Human response to wind turbine noise

Perception, annoyance and moderating factors

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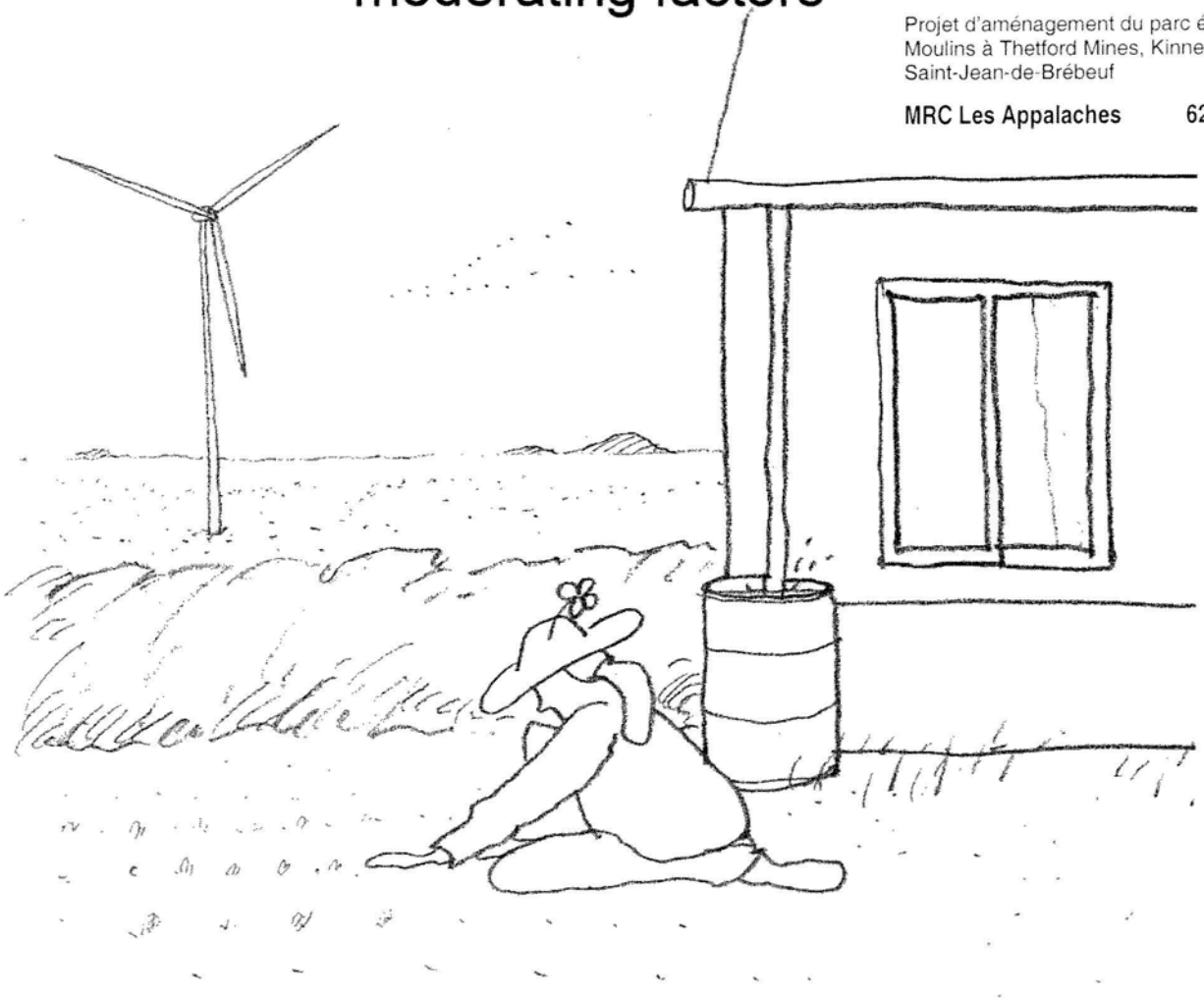

Eja Pedersen

GÖTEBORGS UNIVERSITET

Occupational and Environmental Medicine
Department of Public Health and Community Medicine
The Sahlgrenska Academy

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Abbreviations

ANOVA	analysis of variance
CFI	comparative fit index
CI	confidence interval
DENL	day-evening-night level; a descriptor of noise level based on equivalent sound pressure levels (SPLs) over a year for different times of the day, with a penalty of 10 dB(A) for night-time noise (22.00–7.00 hours) and an additional penalty of 5 dB(A) for evening noise (19.00–23.00 hours)
DNL	day-night level; a descriptor of noise level based on equivalent sound pressure levels (SPLs) over a year for different times of the day, with a penalty of 10 dB(A) for night-time noise (22.00–7.00 hours)
GT	Grounded Theory
LSD	Least Significant Different, a post hoc test
OR	odds ratio
RMSEA	root mean square error of approximation
SD	standard deviation
SEM	structural equation model
SPL	sound pressure level
VRS	verbal rating scale

1. Introduction

Wind consists of large amounts of energy originating from the sun and transferred to Earth every day, energy that will not cease in time imaginable. This large amount of energy is devastating when it hits us as storms or hurricanes, weather situations prophesied to increase with the increased net emission of carbon dioxide. However, the energy in wind is also beneficial, if it is captured and transformed into forms of kinetic or potential energy that can be utilized by humans. Wind has been used for transportation up rivers and over the seas for 6,000 years and has in this function only just recently been substituted by fossil fuels. Wind has also been a helper for strenuous mechanical work where no hydropower has been available. Windmills, with sails that rotated the heavy millstone when it was time to grind the crops, dominated some flat agricultural landscapes in Europe 500 years ago. Wind wheels pumping up water were a common sight on the Great Plains in North America during the last century.

Today the need for highly efficient and flexible forms of energy requires transformation of wind energy into electricity, rather than into mechanical work. Wind turbines for electricity generation have undergone rapid development and after experiments with different designs have found their present shape, three rotor blades sweeping a large area, a generator placed downwind from the rotor blades and a steel tower high enough to reach steady winds not influenced by the ground. The awareness of the limited resources of fossil fuels and the rising concern for the effects of the increased amount of greenhouse gases in the atmosphere have given the wind turbine industry a push forward. Wind turbines are now being produced on a large scale in countries such as Denmark, Germany, the USA, India and Spain, and the demand at the moment is larger than the production.

Wind turbines have, however, not been welcomed in all places where they have been planned to operate. Although wind power has been favoured by the public in general opinion polls, in comparison with other electricity production alternatives, projects have often been opposed locally. People living in areas pointed out as suitable for generation of wind power have expressed a fear of being disturbed by noise and have defended their landscape from what they believe is an intrusion of the environment. Opposition to planned projects, often reported in the media, is not unique to wind turbine development. It is difficult to say whether the voices against

potential disturbers of the peace are raised higher today than in the past, when the windmills for grain crops were built. The overall increased sound levels in our environment, together with other demanding stressors, may, however, have enhanced the need for quiet in our home environment, a need that triggers opposition to potential noise sources such as wind turbines.

On the one hand, there is therefore a social (and economic) requirement for erecting more wind turbines so that electricity can be generated without harm to the environment and hence also to humans. On the other hand, there is an individual need for quiet and peace in the home environment. Both these demands have to be met in the future development of wind power. The probability of adverse reactions to wind turbine noise in relation to noise levels, with all its implications, should carefully be taken into account in the planning process. This will help avoid inappropriate placement of wind turbines. If areas more suitable for wind power are chosen, there will be less of an issue of disturbing the public and the public will not have to worry about disturbance, being confident that this aspect would have been included in the planning. This thesis is an attempt to contribute to the knowledge of response to wind turbines as community noise sources.