Proceedings of the 2nd Meeting on Energy and Environmental Economics

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18th September 2015

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EDITORS:
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University of Aveiro

Department of Economics, Management, and Industrial Engineering (DEGEI)

ME^3 2015

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2nd Meeting on Energy and Environmental Economics

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DEGEI, Universidade de Aveiro, Aveiro

ME^3

DEGEI – Proud to host the 2nd ME^3, 2015

The Department of Economics, Management, and Industrial Engineering (DEGEI) of the University of Aveiro was proud to host the 2nd International Meeting on Energy and Environmental Economics conference, which brought together a total of 16 accepted papers, an effort which involved a total of 57 authors and co-authors, following the peer-review process. Research can thus be seen to increasingly be a team effort. This brings the total number of participants in the ME3 2015 to 45 people. Our thanks to the Organizing Committee, the Scientific Committee, the staff of DEGEI, the Nucleus of Economics Students (NEEC), and to the UA Editora. Special thanks to our sponsors who made the 2nd ME3 possible: DEGEI, UA, GOVCOPP, EDP and Trustenergy. In the 2nd ME3 we had the pleasure of welcoming and listening to Monica Giulietti, from the School of Business and Economics, University of Loughborough in UK and Gürkan Kumbaroğlu, President-Elected of the International Association for Energy Economics and Boğaziçi University in Turkey. Our thanks to these keynote speakers for having shared their valuable experience with us. We hope that the 2nd ME3 was as enjoyable for you as it was for us, at DEGEI, and wish you all the best for the future.

Carlos Costa

Full Professor

Director of the Department of Economics, Management, and Industrial Engineering (DEGEI), University of Aveiro

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Organizing Committee Message

As chair of the 2nd International Meeting on Energy and Environmental Economics (ME^3) I was pleased to welcome you all at the Department of Economics, Management and Industrial Engineering (DEGEI) from the University of Aveiro and to wish you all a very pleasant Meeting. I'm here representing four more colleagues which have been working very hard with me to turn this meeting possible. They are Margarita Robaina, Marta Ferreira Dias and Victor Moutinho, all professors from this department and also Jorge Sousa, our colleague and professor at ISEL in Lisbon.

The meeting is very young because it started in 2014. In 2015 we have turned possible its 2nd edition. It is our intention to keep it in the forward years, turning it an annual event, given that this year we have accomplished our goal of increasing the number of submissions and also of international submissions with respect to the previous year. This year, we had 4 parallel sessions, 2 in the morning and 2 in the afternoon, with 16 papers of very high quality.

But the ME^3 consists in a meeting of researchers, companies and institutions working in the energy and environmental economic fields. The meeting has as main goal the share of experiences and results throughout the scientific, entrepreneurial and institutional communities whose interests are the areas of Energy and Environmental Economics.

With this in mind we have also invited companies and institutions whose presentations occurred in the afternoon. The realization of a meeting under these subjects intends to improve the interchange of knowledge and scientific knowledge but also to connect scientific research to company's reality, once that in the meeting we have the simultaneous presence of persons representing companies and institutions connected to energy markets and resources, companies of high national importance. This year we had EDP, REN, Martifer and ADENE.

This 2nd ME^3 was special for another additional reason. There, we also had the formal presentation of the newly created Associação Portuguesa de Economia da Energia – APEEN (or Portuguese Association of Energy Economics), the Portuguese affiliate of International Association for Energy Economics (IAEE).

The idea of creating this association has resulted from some scientific meetings with other Portuguese University researchers, companies and institutions, and from works developed by a group of researchers/professors from University of Aveiro. Thus the opportunity to create in Portugal the APEEN emerged, a future branch of the International Association of Economists of Energy (IAEE). At the gala dinner which happened at day 18th we have formally presented all the founding members of the APEEN (companies, institutions and professors/researchers) and the founding president at its earlier creation and starting date, Professor Doctor Jorge Vasconcelos.

The goals of APEEN as an organization consist in the promotion of the mutual association of persons interested in Energy Economics, in order to create a professional discussion forum; to proportionate means for professional communication and the interchange of experiences and ideas between the persons interested in Energy Economics; to promote the professional communication between the persons interested in Energy Economics in Portugal and from different countries while being an affiliate of IAEE; and to educate the community in questions about Energy Economics.

To be able to fulfil these goals, the association will promote the organization of conferences, meetings and seminars over issues related with Energy Economics and Environment (being the ME3 one of the first in this action field), the dissemination of works, debates and conclusions which result from these activities and other activities considered as relevant for APEEN and its members.

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Legend: Founding Members photo after the signing of the by-laws

Thank you to all participants of the 2nd ME3, to the direction of this department, to the research center GOVCOOP, to our colleagues, department staff and students who helped us is this conference, and to Trustenergy and EDP for their financial support.

So, we wish that you have all enjoyed the meeting and feel free to contact us if you need anything. We wish you the best and thank you all for turning this event possible. We hope to see you again for the next year.

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Contents

USING CHOICE EXPERIMENTS AND CONTINGENT VALUATION TO ASSESS ENVIRONMENTAL IMPACTS OF WIND FARMS IN PORTUGAL

Botelho, A.[1], Lourenço-Gomes, L.[2*], Pinto, L.M.C.[3], Sousa, S.[4], Valente, M.[5]

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ABSTRACT

Over the last few decades, the number of wind farms installed in Portugal has grown considerably, which has stimulate an intense debate on the environmental impacts associated with wind energy. The use of wind power for electricity generation presents several environmental benefits, but it also presents adverse impacts. Some of the most important benefits mentioned in the literature are the decrease in greenhouse gas emissions (as wind energy partially replaces fossil fuels), a reduction in the external dependency of the economy, and the diversification of the energy mix. The adverse effects of wind farms include noise pollution, landscape intrusion, effects on fauna and flora, electromagnetic interferences and land use impacts. The main objective of this study is to elicit the welfare impacts of the use of wind energy to produce electricity on two groups of stakeholders: local residents (that typically bear the adverse effects) and the general population (who typically enjoys the benefits). To this end three wind farms (Arga, Negrelo & Guilhado, and Lousã II, located in the north and centre of Portugal, respectively) were selected to study the local residents' perspective and a national sample of Portuguese residents was selected to represent the interest of the beneficiaries. The methodologies used in each case are different as the question of interest differs. Concerning local residents we applied the contingent valuation method and elicited the minimum amount of compensation they would require for the nuisances experienced; concerning the general population we applied a discrete choice experiment to elicit the willingness to pay to avoid the environmental impacts of wind farms. The results show that both general population and local residents have clear preferences over wind farms' environmental impacts, and they are willing to pay and receive significant monetary amounts to avoid or be compensated for the environmental impacts, respectively. With the results of this study, we expect to contribute to a more efficient and thorough process of deciding the optimal location of future wind farms or expansion of existing ones, taking into account in a more complete manner the views of these stakeholders.

Keywords: Wind Farms, Contingent Valuation, Discrete Choice Experiments, Environmental Impacts, Public Attitudes.

1. INTRODUCTION

Installed power, production and the number of wind farms (WFs) have all been increasing over the last few decades (Álvarez-Farizo and Hanley, 2002). Several publications document the positive environmental aspects of wind power, identifying it as one of the most efficient renewable energy sources and an important component of the energy mix in many countries. However, despite its doubtless advantages, wind power generation comes along with considerable negative externalities, experienced by the local communities and by the population in general (Drechsler *et al*., 2011). These adverse impacts are due to the inherent operating characteristics of WFs, justifying increasing opposition to the construction of new facilities (Krohn and Damborg, 1999; Álvarez-Farizo and Hanley, 2002; Wolsink, 2007). The environmental benefits of electricity production from wind power are well recognised and accepted, but the environmental costs are less well-known. These are difficult to quantify and are likely to be case-specific. However, any efficient economic assessment of wind energy expansion should incorporate the value of all environmental impacts, both positive and negative (Álvarez-Farizo and Hanley, 2002), in particular not only identify and acknowledge the adverse impacts on the local population but also value them so as to provide a more thorough accounting of the costs.

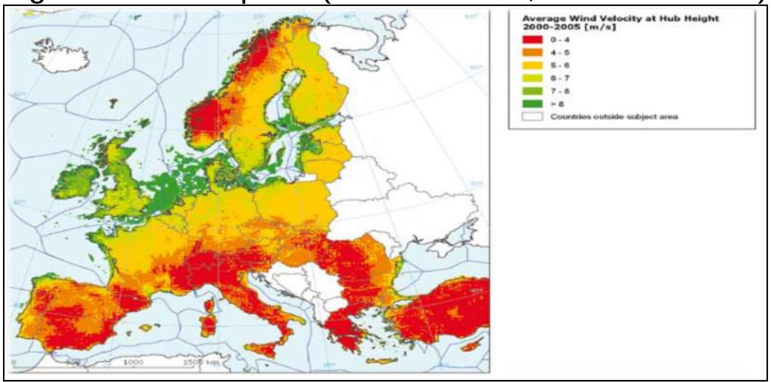
In this study we focus on three WFs in Portugal and present two complementary approaches to estimate the economic value of the adverse environmental impacts. A thorough review of the literature indicates landscape intrusion (e.g. Wolsink, 2007; Gordon, 2001), land use impacts (e.g. Manwell *et al*., 2009; Denholm *et al*., 2009), noise pollution (e.g. Pedersen *et al*., 2009; Van den Berg, 2005, 2006), impacts on fauna and flora (e.g. Mendes *et al.*, 2002; Travassos *et al*., 2005), and electromagnetic interferences (e.g. Manwell *et al*., 2009) as the most significant negative effects associated with the operation of wind power plants. On the one hand we elicit the willingness to accept (WTA) by the local population to be compensated for sustaining these negative externalities. We apply the contingent valuation (CV) method to estimate a straightforward and narrower economic value related to direct use. On the other hand, we elicit the willingness to pay (WTP) of the general population to compensate the local residents for the damage. We apply the discrete choice experiments (DCE) method to estimate the broader economic value attributed by those not directly affected but who nonetheless are stakeholders. We compare both values to clearly understand whether the damage sustained by local residents can be viably supported by those who benefit from the externality-generating activity. Furthermore, either of those values can be used as useful information for policy makers to account for the adverse impacts in an economic analysis, which is often a neglected component.

The reminder of this paper is organized as follows. Section 2 presents the current situation of the use of wind for electricity generation in Portugal. Section 3 provides an overview of the main methodological issues, in which the valuation methods are explained, the survey design described and a brief description of the case studies is presented. Then section 4 presents and discusses the results. Finally, in section 5 the main conclusions of this paper are presented.

2. WIND POWER IN PORTUGAL

Wind is extremely valuable as an energy resource in Europe (EEA, 2008). Figure 1 presents a map with different wind speed regions estimated for different topographic conditions. The wind speed above which commercial exploitation can take place varies considerably between different regions: although countries such as Scotland clearly stand out for having an exceptional potential, we observe that in every European country wind is a technically and economically exploitable resource.

Figure 1: Wind Speed (80 m onshore, 120 m offshore)

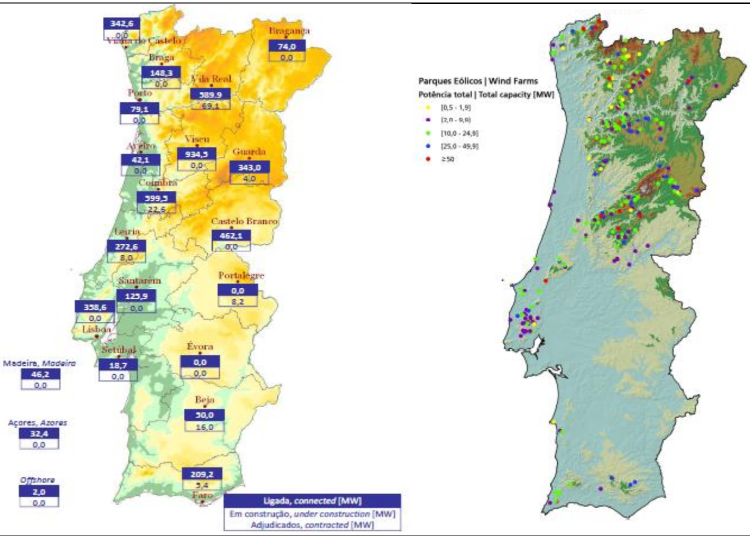


Source: EEA (2008)

Portugal, a mid-sized European Union (EU) country with about 10 million inhabitants, is placed amongst the top ten countries in the world with the highest cumulative wind power capacity at the end of 2013 (EWEA, 2014). This is due to its geographic and geomorphologic characteristics favouring the production of wind energy, along with high investment levels on this energy source in recent decades. In addition, while wind energy investments at the EU level are mostly offshore, all wind energy to date in Portugal is produced onshore (Azau, 2011). It is also important to highlight the role of two essential tools created with the purpose of developing an efficient use of wind power potential in Portugal: the database on wind power potential - EOLOS2.0, which provides information on the physical and energy characteristics of the atmospheric flow in 57 locations on mainland Portugal; and the VENTOS software, which is used for computational simulation purposes of the behaviour of wind flow on complex terrains, whether or not arborized (DGEG, 2007).

Between 2010 and 2013, wind power in Portugal grew 812 MW (21% increase), reaching an installed capacity of 4728.5 MW. Wind farms, as illustrated in Figure 2, are particularly concentrated in the Centre and North of the country, with particular importance in the districts of Viseu, Coimbra, Vila Real, Lisboa, Guarda, Viana do Castelo, Leiria and Faro with the highest installed rated power, all presenting values above 200 MW by December 2013 (INEGI and APREN, 2013).

Figure 2: Location and Installed Power of WFs in Portugal



Note: The Portuguese offshore wind installed capacity consists on the concept demonstration project Windplus. Source: INEGI and APREN (2013)

3. METHODOLOGY

Our study focuses on two groups of stakeholders who value the adverse impacts of WFs. One of them comprises the local residents near three specific WFs in Portugal. To estimate the WTA compensation for the adverse impacts we apply a stated-preference (SP) method that has been used widely in non-market valuation studies: the contingent valuation (CV) method. The other group embraces the general population that benefits from using wind power as an energy source and can potentially value in economic terms the damage sustained by local residents. To estimate this value in terms of the WTP for compensation to the affected parties, we apply a different non-market valuation technique, the discrete choice experiments (DCE), included in the choice modelling approaches. This chapter presents an overview of the applied valuation methods, and briefly describes the three WFs used in the CV study of local residents.

3.1. Contingent Valuation Method

The CV method is a direct survey approach to estimating preferences. Using an appropriately designed questionnaire, a hypothetical (or contingent) market for the good in question is described. This contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are then asked to express their maximum WTP or minimum WTA compensation for a hypothetical change in the level of provision of the good (Mitchell and Carson, 1989; Hanley *et al*., 2001; Atkinson and Mourato, 2008).

In this study, we designed a CV survey to estimate the minimum money amount respondents were willing to accept as compensation for all the burdens caused by the presence of a WF in the proximity of their residence. Following Whitehead (2006), each questionnaire was composed of four sections. After an introductory section with general questions on renewable energy sources, section 2 presents specific questions on the production of electricity through wind power, of which we highlight, due to its relevance, the valuation question. Given that we had no prior information on the distribution of respondents' valuation for choosing the thresholds for a discrete-choice format, this question was formulated as an open question. The chosen payment vehicle was a compensation in the electricity bill, providing a simple and easily understood payment context. The question was formulated as follows:

Taking into account your income and your usual expenses, answer the following question: What is the minimum amount that you would be willing to receive as compensation for the inconvenience that the presence of the wind farm causes to you? The amount would be credited to your monthly electricity bill.

You would be willing to receive ______________ Euros per month.

Section 3 contains some additional questions on respondents' preferences and opinions on different energy sources, renewable and non-renewable. Finally, section 4 includes some questions to gather information on the individuals' socio, economic and demographic characteristics (e.g., gender, educational level, family situation, income, etc.). The questionnaire was subject to an interactive test and review process using pilot studies.

For the CV application we focused on three WFs to be able to elicit the economic value for those specific cases. In the following sub-sections, each of the studied WFs will be briefly presented.

3.1.1. Arga Wind Farm

The Arga WF, operating since April 2006, is located in the Serra de Arga, in the parishes of Arga de Cima and Arga de Baixo, municipality of Caminha, district of Viana do Castelo, at an average altitude of 750 meters. This wind farm has an installed capacity of 36 MW spread over 12 wind turbines Vestas model V90 with 3.0 MW of unitary potency, and with 80 meters height of the rotor axis. The Portuguese company Empreendimentos Eólicos do Vale do Minho, S.A. (EEVM) explores and manages the Arga wind farm. The next two figures present, respectively, the exact location and a panoramic view of the Arga plant.

Figure 3: Location of Arga WF

Source: Authors' elaboration

Figure 4: Panoramic view of Arga WF

Source: EEVM:
http://eevm.pt/index.php?option=com_content&view=article&id=337&Itemid=289

3.1.2. Negrelo & Guilhado Wind Farm

The Negrelo & Guilhado WF, with an installed capacity of 22.3 MW, is located in the Serra da Padrela, in the parishes of Soutelo de Aguiar and Vila Pouca de Aguiar, both in the municipality of Vila Pouca de Aguiar, district of Vila Real. This wind farm started operating in March 2009 with 10 wind turbines Enercon model E82 with 2.0 MW of unitary potency to which were added, in December 2011, an additional wind turbine Enercon model E82 with 2.3 MW of unitary potency. The construction of the Negrelo & Guilhado WF was promoted by ENERNOVA – Novas Energias, S.A., a company of the Group EDP Renováveis. The following two figures present, respectively, the exact location and a panoramic image of the Negrelo & Guilhado plant.

Figure 5: Location of Negrelo & Guilhado WF

Source: Authors' elaboration

Figure 6: Panoramic Image of Negrelo & Guilhado WF

Source: APREN and INEGI: http://e2p.inegi.up.pt/index.asp#Tec3

3.1.3. Lousã II Wind Farm

The Lousã II WF, with an installed capacity of 50 MW, is located in the Alto do Trevim, in the municipality of Lousã, district of Coimbra. This wind farm began operating in November 2008 (in full in early 2009) and aggregates 20 wind turbines Nordex model N90 - R80 with 2.5 MW of unitary potency. The exploration of the Lousã II wind farm belongs to the company Parque Eólico de Trevim, Lda. (Group Iberwind). The following two figures present, respectively, the exact location and a panoramic image of the Lousã II plant.

Figure 7: Location of Lousã II WF

Source: Authors' elaboration

Figure 8: Panoramic Image of Lousã II WF

Source: Iberwind: http://www.iberwind.com/pt/parques/20/

3.2. Discrete Choice Experiments

Complementarily, we used the DCE approach to elicit the WTP of the general population to avoid the environmental impacts of WFs. DCE is based on the notion that value is derived from the specific attributes of a good, in accordance with Lancaster (1966) characteristics theory of value. This survey-based approach asks respondents to choose their preferred option out of a series of sets of alternatives that differ by the attributes/levels included. In each choice task, respondents trade off changes in attribute levels against the associated cost (Hanley *et al.*, 1998, 2001; Bateman *et al*., 2002; Pearce *et al*., 2006).

The chosen attributes resulted not only from extensive literature review but also from pilot questionnaires and focus group discussions. The final configuration of the choice sets included the following attributes: landscape, noise pollution, impacts on fauna and flora, and. To be able to transpose those impacts into monetary terms, as per the methodology, we included a price attribute as an increase in the monthly electricity bill. Following the exploratory study the price attribute had three levels (4, 8 and 12 Euros).

Similarly to the CV approach, the DCE questionnaires were also divided in four parts. First, the degree of respondents' familiarity with RES was assessed in an introductory part. Second, there was the choice experiment section, in which individuals were presented with six choice sets, each consisting of a choice between two alternative ways of producing electricity through wind, differing on the levels of specific attributes. Due to its key role in the questionnaire, we present, for illustration purposes, one of the six choice sets given to respondents:

Table 1: Choice Set Example

Consider the choice between form A of electricity generation through wind and form B of electricity generation <u>also</u> through wind. Tick your preferred option:

	Form A	**Form B**
Significant impact on the landscape	No	Yes
Significant impact on the Fauna/Flora	No	Yes
Produces noise affecting population	Yes	No
Increase in the monthly electricity bill €	4	12
Your choice	☐	☐

Then, respondents were presented with two additional sections with questions on respondents' preferences and opinions on different energy sources (section 3) and to gather information on the individuals' socio, economic and demographic characteristics (section 4). The questionnaire was subject to an interactive test and review process using pilot studies explained in Botelho *et al.* (2014).

4. RESULTS

4.1. Local Residents

During May 2014, a total of 57 questionnaires were collected in the vicinity of three WFs: Arga, Lousã II and Negrelo & Guilhado (25, 12 and 20, respectively). The sample has the following socio-demographic characteristics: 66% have education at the primary school level, 50% are retired, 49% are males, mean age is 60 years old and the mean household monthly income per person is approximately 252 Euros. The most frequently identified environmental problem in Portugal is the waste followed by water pollution and air pollution; most respondents know that wind farms, hydropower and photovoltaic are used to produce electricity, however of these sources, photovoltaic energy is considered the least environmentally friendly. Almost all respondents (98%) consider Portugal a country with good conditions for developing renewable energy sources in the production of electricity and consider that renewables bring benefits to the population. In particular, half of respondents mention reduction of the external dependency of the economy as a benefit, followed by generation of employment. Respondents also associate renewable energy with positive environmental effects. Average monthly electricity bill of respondents was approximately 72 Euros. Regarding the respondents' relationship with the specific WF, for 95% of them it is visible from their home, and the effects on landscape and noise are identified as negative. The majority of the respondents (95%) stated a positive WTA compensation amount (37.95 Euros on average), ranging from 2 to 200 Euros per month.

WTA data collected with the CV method could be interpreted as being generated by two decision' processes. First the respondent decides if he or she is entitled to compensation and then decides the amount of compensation, in integer positive numbers. In addition, it is typically the case of excess zeros. Accounting for the nature of the data, a mixture model should be used. As such we use a mixture model, in particular a zero-inflated negative binomial model to identify the determinants of respondents' WTA amount. According to this specification, the variables determining the decision to be entitled for some compensation need not be the same as those determining the decision on the specific amount. The explanatory variables were selected based on previous empirical applications. However, perfect and imperfect correlation between explanatory variables and estimation feasibility requires some adaptations. The first panel of Table 2 reports the results on the decision to receive compensation, while the second panel reports the results on the amount of compensation demanded.

Table 2: Zero-inflated negative binomial model

		Explanatory Variables	**Coefficient** (robust stdev)
Dependent Variables	**WTA yes/no**	Annoyance	-17.8136*** (0.7209)
		Constant	-2.5567*** (0.6895)
	WTA amount	Incomepc	-0.0008 (0.0007)
		Age	-0.0164* (0.0097)
		Noise Annoyance	0.0259 (0.0858)
		Lousã	-0.0507 (0.4370)
		Vila Pouca Aguiar	0.5317** (0.2755)
		Constant	4.4761*** (0.5736)
		Ln(alpha)	-0.5890*** (0.1890)
N: 57 (zero=3); Wald chi2(4) 9.85*			

Note: *significance level of 10%; **significance level of 5%; ***significance level of 1%

Variables definition: Annoyance: reported degree of annoyance caused by WF (5 point scale); Noise annoyance: reported degree of annoyance caused by noise produced by the WF; Incomepc: reported household income per person.

According to the results presented in the Table 2, it is clear that annoyance is a very important determinant of the decision to be compensated for the environmental negative impacts of the presence of the wind farm, although we would expect a different and positive effect. Regarding the amount of compensation, location and age are significant determinants, with residents in Vila Pouca demanding on average higher amounts of compensation than residents near Arga and Lousã. Older respondents demand, on average, lower amounts. Based on the regression model we predict that the amount of compensation would be on average 34.8 Euros per month, specifically 28.6 Euros in Arga, 34.6 Euros in Lousã II and 42.8 in Vila Pouca Aguiar. The reduced size of the sample collected, resulting from the fact that the villages near wind farms have very few residents, requires some caution in interpreting the results but it does not preclude drawing some implications from the analysis. In particular the amount of compensation demanded is location specific, on average; and, socio-demographic characteristics play some role is the amount of compensation demanded.

4.2. Non-Residents

A stratified random national sample of 250 respondents was selected and questionnaires administered during the first semester of 2014 by a data collecting firm. Respondents are on average 52 years old, 44% of the respondents are male and 38% are retired. Most respondents are married and have secondary level education. In terms of respondents' environmental concerns, air pollution (55%) is identified as the most significant environmental problem in Portugal, followed by waste (45%) and water pollution (40%). According to the data collected, most respondents are familiar with production of electricity through renewables, except for biomass, and consider all sources environmentally friendly and most consider they bring benefits for population. To assess the concern of respondents in renewable energies, they were asked whether they had an interest in knowing the type of energy source used in the production of the electricity they consume, and in fact only 2% did not care about the origin of the electricity. The average monthly electricity bill paid by respondents is 69 Euros. Regarding the choice tasks, 41% of respondents indicated that they considered all attributes during their choices.

Table 3: Binary logit model (with cluster correction)

		Partial effects (stdev)	**Mean WTP** (stdev)
Variables	**Landscape**	-0.1062*** (0.0221)	3.1509*** (0.7675)
	Fauna/Flora	-0.2696*** (0.0272)	7.8035*** (1.2952)
	Noise	-0.2368*** (0.0257)	7.30997*** (1.3036)
	Price	-0.0334*** (0.0040)	------
Log likelihood function		-1858.4726***	

Note: *significance level of 10%; **significance level of 5%; ***significance level of 1%

In the present DCE, individuals are asked to choose between two alternatives (each corresponding to a specific *form of electricity generation through wind* production), sequentially six times. The dependent variable is hence a binary variable and each individual is observed repeatedly. Accounting for the nature of the dependent variable, we specify a binary logit model with cluster correction to estimate the partial effects of the attributes on the response probability of an alternative. Table 3 reports the results, and we conclude that all the attributes describing the wind energy source have a negative and statistically significant influence on the utility of an alternative. As expected, the impact on the fauna/flora, on the landscape, the emission of noise and the price (in the form of an increase in the value of the monthly electricity bill) are significant determinants associated with the disutility due to the production of electricity through wind farms. Moreover the most important determinant is the impact on fauna and flora, followed by the impact of noise, while the impact on the landscape appears in the third place. Predictions for respondents' WTP to avoid environmental impacts range from 3.15 Euros per month to avoid significant impacts on the landscape, to 7.80 Euros per month to avoid significant impacts on the fauna/ flora. Respondents' predicted average WTP to avoid production of noise that significantly impacts the local population is approximately 7.31 Euros, thus very close to the value attributed to the impact on fauna and flora.

4.3. Comparing Results

The application of the CV and DCE methods allowed the estimation of the WFs' welfare effects by two distinct stakeholders: the local residents who are directly affected by the negative effects caused by the activity of the WFs installed in the surroundings of their residences; and the population in general who potentially benefit from the advantages of the use of wind for electricity generation (e.g., lower CO_2 emissions) and thus experience welfare benefits. The most relevant difference of the two samples regards income, age, and education, with local residents being older and less educated.

Through the CV method, we were able to predict that the compensation amount demanded by local residents would be on average 37.95 Euros per month. On the other hand, the application of the DCE method among the general population allowed us to conclude that, on average, respondents are willing to pay between [3.2 Euros; 7.8 Euros] depending on the impact considered. Thus, as the number of residents to be compensated are those residing close to the installations, while those willing to pay for compensation are the entire population, it is safe to conclude that the welfare benefits more than compensate the costs and thus, without considering equity issues, the use of WFs for electricity generation is potentially welfare improving.

5. CONCLUSIONS

The use of wind power for electricity generation has unquestionable environmental advantages, particularly if compared with the use of fossil fuels. Nevertheless, several adverse impacts have been associated with the operation of WFs, affecting individuals' wellbeing. In this study, based on the application of two stated preference methods, the CV and the DCE, we were able to value the welfare effects of the environmental impacts caused by the activity of WFs by two distinct stakeholders: local residents and the general population. Among the local residents, we estimated the minimum monetary amount demanded as compensation for the negative impacts caused by the proximity of three Portuguese WFs (on average 37.95 Euros per month). On the other hand, among the general population in continental Portugal, we computed the value of each environmental impact caused by the activity of WFs, by asking individuals the monetary amount they were willing to pay in order to have electricity generated by WFs, but with the possibility of avoiding specific adverse impacts. The values obtained ranged from 3.2 Euros to 7.8 Euros per month, depending on the impact considered. The results of this paper confirm the relevance of considering the environmental impacts of WFs in the siting decision process. Moreover, as the impacts depend on the site and location of the WFs, policy makers should use this information to integrate these parameters into their decision-making process, otherwise adverse impacts are merely acknowledged rather than fully considered in economic terms.

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