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INTERACTION BETWEEN PHYSICAL AND PSYCHOLOGICAL FACTORS IN WIND TURBINE NOISE PERCEPTION

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Abstract

The impacts associated to the deployment of wind turbines in Portugal have not yet been fully assessed. Besides the well known aesthetical and environmental impacts, the use of land and the effect on human health are worth consideration. Amongst the latter, the effect of noise is paramount. People living close to wind turbines often consider that their sleep quality is affected or complain of headaches, irritability, difficulty in concentration and other disturbing symptoms. On the other hand, various studies concluded that psychological or behavioural factors affect the way turbine noise is perceived and the reaction of people to it. In the present study we measured the physical characteristics of the sound emitted by turbines in a wind farm in the north of Portugal and crossed the data with the answers to a questionnaire done in four villages in its immediate vicinity. Preliminary results indicate that peripheral factors, namely the financial interest the people inquired may have on the turbines, critically determine their perception and response to the noise effectively measured.

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1 Introduction

In April 2010, the Portuguese council of ministers established a national strategy for energy (ENE 2020), whose prime objective was to reinforce Portugal's leadership in energy sustainability up to 2020. ENE 2020 defined an agenda for competitiveness, economic growth, and energy independence of Portugal through a sustained investment in renewable energies. It also envisaged ensuring a secure energy supply, with enhanced integrated efficiency, and an economic and environmentally sustainable energy model [1]. In what concerns wind energy, the objectives were to grow from the 2009 power capacity of 3,500 MW to 5,500 in 2012 and to 8,500 MW in 2020. Furthermore, an additional 400 MW power could be made available as a result of a full exploitation of the equipment already installed in the existing wind farms.

In 2012, the Portuguese government, through the *Direcção Geral de Energia e Geologia*, considering the economic situation, in Portugal and worldwide, decided to revise the targets set in ENE2020. Although still under discussion, the major guidelines of the National Action Plan for Renewable Energy (PNAER) foresee the commissioning up to 2020 of only 1,742 MW for all renewable power sources (totalling 8,779 MW)[2]. Of these, wind power will represent 5,300 MW (circa 60.4%). Considering that by the end of 2011 the existing wind power capacity was 4,351 MW, this means that in the next nine years only 949 MW will be installed.

The 3,200 MW downsize in the installation of wind turbines will have a major consequence in land occupation and in other impacts of the turbines. Amongst these, the effect of noise in human health is paramount. Wind turbine (WT) noise can be easily perceived (and be a nuisance) even for low sound pressure levels, making it generally incongruous with background noise [3]. The two major sources of noise are mechanical and aero-dynamical. Currently, aerodynamic noise is often the dominant nuisance, as turbine manufacturers have been able to significantly diminish mechanically derived noise [4]. Aerodynamic noise that has a broadband character, results primarily from airflow around the turbine propellers. Consequently, sound pressure levels should increase with wind speed. However, most WTs in operation today can keep a constant rotor speed, and hence the rotor blades will generate the same aerodynamic noise for different wind speeds. In any case, even if the aerodynamic noise can be upper limited, as the background noise in rural areas is usually low, it is often difficult to keep it unnoticed [4]. In fact, it has been demonstrated that WT noise can only be completely masked by natural sounds at sound to noise ratios of -8 to -12 dB [5].

In Portugal, the effect of WT noise in human health has not been fully investigated, especially for medium and long periods of exposure. In other countries, however, this topic has been the object of various studies. Some of these studies highlight the fact that approximately 75% of the people that oppose the installation of WTs consider noise as one of their major worries [6]. A recent research by Shepherd et al. in New Zealand [7] refers that the populations exposed to WT noise report a lower sleep quality and consider their environment less restful. Furthermore, a study done in December 2011 demonstrated that dynamically modulated low frequency and infrasonic energy from WTs can be amplified inside nearby houses at frequencies below 10 Hz[8]. This effect caused people indoors to experience, within a few minutes, significant debilitating health effects. The sound levels were found to inversely correlate with these adverse health effects; that is, the effects were more severe indoors where the levels were much lower (around 20 dBA) than in the open air. The increase in total sound pressure inside the houses appeared to be related to a "whole-house" cavity response, in which the outside pressure pulsations excited the interior acoustic pressure [8].

Some people that live near wind farms report a variety of negative symptoms that, in certain cases, are sufficiently serious to force them to abandon their residences. Amongst these symptoms, sleep disturbances, headaches, concentration difficulty, irritability, tiredness and auditory system related problems are often mentioned [9]. However, in the literature there is also evidence that the various nuisances due to perceived noise do not correlate well with its actual level. In fact, those nuisances are often ascribed to other causes, such as a generic negative public opinion towards WTs [6] and their visual impact [10], or to the reflexes caused by the rotor blades or even to their shadows [4]. Conversely, they can be mitigated if the respondent has an economic interest in the existence of the wind farms [11]. It seems evident that the nuisance caused by WT noise is primarily connected to various other complaints that should be seriously considered by the local public health and environment authorities. Even when the individual perception of noise is determined by extraneous factors, this does not mean it can be taken lightly. On the contrary, a wider understanding of the noise impacts occurring in the wind energy sector may contribute to minimize negative attitudes towards specific wind farm projects [6].

In the present study we address this problem, by measuring the physical characteristics of the sound generated by the turbines in a wind farm in the north of Portugal and crossing the data with the answers obtained in a questionnaire. This questionnaire, which contemplates most of the situations and symptoms mentioned above, was done in four chosen villages in the immediate vicinity of the wind farm.

2 Methodology

Considering the specificity of wind turbine noise and the findings of previous studies, the assessment of its impact on exposed populations should consider:

i) *The aesthetical reaction to the turbines of the respondents to any questionnaire on the effects of environmental noise*. In fact, the visual impact of the noise source is not the only factor that should be considered in this type of surveys. For instance, the association between noise exposure and its perception by the respondents can also vary for different landscapes [12].

ii) *The direct visibility of the noise source*. It has been reported that the negative reaction to WT noise seems to increase when they are clearly visible, or emit swishing, whistling, pulsating/throbbing sounds, or with the persistence of sound emission during the night hours [4].

iii) *The tonal and impulsive acoustic characteristics*. In some studies the number and severity of noise complaints near wind farms are at least partly explained by the actual sound levels being considerably higher than expected and by the specific characteristics of that sound (a 'thumping', impulsive sound emitted at high rotational speeds) [13].

iv) *The psycho-acoustic profile of the emitted noise*. Previous studies have demonstrated that different sound characteristics, not fully described by the equivalent noise level, are of importance for annoyance and noise perception. Descriptors such as "lapping", "swishing" and "whistling" can be related to easily noticed and potentially annoying sounds, while "low frequency" and "grinding" descriptors seem to be related to less intrusive and potentially less annoying sounds [14].

v) *The economic dependence of the respondents towards wind energy*; some studies have shown that persons who benefit economically from WTs are less prone to feel significantly annoyed when exposed to equivalent level sounds [11]. This factor should indeed be considered in any impact evaluation.

Considering the above data, the planned research aims at evaluating the impact of the sound generated by the turbines of wind farms in Portugal, according to the following protocol:

1) To characterize the number and main features of the wind farms installed in Portugal;
2) To characterize their location relatively to nearby populations; this characterization should be based on a specific typological classification, considering, amongst other factors, the visibility of the turbines;
3) To characterize the relevant meteorological (prevailing wind, temperature gradients, etc.) and topographical (height pressure) local data;
4) To select a restricted number of wind farms based on the preceding three items, as well as in the logistics inherent to the studies to be performed;
5) To make direct sound measures in the selected areas, with a view to assess the acoustic impact of the wind farms, including:
   5.1 Monitoring the sound levels in different periods of the day;
   5.2 Comparing the impact of the different turbine types;
   5.3 Comparing different wind farms (allowing for the topography and meteorological conditions).
6) To elaborate a questionnaire on noise perception based on those previously developed by Pedersen and Waye [4], properly adapted to the Portuguese situation;
7) To obtain the answers to that questionnaire amongst the residents of chosen villages in the immediate vicinity of the selected wind farms.

In the present work, we report only a preliminary study, done in the Fafe High Land (Terras Altas de Fafe) wind farm in the north of Portugal. This farm is located in the municipalities of Fafe and Celorico de Basto, in a mountain area, 851 metres height in average, with GPS coordinates ranging from 41º27'N to 41º30'N and 7º47'W to 8º09'W. The farm is composed of 53 Gamesa G87-2MW WTs, corresponding to a 106 MW total installed capacity. The annual production is estimated at circa 210 GWh (for an equivalent of 2,000 hours of full load/year), which is approximately the electricity consumption of three nearby towns with around 90,000 inhabitants. The turbines are all identical, with a 67 metres height tower and a rotor diameter of 87 metres [15].

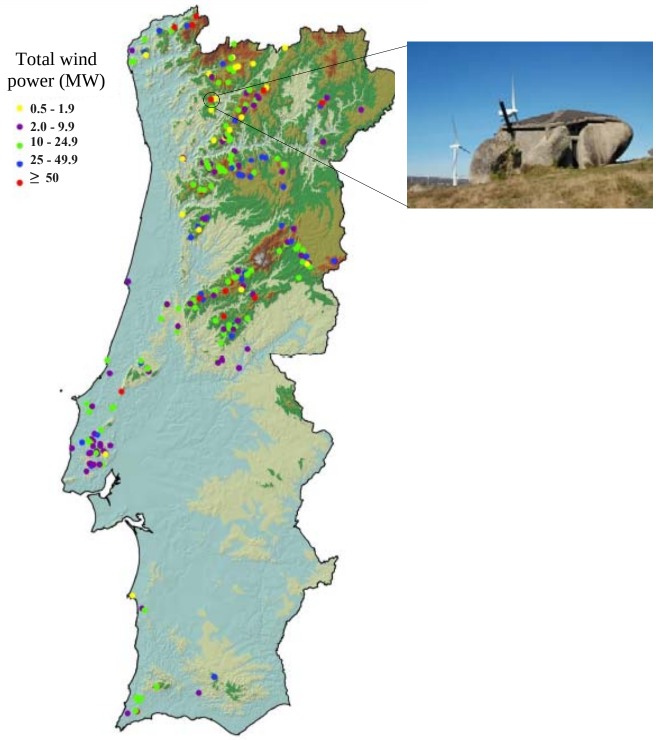

Figure 1 – Distribution of wind farms in Portugal and location of Fafe High Land wind farm (from [16], picture from [15])

2.1 Sound measurements and questionnaire

The sound measurements were done in four small villages in the immediate vicinity of the wind farm, Campo Dianteiro (CD), Lagoa (L), Várzea Cova (VC) and Vila Pouca (VP). A Bruel & Kjaer sound level meter model 2260 type 1, equipped with a tripod, was used in the measurements, according to the protocol described in the next section.

The questionnaires were organized in two sections with distinct types of questions. In Section I the questions aimed at masking the intention of the questionnaire and at knowing how the respondents reacted to their environment. In section II the questions were directed to the perception of WT noise. The final version of the questionnaire is shown in Annex 1.

When the questionnaires were presented to the inhabitants of the above localities there were some difficulties. Most of them were old people, a few almost illiterate, which had serious difficulties in understanding them. As a consequence, only some questionnaires were directly answered by the respondents. In a number of cases, it was necessary to read and explain them, in a very simple way, so that they could be understood and responded. In other cases, to overcome the initial interaction difficulties, it was even necessary to present the questions in an informal way, almost like as in a conversation, and write the answers ourselves.

3 Results

The results of the sound measurements are synthesized in Table 1. Noise measurements were carried out at 4 different locations, designated by initials for the sake of simplicity. During the

noise measurements the wind speed was also assessed and registered and found to be consistently low, i.e., less than 2 m/s.
The sound pressure levels (SPLs) were registered considering a 5 minutes measurement period for each location, during which the background noise was continuously monitored with the aim to avoid the inclusion of "external" relevant noise events. When one such event occurred, as for example, the sudden barking of a dog, or a car passing near the sound level meter, the measurement was stopped and the event eliminated.

Table 1 – Synthesis of the sound measurements data.

Location	**No. of measurements**	**L_{Aeq} range (in dB(A))**
CD	8	37.4-49.3
L	5	40.9-49.1
VC	2	46.4-46.7
VP	5	37.2-48.0

It is also important to highlight that some sporadic impulsive characteristics were identified, mainly from the existent background noise on the measuring location, which seemed not to affect the registered WTs overall SPLs. According to Table 1, it is also possible to notice that the sound pressure levels from WTs are relatively low, when compared with those reported in other studies. Although not included in this table, a noise measurement near a WT (approximately 10? metres from the WT) was made and a value of 51.6 dB(A) was registered. When comparing this value with those presented in table 1, it is possible to see that they are not very different, which may indicate that the distance between the WTs and the analysed location is not enough to reduce significantly the exposure to the WTs sound pressure levels. Nevertheless, it should be highlighted that it is possible that these values were somehow affected by the weather, as most of the measurements were made during summer and, as mentioned above, with low wind speeds. These values were also measured at different distances from the WT, depending on the specific location of the considered villages.
As also mentioned earlier, most of the results of this preliminary work are based on a questionnaire. Due to the compulsory restrictions in terms of length, data was only analysed for some variables. The main idea was to examine the relationship between some aspects of the self-reported opinion about WTs and the corresponding noise nuisance, both in outdoor and indoor activities. The first analysis considered both the reported nuisance and the noise sensitivity and their possible relationship with the direct visibility of the WTs (see Table 2), as previously reported by other authors [3][14].
Noise nuisance was classified according to a scale in which 1 point corresponded to the less annoying situation (*do not notice*) and 5 points to the other extreme (*very annoyed*). The same codification was applied to the sensitivity scale, with 1 point corresponding to the option "*not sensitive at all*" and the maximum of 5 points to the "*very sensitive*" option. Accordingly, high scores on both nuisance and sensitivity mean that a specific person reports a high nuisance by noise, as well as a high sensitivity to noise.
From the data in Table 2 it is possible to verify that, differently to what it was expected, people with direct visibility of WTs are the ones who reported a lower noise nuisance. In terms of noise sensitivity the result was reversed. Nevertheless, and considering the statistical test for analysing the differences between samples presented in Table 2, it is possible to perceive that none of the differences is statistically significant for a 0.05 level. Therefore, we can conclude that in our sample the direct visibility of WTs does not seem to affect the reported noise nuisance or sensitivity.

Table 2 – Noise nuisance and sensitivity as a function of WT visibility.

Variable	WT direct visibility	Mean score	Standard deviation	Independent samples t-test (p value)
Noise nuisance when outdoor	Yes	3.39	1.443	0.693*
	No	3.67	1.506	
Noise nuisance when indoor	Yes	3.21	1.542	0.655
	No	3.50	1.049	
Noise sensitivity	Yes	3.43	0.712	0.207*
	No	2.83	0.983	

* Equal variances not assumed, considering Levene's test

Another important aspect that may affect the way people report noise nuisance is their general opinion about WTs. In the questionnaire this was assessed by asking the respondents to state their general opinion about WTs by selecting one the following options: "*Very positive*" (VP), "*Positive*" (P), "*Neither Positive nor Negative*" (NPN), "*Negative*" (N), "*Very negative*" (VN). These five options were also transformed in numerical values, from 1 to 5 points, respectively.
Table 3 presents the corresponding results for noise nuisance in outdoor and indoor activities. In the table, "N" corresponds to the number of respondents, "Mean score" to the average of nuisance scores and "sd" to the standard deviation, and the two last columns to the minimum and maximum values, respectively.

Table 3 – Descriptive statistics for noise nuisance according to general opinion on WT.

Noise nuisance	Opinion about WT	N	Mean score	sd	Min	Max
Outdoor	VP	8	4.38	0.518	4	5
	P	9	3.89	1.269	2	5
	NPN	15	3.40	1.549	1	5
	N	10	2.60	1.506	1	5
	VN	2	2.00	<0.001	2	2
Indoor	VP	8	4.00	1.604	1	5
	P	10	3.50	1.434	1	5
	NPN	14	3.14	1.562	1	5
	N	11	2.64	1.286	1	5
	VN	2	3.00	1.414	2	4

According to the results in Table 3, it is also possible to conclude that, both for indoor and outdoor activities, people who have a favourable opinion about WTs tend to report that they are more annoyed by their noise, which seems contradictory by nature.
Table 4 depicts the results of the statistical test ANOVA applied to the above data. According to this test, the variation between different categories of opinion is statistically significant at a $p<0.05$ level for noise nuisance in outdoor activities ($p=0.037$).

Table 4 –ANOVA for noise nuisance (outdoor and indoor) considering the opinion about WTs.

Variable		Sum of Squares	df	Mean Square	F	Sig.
Outdoor	Between Groups	20.032	4	5.008	2.840	0.037
	Within Groups	68.764	39	1.763		
	Total	88.795	43			
Indoor	Between Groups	9.551	4	2.388	1.101	0.369
	Within Groups	86.760	40	2.169		
	Total	96.311	44			

To contextualise the above data, it should be mentioned that during the application of the questionnaire (interview) the researchers had the opportunity to verbally explore and detail some of the opinions of the respondents. According to these unstructured registries, it was possible to notice that two main factors seemed to affect people's opinion about the WTs and the impact of their noise. The first factor is the feeling that, despite the reported nuisance, wind generated energy is a clean and green option, thus with much more appeal from a societal point of view. Accordingly, they seemed to be "proud" of having such a technological development in their "backyard". The second factor is related with the belief that the WTs brought some activity to their villages. In fact, they were convinced that, since the construction of the WTs, the village was more and more visited by groups of people interested somehow in them. They saw this as a positive factor, since the local commercial activities were quite stimulated by those visitors, which they consider as a general benefit, even if indirect. This last factor was much more noticeable amongst young people, as it was also observed that old people had difficulty in understand the real importance of wind energy.
On the other hand, it is possible to hypothesise that people's opinion might be influenced not only by their attitude regarding WTs but also by their specific concerns about the impact of the turbines on the landscape, as reported in other studies [12]. Thus, the analysis mentioned above was also applied to verify this hypothesis. The scale and the codification scheme used were the same as before. For comparison purposes, that scale was also transformed into numerical values, from 1 to 5 points.
Table 5 presents the results of this cross-analysis.

Table 5 – Descriptive statistics for noise nuisance according to the impact of WT on landscape.

Noise nuisance	Impact of WT on landscape	N	Mean	sd	Min	Max
Outdoor	VP	9	4.56	0.527	4	5
	P	13	3.92	1.115	2	5
	NPN	13	2.85	1.463	1	5
	N	7	2.71	1.604	1	5
	VN	2	1.50	0.707	1	2
Indoor	VP	9	4.33	1.118	2	5
	P	14	3.57	1.284	1	5
	NPN	12	2.42	1.621	1	5
	N	8	2.88	1.126	2	5
	VN	2	2.50	2.121	1	4

From the results therein it is possible to conclude that, again unexpectedly, there is a direct relationship between the reported noise nuisance and the opinion of the respondent about the impact of WTs on the landscape. For instance, people reporting a very positive opinion about that impact are also those with higher reported noise nuisance and vice-versa.
An ANOVA statistical test was also applied to the results of table 5, which revealed that the abovementioned trend is statistically significant both for outdoor (p=0.002) and indoor activities (p=0.027) (table 6). This means that, regardless the type of activities, people tend to be more annoyed by noise if their opinion about the impact of WT in landscape is positive.

Table 6 – ANOVA for noise nuisance considering the impact of WTs on landscape.

Variable		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Noise nuisance outdoor	Between Groups	30.029	4	7.507	4.982	.002
	Within Groups	58.766	39	1.507		
	Total	88.795	43			
Noise nuisance indoor	Between Groups	22.591	4	5.648	3.064	.027
	Within Groups	73.720	40	1.843		
	Total	96.311	44			

An additional factor that other authors have suggested may play a significant role on people's opinion about WTs and the corresponding noise emission is the economic relationship with a specific WT farm or the wind energy sector as a whole [11]. Considering this, the questionnaire also asked people whether they owned any WT or were involved in the WT businesses.
In fact, in this preliminary study only 5 questionnaires were completed by people with some sort of economic link to WTs. Therefore, although the results are presented in table 7, no statistical analysis was made on them. According to these results, and despite the small sample considered, it is possible to see that, as expected, people with economic connections to the WTs tend to feel less annoyed by their noise. In terms of noise sensitivity, the economic interest does not seem to affect people's answers.

Table 7 – Noise nuisance and sensitivity according to economic link with WT.

Economic interest in WT?	**N**	**Noise nuisance**		**Noise sensitivity**
		outdoor	**indoor**	
No	41	3.615	3.425	3.341
Yes	5	2.000	1.800	3.399

Regarding the questions on sensitivity, only the one specifically about noise was considered. This question has 4 optional answers, namely, "*Not sensitive at all*" (NS), "*Slightly sensitive*" (SS), "*Rather sensitive*" (RS), "*Very sensitive*" (VS), which were classified as 1 to 4 points, respectively, for quantitative analysis purposes.
Using the same scoring scheme, the reported noise nuisance and sensitivity were jointly analysed. Table 8 presents the cross-table for the data of these two variables.
Noise sensitivity is assumed to be an independent variable, i.e., it does not depend on other variables. Theoretically, noise sensitivity is something that is intrinsic to someone. However, we are measuring the self-reported sensitivity and it can be expected that this sensitivity may change if someone is exposed to noise from WTs or if he/she feels that the noise is a source of nuisance. According to table 8, it seems that the more sensitive people tend to report more noise nuisance, although this is not a quite straightforward conclusion for the sensitivity categories considered.

Applying the ANOVA test to these values allows understanding whether this trend is statistically significant or not. Table 9 that shows the results of this analysis allows the conclusion that only for nuisance in indoor activities the relationship with sensitivity is statistically significant (p=0.017). Although there is a slight variation between categories, this variation is not significant for nuisance when carrying out outdoor activities. In what concerns indoor activities, the difference between categories is not clear, as there is no clear trend in the results. Henceforth, no conclusion may be drawn from the comparison of these two variables.

Table 8 – Descriptive statistics for noise nuisance according to reported noise sensitivity.

Noise nuisance	Sensitivity	N	Mean score	sd	Min	Max
Outdoor	NS	1	1.00	.	1	1
	SS	5	3.60	1.342	2	5
	RS	17	3.12	1.495	1	5
	VS	21	3.76	1.338	1	5
Indoor	NS	1	1.00	.	1	1
	SS	5	3.80	1.304	2	5
	RS	16	2.50	1.366	1	5
	VS	23	3.74	1.356	1	5

Table 9 – ANOVA for noise nuisance considering noise sensitivity.

Variable		Sum of Squares	df	Mean Square	F	Sig.
Noise nuisance outdoor	Between Groups	10.021	3	3.340	1.696	0.183
	Within Groups	78.774	40	1.969		
	Total	88.795	43			
Noise nuisance indoor	Between Groups	21.076	3	7.025	3.829	0.017
	Within Groups	75.235	41	1.835		
	Total	96.311	44			

Finally, an attempt was made to verify whether noise sensitivity differs from the sensitivity regarding other environmental factors, namely those included in the questionnaire (air pollution, odours and littering). For that, the correlation coefficients between the answers for each sensitivity factor were computed.

From table 10 it is possible to conclude that there is a strong and statistically significant correlation between the reported sensitivity for the 4 different environmental factors. It seems that people with environmental concerns tend to report a higher sensitivity to all environmental factors and not to elect a “single” sensitivity.

Table 10 – Pearson correlation coefficients between reported sensitivity to environmental factors.

	Air pollution	Odours	Littering
Noise	0.607**	0.706**	0.838**

** Correlation is significant at the 0.01 level (2-tailed).

Despite the exploratory nature of this paper, some limitations should be acknowledged and considered in future analysis of the data. For instance, it should be highlighted that no gender analysis was carried out. However, during the interviews it was possible to notice that female respondents seemed to be generally more annoyed with WT noise than men, which may (or not) be due to the fact that they stay at home for longer periods of time. Another important variable that seemingly should be registered is the condition and age of the dwellings, as they apparently have a strong effect on the way respondents perceive WT noise. For instance, in old houses, with poor sound insulation, people often complain about noise, whereas in more modern ones, the turbines are occasionally not even noticed. In fact, when the latter were built, the owners were already conscious of potential noise impacts and invested in insulation.

4 Conclusions

According to the results obtained, and taking into consideration the limitations of this study, some preliminary conclusions can be drawn, such as the following:

- The registered background and WT sound pressure levels are relatively low, when compared with noise levels reported by other authors, with a maximum registered5 minute Leq of 51.6 dB(A);
- Direct visibility of WT does not seems to affect the noise nuisance or sensitivity reported by the respondents;
- People who have a favourable opinion about WT tend to report that they are more annoyed by noise from WT, which seems contradictory by nature. This relationship is statistically significant for noise nuisance in outdoor activities (p=0.037);
- There is a statistically significant, direct and positive relationship between noise nuisance and the opinion about the impact of WT in landscape;
- Despite the limitation of the small sample analysed, it was confirmed that people with an economic interest in WT tend to feel less annoyed by noise;
- Apparently people tend to report more sensitivity to all environmental factors and not to elect a “single” factor, such as noise sensitivity.

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ANNEX 1

Questionnaire on Wind Turbine Noise Perception

Section I

1. How satisfied are you with your living environment? *Very satisfied, satisfied, not so satisfied, not satisfied, not at all satisfied*!

2. Have there been any changes to the better in your living environment/municipality during the last years? *No, yes*! If yes, state what changes.

3. Have there been any changes to the worse in your living environment/municipality during the last years? *No, yes*! If yes, state what changes.

4. State for each of the following factors your degree of nuisance when you spend time outdoor at your dwelling: odours from industries (if applicable), odours from fertilizers, insects, fans, noise from wind turbines, railway noise (if applicable), road traffic noise, lawn mowers noise: *Do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed*!

5. State for each of the following factors your degree of nuisance when you are indoor in your dwelling: odours from industries (if applicable), odours from fertilizers, insects, fans, noise from wind turbines, railway noise (if applicable), road traffic noise, lawn mowers noise: *Do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed*!

6. How would you describe your sensitivity to the following factors: air pollution, odours, noise, littering? *Not sensitive at all, slightly sensitive, rather sensitive, very sensitive*!

Section II

7. Are you able to see any wind turbine from your dwelling or your garden? *Yes, no*!

8. What is your opinion on the impact of wind turbines on the landscape? *Very positive, positive, neither positive nor negative, negative, very negative*!

9. State for each of the following factors how you are affected by wind turbines when you are indoor in your dwelling: shadows from rotor blades, reflections from rotor blades, sound from rotor blades, sound from machinery, changes in the view? *Do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed*!

10. If you are annoyed by noise, shadows and/or reflections from wind turbines, state how often does this happen? *Never/almost never, a few times per year, a few times per month, a few times per week, daily/almost daily*

11. If you can hear the sound generated by wind turbines, how would you describe that sound and what is your reaction to it: tonal, pulsating/throbbing, swishing, whistling, lapping, scratching/squeaking, low frequency, resounding? *Do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed*!

12. How would you characterize the sound from wind turbines in the following special occasions: when the wind blows from the turbine towards my dwelling, when the wind blows towards the turbines, when the wind is week, when the wind is strong, in warm summer nights? *Less clearly heard, more clearly heard, no difference, do not know*!

13. Are you annoyed by sound from wind turbines during any of the following activities: relaxing outdoor, barbecue nights, taking a walk, while gardening, other outdoor activities? *Do not notice, notice but not annoyed, slightly annoyed, rather annoyed, very annoyed*!

14. Do you own any wind turbines, or are you involved in wind energy? *No, no but I rented a space for wind turbines installation, yes I own one or more turbines, yes I own shares of a company that builds/installs wind turbines, yes I own shares of a company that generates electricity from turbines*.

15. What is your general opinion on wind turbines? *Very positive, positive, neither positive nor negative, negative, very negative*!

16. Please mark the adjectives that you think are adequate for wind turbines: *efficient, inefficient, environmentally friendly, environmentally harmful, unnecessary, necessary, aesthetically ugly, aesthetically nice, attractive, threatening, natural, harmonious, other* (if other, identify it).