a number of studies conducted using hedonic pricing (Bond & Hopkins, 2000; Bottemiller, Cowger, & Cahill, 2000; Callanan & Hargreaves, 1995; Colwell, 1990; Cowger, Bottemiller, & Cahill, 1996; Delaney & Timmons, 1992; Des Rosiers, 2002; Gregory & von Winterfeldt, 1996; Hamilton & Schwann, 1995; Ignelzi & Priestley, 1991; Jackson & Pitts, 2010; Kinnard & Mitchell, 1984, 1988; McNair & Abelson, 2010; Pacific Consulting Services, 1991; Sims & Dent, 2005), but the results have not been uniform regarding the effective impact of HVOTLs on property values. In general the reduction in value seems to fade almost entirely at a short distance from the pylons and a significant effect has rarely been found on the value of properties situated at more than 100 m. In a recent literature review Jackson and Pitts (2010, p. 258) found that "the effects that were found ranged from approximately 2% to 9%" but "in most studies no effects were found and in some cases a premium was observed".

Nevertheless, with this approach it is not possible to correctly evaluate the overall loss of social benefits due to the presence of power lines since landscape has both use and non-use values (Mendes, 2012, p. 238; Turner, Pearce, & Bateman, 1984), and hedonic pricing is not suitable for estimating non-use values. Moreover in most rural areas the population density is very low so it is not possible to estimate the landscape impact of HVOTLs on house prices because there is insufficient buying and selling for the hedonic pricing method to be applied.

Only a few studies have utilised stated preferences (Atkinson et al., 2004; Garrod & Willis, 1998; Giaccaria, Frontuto, & Dalmazzone, 2010; Girardi, Maran, & Brambilla, 2012; Marazzi & Tempesta, 2005; McNair, Bennett, Hensher, & Rose, 2011; Navrud, Ready, Magnussen, & Bergland, 2008) and they mainly regarded urban areas. According to these studies, is still difficult to establish if, from a social point of view, it would also be worthwhile burying the cables in the countryside, where the benefits may vary notably depending on the landscape characteristics and environmental quality of an area. For example, it can be hypothesised that the social damage will be higher in protected areas than in areas of less environmental importance because the former are generally more frequented for tourism-recreational purposes.

To be able to establish if the benefits from the burial of power lines are greater than the cost it is therefore necessary to obtain information referring to different landscape and environmental contexts. The objectives of this research are first to estimate the social benefits from the burial of HVOTLs in rural areas of Italy, and second to make a comparison of the landscape benefits (that are only a part of the total benefits) with the costs of burial on the plain (the only geographic area for which we have a mean estimate of the burial costs). To accomplish the first objective, a choice experiment was conducted in which it was hypothesised that, with a surcharge on the electricity bill, the pylons could be eliminated in areas of different environmental quality (parks and nature reserves vs. non-protected areas) and in different geographical contexts (plain vs. hill and mountain). Urban and populated areas were deliberately excluded from the study in order to focus attention exclusively on the landscape benefits for rural areas. This choice is due to the fact that the reactions of the population to