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ABSTRACT:

ENVIRONMENT IMPACT OF WINDPOWER CASE STUDY OF WIND TURBINES IN LIVING ENVIRONMENT

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ABSTRACT

The aim of this project has been to get more knowledge about the impact of noise, shadows and on the view of the landscape from wind turbines. Further to be able to increase the reliability and relevance of the methods used to calculate and evaluate nuisances from wind turbines in applications for windpower development. We have also tried to find other factors that can play a role for the evaluation of wind turbines, if they will be considered as a nuisance or not. The research has focused on a critical review of the methods and regulations that are used in Sweden and other countries, and case studies to find out how people living neighbors with wind turbines will be affected by noise, rotating shadows, visual intrusion and other factors. This report includes the case studies of wind turbine areas at Gotland.

Three different areas on the island Gotland in the Baltic Sea, with wind turbines in the close neighborhood, were chosen for case studies: A) När, B) Klintehamn, C) Näsudden. In these places only persons who live close to wind turbines have been interviewed; in När all who live within 1100 meters from two large wind turbines, in Klintehamn a sample of those who live ESE of the turbines and get shadow flicker from them during sunset, and on Näsudden those households that live in the middle of a large wind farm with 81 turbines. In total 94 persons in 69 households have been interviewed.

Considering that all persons that have been interviewed live close to wind turbines, the nuisance reported are surprisingly small. Very few of them are annoyed by noise, shadows or consider that their view of the surrounding landscape has been destroyed. Of the total number of persons interviewed, 85 percent are *not* annoyed by noise from the wind turbines around their homes. For rotating shadows the share of *not* annoyed is even bigger; 94 percent. Quite few of the person living at Näsudden, where there are 81 wind turbines on line, think that their view of the surrounding landscape has been negatively affected by this; 13 percent. Of all persons in all three areas, 89 percent are of the opinion that their view has not been annoyed by wind turbines.

The acceptance of windpower among people living as close neighbors is quite high. However, the nuisance and annoyance can be reduced further, if the recommended values for noise immission etc are applied correctly. To do that the ability of project developers and authorities that grant permissions to evaluate the calculated immissions has to be raised, since specialist competence and experience is necessary to do predictions of actual immissions from the models used for calculations.

Results from case study

Noise. There is a statistically significant connection between calculated noise immission and annoyance from aerodynamic noise. In total for all areas 12 % of the respondents with an immission of < 40 dBA were annoyed by noise. The largest share of annoyance was found in När. This is probably due to the location of the houses in relation to the predominant wind direction, etc. Of respondents with a calculated noise immission over 40 dBA, 44 percent were rather or much annoyed by aerodynamic noise from wind turbines. This point to that 40 dBA is a reasonable recommendation for noise immission.

Shadows. Although none of the respondents in Klintehamn according to calculations of shadows on the facade, in the worst case, has more than 30 hours/year and a maximum of 30 minutes/day 24 % are rather or much annoyed by shadows. On Näsudden 17 % of the respondents had according to calculations more than 30 hours/year (facade, worst case) but only 4 % are rather or much annoyed by shadows. In När nobody was annoyed by shadows. One possible explanation that so many in Klintehamn are annoyed by shadows, could be that most of the respondents live east south east of the turbines, and will get shadow flicker in the evenings during the period April to September (90 % of the respondents), that is when the shadows are most intensive and most people are at home. On Näsudden half of the respondents get shadows in the evening, while the rest get shadows in the morning or in the middle of the day. Respondents that are not annoyed by shadows although they have a large shadow impact, these appear in the morning or during winter. Respondents that are annoyed although the shadow impact is small, the shadows appear in the evening. In När no respondent gets shadows during summer evenings. The conclusion from this is that it is more important at what time of the day and the year shadows have an impact, than the total calculated time in hours a year of shadow impact.

On Näsudden there is no connection between calculated duration of shadow impact and annoyance. There is however a moderate-strong connection between the distance to the closest turbine and annoyance from shadows. This could indicate that the geometrical model for shadow impact calculation is not accurate when there are several turbines at large distances from a building, since the shadow impact from distant turbines are included, although the shadows, according to a recent study, have a maximum extension of approximately 1 km (Freund 2002).

Since a new rule about calculation of shadow impact, which states that the calculation should be made for the building lot (garden), instead of window, has been introduced by the Swedish building authority (Boverket), the time for shadow impact in Klintehamn has been calculated for both lot and façade. There is a statistically significant *moderate* connection between shadow *minutes/day on facade* and annoyance. There was no connection between minutes/day on *lot* and annoyance. The calculated time for shadow flicker on lot instead of facade is approximately 3 times longer. To introduce a new rule about calculation for lot without a simultaneous change of recommended duration of shadow impact does not seem reasonable.

Visual impact. In all three areas very few respondents consider themselves annoyed by the change of views due to wind turbines. On Näsudden 6 % are much annoyed by the changed view, while in Klintehamn and När nobody is much annoyed by this.

Distance. On a distance to the closest wind turbine of more than 750 meters only 3-5 % were annoyed by noise, nobody was disturbed by shadows and only one of all respondents was annoyed by having wind turbines in view.

Other factors. In När and Klintehamn there is a statistically significant connection between the attitude to windpower in this case (i.e. to the turbines standing in their neighborhood) and annoyance from noise and shadows respectively. On Näsudden there is a statistically significant connection between general attitude to windpower and annoyance from noise. In all areas there is a significant connection between attitude in this case, and annoyance from

changed view (visual impact). This could suggest that those who have a positive attitude to windpower will not be annoyed in the same way as those who have a negative attitude. It could however also be the other way around, those who are not annoyed will not have a negative attitude. It is not possible to find out the relation between cause and effect from this study.

The recommended minimum distances between wind turbines and houses that some communities have introduced, for example on Gotland (minimum 1000 meters as a general recommendation, but with an option to reduce it to 500 meters if circumstances allow this), creates limitations for landowners to use their land close to wind turbines. Another factor that was found was that a landowner who has a wind turbine installed close to the border to his neighbor's land, limits the neighbor's opportunity to erect a turbine on his land, since there must be a minimum distance between turbines. This problem can be solved by defining the area used by a turbine as it's wind catchment area (a circle with a radius of 2,5 rotor diameters), instead of only the few square meters where the foundation is located.