



International Legislation for Wind Turbine Noise

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Summary

The analysis of wind turbine noise is considered an important aspect during the planning process of wind farms. Governing authorities, developers and the public are interested in reliable references from other countries in order to gauge their own specific needs for defining noise regulation limits.

The intent of our study is to provide a comparison of wind turbine noise regulations in the countries of Belgium, France, Germany, The Netherlands, United Kingdom, Denmark, Sweden, Norway, Finland, Australia, New Zealand, United States of America, and Canada. The findings of this study are proposed to further educate the governing authorities, the wind industry and the public as well as assist to improve the quality of advice within industry and governing authorities.

Research shows numerous European countries have strict regulations for wind turbine compliance noise threshold limits. In converse to Europe, the United States and Canada do not include national legislation whereby deferring to local province, state, and county.

Overall, research indicates that noise regulations implemented for limiting wind turbine noise is shown to widely vary between these countries. No common influence or application of metrics can be identified between sampled jurisdictions. Depending on the noise metric used, the range in noise impact threshold limits could be a difference of 20 decibels or greater.

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1. Introduction

The analysis of wind turbine noise is considered an important aspect during the planning process of wind farms. When developing new policy or regulations governing authorities are interested in reliable references from other countries in order to gauge their own specific needs for defining noise regulation limits. Where regulations are lacking developers look for references how to avoid or judge noise complaints. The public often refers to (seemingly) stricter legislation in other countries, but misinterpretations are quite common.

This overview study is an initial attempt to conduct a comparative analysis incorporating 41 governing jurisdictions spanning Europe, Australia, New Zealand and North America. It provides a summary evaluation of a variety of

these regulations by identifying and comparing specific noise metrics. The sampled jurisdictions were evaluated and are succinctly summarized in this paper.

The findings of this study are proposed to further educate the governing authorities, the wind industry and the public as well as assist to improve the quality of advice within industry and governing authorities.

2. Legislation and Regulations Governing Wind Turbine Noise

To give the reader a sense of the disparity of wind turbine noise code regulations, an overview is presented in Table I summarizing the noise regulations and threshold limits as published by a variety of different countries and jurisdictions.

Table I. Overview of Noise Metrics and Threshold Limits.

Governing Jurisdiction	Noise Metric	Rural Area	Residential Area
Belgium – Flanders [1]	L_{Aeq} @ 95% nominal power [dB(A)]	Day: 48 Evening/night: 43	Day: 44 Evening/night: 39
Belgium – Wallonia [2]	L_{Aeq} @ all wind speeds [dB(A)]	45	
Canada	No National Legislation for Wind Turbine Noise		
Canada – Alberta [3]	L_{Aeq} [dB(A)]	40 (basic limit)	40 (basic limit)
Canada - Ontario	L_{Aeq} [dB(A)]	40 @ 4 m/s – 51 @ 10 m/s; 45 @ 8 m/s	45 @ 4 m/s – 51 @ 10 m/s; 45 @ 8 m/s
Canada - Prince Edward Island [4]	No Province Legislation for Wind Turbine Noise, but Setback Distance of 3 Times Total Turbine Height to Neighbouring Residences		
Denmark [5]	L_r [dB(A)] L_r [dB(A)] L_{pALF} (indoors) [dB]	42 @ 6 m/s 44 @ 8 m/s 20 @ 6 and 8 m/s	37 @ 6 m/s 39 @ 8 m/s 20 @ 6 and 8 m/s
Finland [8]	L_{Aeq} [dB(A)]	Day: 45 (<i>draft</i>) Night: 40 (<i>draft</i>)	
France [6]	L_{Aeq} @ all wind speeds [dB(A)]	Day: increase of 5 dB(A) with reference to background noise level Night: increase of 3 dB(A) with reference to background noise level	
Germany [7]	L_r @ all wind speeds [dB(A)]	Day: 60 Night: 45	Day: 50-55 Night: 35-40
The Netherlands [9]	L_{den} [dB] L_{night} [dB]	L_{den} : 47 L_{night} : 41	
New Zealand [10]	$L_{A90(10min)}$ [dB(A)]	35 or background $L_{A90(10 min)} + 5$	40 or background $L_{A90(10 min)} + 5$
Norway [11]	L_{den} [dB]	L_{den} : 45	
South Australia [12]	$L_{Aeq,10}$ [dB(A)]	35 or background $L_{A90(10 min)} + 5$	40 or background $L_{A90(10 min)} + 5$
Sweden [13]	L_{Aeq} @ 8 m/s [dB(A)]	35	40
United Kingdom [14]	$L_{A90(10min)}$ [dB(A)]	Day: background + 5 dB(A), with a lower limit of 35 to 40 dB(A) Night: background + 5 dB(A) with a lower limit of 43 dB(A)	

Governing Jurisdiction	Noise Metric	Rural Area	Residential Area
United States of America [15]	No National Legislation for Wind Turbine Noise EPA: L_{dn} [dB(A)]	55	
Colorado	No State Legislation for Wind Turbine Noise		
Colorado - Arapahoe County [16]	L_{Aeq} [dB(A)]	---	Day: <55 Night: <50
Georgia [17]	L_{Aeq} [dB(A)]	55	
Illinois [18]	Octave Band Analysis		
Indiana	No State Legislation for Wind Turbine Noise		
Indiana – Tipton County [19]	$L_{Aeq,10}$ [dB(A)]	45	
Michigan [20]	L_{Aeq} [dB(A)]	55 or background + 5 dB(A)	
Michigan – Huron County [21]	L_{A10} [dB(A)]	45 or background + 5 dB(A)	
Minnesota [22]	L_{Aeq} [dB(A)]	50	
Minnesota - Lincoln County [23]	L_{Aeq} [dB(A)]	50	
Nevada	No State Legislation for Wind Turbine Noise		
Nevada - Lyon County [24]	L_{Aeq} [dB(A)]	55	
New Mexico	No State Legislation for Wind Turbine Noise		
New Mexico - San Miguel County [25]	L_{Aeq} [dB(A)]	< background	
New York	No State Legislation for Wind Turbine Noise		
New York - Town of Jefferson [26]	L_{A10} [dB(A)]	---	50 or background + 5 dB(A)
North Carolina [27]	L_{Aeq} [dB(A)]	55	

Governing Jurisdiction	Noise Metric	Rural Area	Residential Area
Oregon [28]	L_{A50}	Day: 55 Night: 50	
Pennsylvania	No State Legislation for Wind Turbine Noise		
Pennsylvania - Potter County [29]	L_{Aeq} [dB(A)]	background + 5 dB(A)	
Wisconsin [30]	L_{Aeq} [dB(A)]	Day: 50 Night: 45	
Wisconsin - Shawano County [31]	L_{Aeq} [dB(A)] / Octave Band Analysis	background + 5 dB(A)	
Wyoming [32]	No State Legislation for Wind Turbine Noise		
Wyoming - Laramie County [33]	L_{Aeq} [dB(A)]	50	

3. Wind Turbine Noise Metrics

Noise limits are established and regulated by applying specific noise metrics to ensure the quality of life within local communities. The noise metrics used to regulate noise from wind turbines have been shown to contain a large variation between countries and jurisdictions.

Research shows that the L_{Aeq} metric is the most common metric used for regulating wind farm noise. A total of 20 of the 41 governing jurisdictions sampled in this analysis use the L_{Aeq} metric. Five countries use a metric that is derived from the L_{Aeq} metric, like L_r , L_{dn} , L_{den} and L_{night} , but include a penalty for times of day with increased sensitivity like part of the day (L_r in Germany), the evening (L_{den}) and the night (L_{den} , L_{dn}). Further, L_{den} and L_{night} as defined in the EU Directive Environmental Noise (2002/49/EC) are year average noise levels. Besides the metric L_r , Denmark also uses the metric L_{pALF} for the low frequency noise indoors.

The metric L_{Aeq} is defined as the “equivalent sound level” and is based on a time-integrated measurement period which does vary between countries and jurisdictions. These integrated time

periods range from a 10 minute measurement to a 24 hour measurement (evaluation period).

Statistical noise metrics (L_{10} , L_{50} , and L_{90}) were found in 5 of the 41 of the sampled jurisdictions. However, similar to the L_{Aeq} metric, these metrics showed variation in threshold values and time durations. Additionally noted were frequency octave band noise threshold limits which were found to be incorporated into 2 of the jurisdictions. In 9 of the 41 jurisdictions no noise regulations were published.

Possible tonal issues associated with wind turbines were addressed in a number of the governing jurisdictions. This included several in Europe (Denmark, Germany, Sweden, and the United Kingdom), South Australia and three in the USA (Township of Jefferson, Huron County and Shawano County). The tonal analysis was identical within all but one of these jurisdictions, which incorporated a 5 dB penalty added to the established threshold limits. Germany is the exception. It does include a penalty for possible tonal noise, but the penalty is 3 or 6 dB depending on the distinctiveness. Out of these jurisdictions, Shawano County was the only one that included a low frequency one-third octave band analysis. Denmark regulations also include a

low frequency analysis from 10 Hz to 160 Hz, but this is a single overall number for this frequency range.

4. Limit Values

Figure 1 gives an overview of night time limit values for jurisdictions with L_{Aeq} noise metrics. The limit values show a variation of approximate 20 decibel variation depending on the governing jurisdiction.

Countries like France, Sweden, South Australia and New Zealand have more stringent noise limits for rural areas with relatively low background noise levels than for residential areas. In contrary, the Belgian Region Flanders, Denmark and Germany in general allow higher noise levels at dwellings in a rural area than at residential areas.

Furthermore, 9 of the 41 jurisdictions did not contain any published noise regulations. These jurisdictions were typically Countries or States that

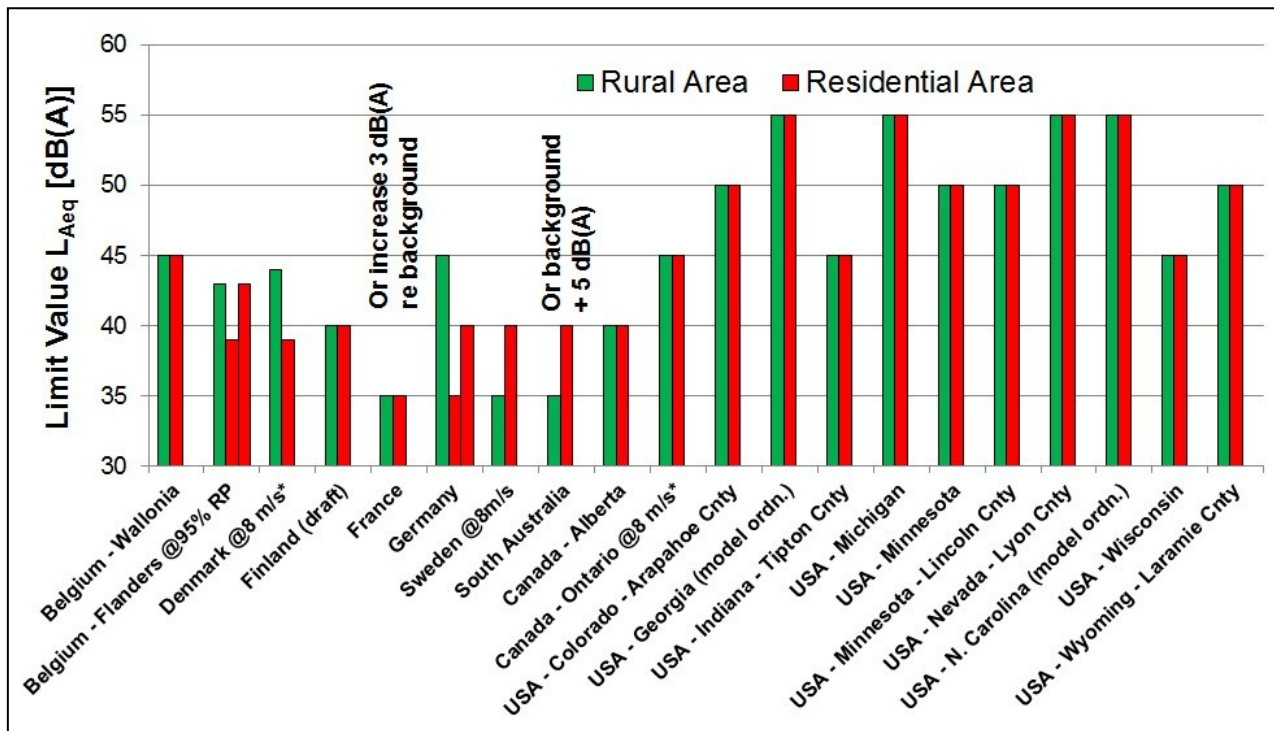


Figure 1. Comparison Between Countries with L_{Aeq} Noise Limits for Rural and Residential Areas (Night Time Limit Values).

Figure 1 shows that jurisdictions within the United States have in general higher threshold limits for wind turbine noise, than Europe and South Australia. France, Germany, Sweden and South Australia contain the lowest threshold limits when applying the L_{Aeq} metric.

Most countries in Europe, but also South Australia, New Zealand and a number of states and counties in the USA, have a noise limit which depends on the land use or the existing background noise levels. Exceptions are The Netherlands, Norway, the Belgian Region Wallonia, Finland (draft) and a number of states and counties in the USA, which all have fixed limit values.

would defer noise regulations to the local state, province or county. This was most common in North America and found in both the United States and Canada.

A high percentage of jurisdictions evaluated contain set back distance requirements for wind turbines. However, these setback requirements were mainly enforced for safety issues or visual impact or are general guide values.

5. Conclusion

Many jurisdictions responsible for governing wind turbine noise possess a wide range of noise regulations that span between country and county authorities. There is no common influence or application of metrics that can be identified between the sampled jurisdictions. However, research shows that the most common noise metric

used is the L_{Aeq} metric. There is a wide range on how stringent a jurisdiction is when regulating noise from wind turbines. Depending on the noise metric used, this range in noise impact threshold limits could be a difference of 20 decibels or greater; a difference significant enough to consider whether or not a wind farm may be permitted for development and whether or not it may generate community complaints.

References

- [1] VLAREM II, Besluit van de Vlaamse regering van 1 juni 1995 houdende algemene en sectorale bepalingen inzake milieuhygiëne.
- [2] Cadre de référence pour l'implantation d'éoliennes en Région Wallonne, Gouvernement Wallon, 21 February 2013.
- [3] Alberta Utilities Commission, Rule 012, Noise Control.
- [4] Prince Edward Island Department of Environment, Energy and Forestry, 2010, Wind turbine approval.
- [5] Bekendtgørelse om støj fra vindmøller, BEK nr. 1284, Miljøministeriet, 15 December 2011.
- [6] Arrêté du 26 août 2011 relatif aux installations de production d'électricité utilisant l'énergie mécanique du vent au sein d'une installation soumise à autorisation au titre de la rubrique 2980 de la législation des installations classées pour la protection de l'environnement, NOR: DEVP1119348A, Ministère de l'écologie, du développement durable, des transports et du logement.
- [7] Sechste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zum Schutz gegen Lärm - TA Lärm) vom 26. August 1998 (GMBI Nr. 26/1998 S. 503).
- [8] M. Antila: Wind Turbine Excess Noise Evaluation. Presentation EWEA Technology Workshop Wind Turbine Sound 2014.
- [9] Besluit van 19 oktober 2007, houdende algemene regels voor inrichtingen (Besluit algemene regels voor inrichtingen milieubeheer).
- [10] NZWEA factsheet on the New Zealand Wind Farm Noise, February 2010.
- [11] Retningslinje for behandling av støy i arealplanlegging', T-1442/2012, 2 July 2012.
- [12] Wind farms environmental noise guidelines, Environment Protection Agency South Australia, July 2009.
- [13] www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledning-amnesvis/Buller/Buller-fran-vindkraft/buller-vindkraft-riktvarden, site visited 23 April 2013.
- [14] ETSU-R-97, The Assessment and Rating of Noise from Wind Farms. The Working Group on Noise from Wind Turbines, September 1996.
- [15] The U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974.
- [16] Land Development Code, Chapter 12: Specific Regulation, Section 12-700 Small Wind Energy Conversion Systems, 30 June 2010.
- [17] Georgia Wind Working Group, Model Wind Ordinance for Wind Energy Facilities, March 2010.
- [18] State of Illinois. 2006. Title 35: Environmental Protection, Subtitle H: Noise, Chapter I: Pollution Control Board, Part 901: Sound Source Emission Standards and Limitations for Property-Line Noise Sources.
- [19] Ordinance 2014 - Amendment of Tipton County Zoning Ordinance. Ordinance 2008-12. Article Ten Enactment. Section 1002 Amendment.
- [20] Michigan Siting Guidelines for Wind Energy Systems, 14 December 2005.
- [21] Article X, Huron County Wind Energy Conversion Facility Overlay Zoning Ordinance.
- [22] Minnesota Pollution Control Agency (MPCA), Chapter 7030-Noise.
- [23] Lincoln County Comprehensive Development Ordinance No. 40. (2009). Section IX. Wind power.
- [24] American Wind Energy Association, www.awea.org/learnabout/smallwind/upload/Wind-Ordinances-by-State-NV.pdf.
- [25] San Miguel County Ordinance No. SMC-03-08-11-Wind.
- [26] Town of Jefferson Wind Energy Facilities Law, Section 4: Development Standards.
- [27] North Carolina Wind Working Group, Model Wind Ordinance for Wind Energy Facilities in North Carolina, July 2008.
- [28] Department of Environmental Quality, Division 35, Noise Control Regulations. Section: 340-035-0035 Noise Control Regulations for Industry and Commerce.
- [29] Article 12, County of Potter, Commonwealth Pennsylvania, Ordinance No. 1-2008.
- [30] State of Wisconsin Legislation, Chapter PSC 128 Wind Energy Systems.
- [31] Shawano County, Planning and Development, Wind Energy Conversion System.
- [32] Wyoming State Section 18-5-501 through 513.
- [33] Section 55.300 Laramie County Wind Energy System Regulations.