Management for wind turbine generated environmental noise

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INTRODUCTION

One of current environmental problems in Latvia and in the world, that still is under evaluated and waiting to be resolved, is environmental noise. The process of management of environmental noise in Latvia was started in 2004, when Latvia joined the EU and the requirements of corresponding directives were incorporated into state's legislation. However, even now on national or municipal level the administrators of resources fail to see the noise pollution as a matter of priority.

One type of environmental noise sources that should be managed, are stationary facilities, among them wind energy facilities. The activity of wind turbine generates tonal, broadband, low frequency and impulsive sound (Rogers et al. 2002). The level of noise generated by wind energy facilities depends on the parameters of the wind turbine, the distance to the receiver, air absorption, orographic conditions, meteorological conditions as well as sound obstructions.

The noise generated by the wind energy facilities may cause social behavior disorders in the receptor; for example, discontent, aversion and annoyance, or it can advance disorders of speech, sleep or intellectual work performance (Rogers et al. 2002). In practice it is believed, that with appropriate wind park layout planning the negative influence of the noise can be reduced, although the perception of the noise and consequently the level of its impact is determined by various subjective factors. Whether the sound becomes undesirable depends on the type of sound, the sensitivity of hearing and on other factors that may affect every particular person. In sensitive people the agitation caused by the noise might cause stress induced illnesses. Still, part of the society considers the infrasound to be one of the main problems caused by the wind parks, even though so far no evidence of its negative influence has been found (Wind noise turbine conference 2011). Due to the above mentioned subjective considerations, it is impossible to clearly determine the effects of noise generated impacts and their accompanying reactions.

The development of wind parks has become one of the most disputable questions also in Latvia. Imperfections in legislation and in concepts of planning, as well as insufficient communication among involved parties about the development of wind parks and their diverse impacts, have increased the emergence of negative attitude in part of the society as well as popular protests. In year 2010 several constitutional law-suits related to the impact of wind park development on society´s health and rights to live in a congenial environment, have been adjudicated. Problematic situations of the development of wind turbines have been widely reflected in mass media and several research studies about the future development have been started.

The use of wind parks in production of renewable energy recourses in Latvia

The need to construct wind parks is determined by the necessity to develop the use of renewable energy thus enabling the sustainable management of natural resources

and ensuring state's energetic independence from foreign countries. The potential of wind energy in Latvia is determined by its location and meteorological conditions.

Considering the wind velocity and the orographical aspects, the most suitable territories for development of wind parks in Latvia are in the west coast (see Figure 1).

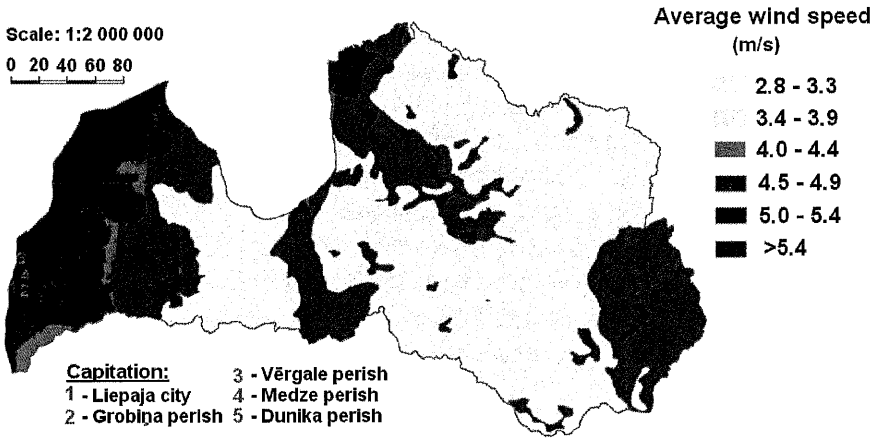

Figure 1: The average wind velocity in Latvia at 10 meter altitude (Wind energy website 2011)

The use of wind energy in Latvia began in 1995, when the first wind energy facilities were established. In 2010, there were 47 wind energy facilities operating at 27MW, which represents 0.6 % of total electrical power consumed (Barons 2008).

Although the use of wind turbines for generating electric energy in Latvia still is under developed, the role of this renewable energy resource in Latvia's energy balance is becoming more significant. In 2010 the volume of used onshore generated wind energy reached 1.8 %, and it is anticipated that by 2020 it will amount up to 11 % of the total of renewable energy (Ministry of Economics of the Republic of Latvia 2010) (see Figure 2).

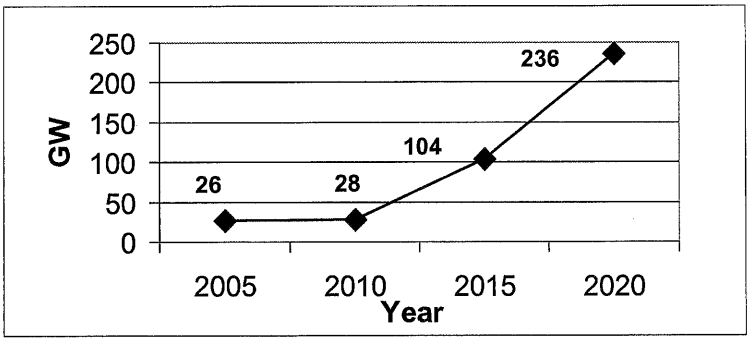

Figure 2: The use of onshore wind energy in Latvia, Years 2005-2020
(Author, using the data of the Ministry of Economics of the Republic of Latvia 2010)

These wind energy production plans, the decrease of different administrative, infrastructural, financial and social obstacles, the attachment of wind energy's purchase price to the tariff of natural gas, as well as the high mandatory purchase prices of wind energy have created a favorable situation for wind park development in Latvia (Barons 2008).

METHODS

The methodology of the research study

The study consists of research of Liepāja region´s territory in the context of wind turbines and wind parks development. Liepāja region as a research territory was chosen due to the following reasons: the meteorological and orographic situation, the existence of wind parks and their development perspectives, complains and constitutional law-suits brought to the courts by local residents. The case study includes on the site inspection of research territory at the parishes of Grobiņa, Medze, Dunika and Vērgale (hereafter in the text when speaking about the parishes, only the toponym will be used), studies of literature, documents and legislation, as well as structured interviews. The interviews were held with the representatives of local administration and with inhabitants of Grobiņa and Vērgale that are living within 500 m of the wind turbines. The selection of interviews includes 50 % of Grobiņa residents and 100 % of those of Vērgale. The interviews included questions about respondents' point of view regarding the acoustic discomfort created by the wind turbine noise, residents' awareness of the possible negative effects of wind energy facilities, as well as the population's activity in processes of territorial planning.

Location of the research

Within the framework of the case study the operating wind parks in Grobiņa and Vērgale and the planned ones in Medze and Dunika were inspected. The technical characteristics for them are shown in Table 1.

Table 1: Technical characteristics of the wind parks (Author, using the data from Environment State Bureau website 2011; Constitutional Court of the Republic of Latvia 2011a, b)

Territory	Year of construction	Number of wind turbines	Power of the wind park (MW)	Height of the turbines (m)
Grobiņa	2002	33	20	77
Vērgale	2007	3	2,5	30,50 and 80
Medze	*Scheduled for 2011*	4	1	51
Dunika	*Scheduled for 2013*	41	117	148

All wind turbines are located in areas of detached houses and recreation, where the construction of wind turbines is permitted. The closest houses in Grobiņa, Vērgale and Medze are located at a distance of 250-300 m from the wind turbines, but in Dunika – at a distance of 500 m. The wind park of Grobiņa is located in an open field where circa 30 residential houses are situated. In Vērgale, however, the wind turbines are located at the edge of a forest and there are 2 residential buildings near.

RESULTS

The data gathered in the investigation are examined and analyzed in several sections: the noise level created by the wind turbines and its impacts, the information delivered to the society, the involvement of the local population, the territorial planning process as well as monitoring.

Levels of noise, their influence and the attitude of local residents towards the wind parks

The data obtained from the interviews indicates that the majority of respondents living in near proximity to the wind parks perceived the sounds created by the wind turbines as undisturbing. In the meantime, part of the residents point out the impacts on health caused by the noise, acoustic discomfort generated by the wind turbines, the limitations of outdoor recreation caused by vibrations, as well as express their concerns regarding wind turbine impacts on health. People who express negative attitude or are drawing the attention to health hazards are the owners of properties near the land where the wind turbine is located, consequently they obtain no direct profit from the development of wind park. The results of the interviews are summarized in Table 2.

Table 2: The responses of respondents about the noise of active wind turbines (Author 2011)

Criteria	Grobiņa		Vērgale	
Level of noise	Within the level permitted by the regulations		Within the level permitted by the regulations	
Percentage of inhabitants that felt the disturbance	8 %	Felt sleep disorders, agitations, headaches	0 %	-
		Had objected to the construction of wind turbines		
		The results of visual inspection revealed the poor technical condition of residential buildings of these respondents		
Percentage of residents that were insusceptible to direct disturbance from the noise, but still experienced negative impact	3 %	Felt the transmission of vibration on earth´s surface	50 %	Disliked the humming sound from wind turbine at 2 MW
	6 %	Considered that the low frequency sounds affect health. All the responders objected to the construction of wind park		
Percentage of residents that noted other impacts on health	3 %	Concerned about the morbidity of cancer and the rise of blood pressure	0 %	-

In the meantime, the negative attitude towards wind turbines of large part of the population inhabiting the territory of existing or planned wind parks is based on possible decrease of their quality of life. It is proved by petitions against the construction of wind parks, addressed to the municipalities, signed by 55 inhabitants of Medze (pop. 1,558) and 182 of Dunika (pop. 749), that are based on their concerns about impacts of wind turbines on human health, inclusive about the acoustic discomfort (Constitutional Court of the Republic of Latvia 2011a, b). Although the foreseen level of noise in these parishes is lower than the maximum permitted, the worries of residents of Dunika are increased by the fact, that the results of simulation anticipate level of noise of 39 dBA at the nearest dwelling that is by 1 dBA lower than the permissible level of environmental noise at night in this building zone (Constitutional Court of the Republic of Latvia 2011b).

In addition to submitting the above mentioned petitions, in year 2010 with the support of non-governmental organizations residents of Medze and Dunika have brought a petition to the Constitutional Court (Constitutional Court of the Republic of Latvia 2011a, b) to litigate the territorial planning, that provides the construction of the wind

turbines near the dwellings of the litigators and the incorporation of their properties in the territorial zoning of wind park, thus infringing property rights of these residents and their rights to live in congenial environment.

In both cases the Constitutional Court ruled that in the territorial planning plaintiffs´ ownership limitations have been foreseen, but that has been done with a legitimate purpose: to ensure the welfare of the society. The Constitutional Court pointed out that defining the planned use of the territory as that of a wind park, is hazardless to the health and life quality of the residents, because regardless of the solution chosen in the territorial plan, the operation of the wind park will be permissible, only in the case that the environmental noise is under the levels stipulated by the law.

Conditions of securing the quality of information

The inhabitants of Grobiņa and Vērgale consider that in overall the information they received from the municipalities, the enterpriser and non-governmental organizations, has been of limited quantity and quality, in consequence they lack certainty that the wind turbines are harmless. All the respondents recognize that they would have wished and still desire to receive extensive and reliable information about the possible impacts of the wind park. For further information, see Table 3.

Table 3: The answers of the respondents about the quality and volume of available information (Author 2011)

Criteria	Grobiņa	Vērgale
Information about the wind park and the process of its planning and construction	100 % of the owners of the land where the construction of the wind turbines were planned consider that they have received the information on time and in a sufficient amount.	50 % of all inhabitants consider to have lacked sufficient information
	55 % of inhabitants that live near the wind turbines, which stand on land owned by others, lacked sufficient information on any stage of the development of the wind park	50 % of all inhabitants were invited to public discussion, but failed to attend. They lacked access to additional information.
	8 % of inhabitants that live near the wind turbines, which stand as planned on land owned by others, learned about the construction of the wind park only when the construction works begun.	
Information about the level of noise created by the wind turbines	All inhabitants consider they lacked information about the level of noise	All inhabitants consider they lacked information about the level of noise

People, who own properties neighboring lands on which the wind turbines are located, point out that their opinion before the construction of the wind park was unsolicited and a survey to determine public opinion should have been conducted. It also should have been ensured that the people inhabiting in the vicinity of the wind turbines had had direct information about the municipality´s plans.

Conditions of ensuring the public activity

The research shows that in the process of elaboration of the territorial plan and detail planning only a small part of Grobiņa respondents and none of Vērgale respondents participated. Both Vērgale and Grobiņa residents were inactive in the processes of planning of the wind parks, due to the belief that public activities have no impact on

the result. The residents of Grobiņa indicate that the low level of their participation is related to lack of information about the process of public discussion. For further information, see Table 4.

Meanwhile the inhabitants of Dunika draw out attention to a formal process of public discussion of the territorial plan and the detail planning, where the objections of the public were discarded and no reasonable arguments given why the public opinion has been dismissed. The local population believes that it was insufficiently informed about the public discussion and the municipality failed to respond to their questions and deal with their petitions (Constitutional Court of the Republic of Latvia 2011b).

Table 4: Respondents' answers about the processes of public involvement (Author 2011)

Criteria	Grobiņa	Vērgale
Percentage of residents that have participated in the process of elaboration of territorial planning and detail planning	8 % of all inhabitants	0 % of all inhabitants that live in neighborhood of land where the wind turbines are constructed
	100 % of owners of the lands where the wind turbines are constructed	
	3 % of inhabitants that live near the wind turbines, which stand on land owned by others	
	25 % of respondents that initially have been against the construction of wind park	

Conditions of monitoring

The legislation does not stipulate the need to conduct monitoring of levels of environmental noise. Residents have doubts about the stimulated level of noise, considering that these actions are performed by the developers of the wind parks; neither have the belief that these levels are observed.

Conditions of elaboration of territorial planning

The inhabitants of Dunika have indicated to procedural violations in the elaboration of territorial plan, when the area of the wind park was defined after the public discussion and after the documents were send out for adjustments to the controlling institutions. After adjudicating this case, the Constitutional Court (Constitutional Court of the Republic of Latvia 2011b) has concluded that municipality of Dunika has committed procedural violations, and as a result the strategic evaluation procedure of impact on the environment was left out.

DISCUSSION

The analysis of results outlined several problematic matters:

- Local population considers the wind parks to be significant sources of environmental noise, which can have an impact on quality of their life. The residents experience the acoustic discomfort, the health and social behavior disorders, and they point out to other possible impacts that lack scientific proof. That demonstrates the public´s concerns about possible impacts of wind parks on their health;
- The acoustic discomfort is higher from big wind turbines, groups of wind turbines and in places with higher population density, but considered layout of the wind turbines could diminish negative reaction of the population;

- The wind parks are designed to operate close to permissible levels of noise, thus increasing the society's concerns about their possible impacts on health. Similarly it should be indicated, that by the law the level of environmental noise is measured as L_{day}, $L_{evening}$ and L_{night}, considering all the periods during a year, thus indicating a general level of acoustic discomfort, but fails to do so with short-term, accidental exceeds of noise level, which also can cause changes in social behavior;
- Wind parks are developed without real evaluation of the local situation and analysis of public opinion, as well as without sufficient and good quality information about wind parks ensured to the public. These factors along with procedural violations in the process of territory planning have contributed to concerns of the local population about the insufficient evaluation of impacts of wind park development, which prevent the acceptance of development of wind energy facilities as a harmless process of municipality's development and creates protests from the residents;
- The discomfort, health disorders and changes in the social behavior generated by the wind parks affects more those people, whose dwellings are of poor technical condition, residents that have no wind turbines located on their properties but on those of their neighbors. Negative attitude is also expressed by those residents that gain no benefits from construction of wind turbines or those who believe that the promises of the developers of wind park have failed to come true.
- The residents failed to initiate any activities related to wind parks due to the belief that the municipality had no interest in their opinion and they lack power over processes of development of the municipality. On the occasions when mediators are involved in wind park processes and similar activities take place in other territories, the residents take more active participation in the processes of wind park planning;
- The residents desire to receive reliable and scientific information about the wind parks, their impact on the health and actual noise level, that would be monitored regularly, before and after the construction of the wind parks;
- The study shows that the solution of issues related to the management of environmental noise generated by the wind turbines in the municipalities should be developed in five main directions, using normative, institutional, communication and planning instruments.

1. Analysis of local situation and public opinion. Before the development of wind park it is necessary to conduct surveys in order to learn public opinion, to obtain information about the unclear matters and issues of public interest, to identify the potential level of opposition, to prepare a full public awareness and participation program, as well as to stimulate the creation of reflexive connection. Such activities would help diminish the society's concerns regarding an unfair threat to their environment and health.

When assessing the changes in life quality caused by the wind-turbine generated noise, not only the securing of law permitted outdoor noise level should be taken into account, but also the technical condition of the dwellings and the possibility of securing an appropriate indoor noise level, the excess of which can be the reason for sleep disturbance. Municipalities in the territorial planning and the environmental institutions in their licenses should stipulate the demand to simulate and measure in-

door noise level, and in case of excess, order as the wind park developer's duty to ensure anti-noise measures.

2. Ensuring the information. The society at all stages of wind park development should be informed about wind parks' technical parameters, their interpretation, as well as specific impacts to expect. The given information should be verified, reliable and as objective as possible, and at the same time it should be comprehensible for any audience. The accessibility of the information should be also insured in mass media and public spaces and via individual communication with those residents on whose land the equipment is to be constructed or those who live in close proximity.

3. Ensuring the public activity. Municipalities should avoid formal involvement of the society and should decide about addition distribution of the information. The municipality should ensure the distribution of the announcements in public spaces, and should determine them based on analysis of everyday's movements of the population as well as by evaluating the possibilities of residents of location where a particular project is being developed, to get acquainted with the information. During the process of public discussion the municipality should ensure the participation of independent experts, in order to give a justified response to public questions and to decide about implementing the public suggestions.

4. Monitoring. Monitoring of environmental noise should be performed at all stages of development of wind parks, and the gathered information should be offered to the society, thus ensuring a permanent sense of acoustic security for public. In addition, the legislation or the permissions granted by the environmental institutions should stipulate the obligation of the contractor to conduct a regular monitoring of indoors and outdoors noise level.

5. Territorial planning. Municipalities should ensure that the process of territorial planning is being realized in compliance with laws and regulations. Procedural violations in the process of territorial planning increase suspicions and opposition towards the planned activities in the society.

This approach could be used for other projects that anticipate issues with populations' subjective perception of noise, because it stimulates a more favorable attitude in the society and helps to prevent ungrounded complaints.

CONCLUSIONS

1. The society perceives the environmental noise generated by the wind parks as an important factor that influences on the quality of the life, but about which in general they lack information. Because of the shortage of the information, with concerns about the evaluation of the impacts of wind parks and bearing negative attitude towards the project, residents consider noise to be a bigger threat than is has been proven by the simulation data and scientific studies and protest against the planned type of municipality's development.

2. Acoustic discomfort is higher when sound is generated by more powerful wind turbines, groups of them and in places with higher population density. The subjective level of discomfort and the level of impacts on health depend on the fact if the turbine is located on the land of the respondent, if the wind turbine gives not only a general but also a private gain, and on the technical condition of the dwellings.

3. In order to diminish the negative attitude in the society and to promote the acceptance of wind parks as a territory acoustically safe for the health and life quality, by using the normative, institutional, communicational and planning instruments various actions should be implemented: 1) a territorial planning should be conducted in compliance with the legal procedures; 2) a detailed analysis of the situation and public opinion should be carried out; 3) based on the results of the later, the society should be sufficiently informed; 4) the public should be genuinely involved and reflexive connection should be ensured; 5) regular noise monitoring indoors and outdoors should be conducted and, if necessary, anti-noise measures should be applied.

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