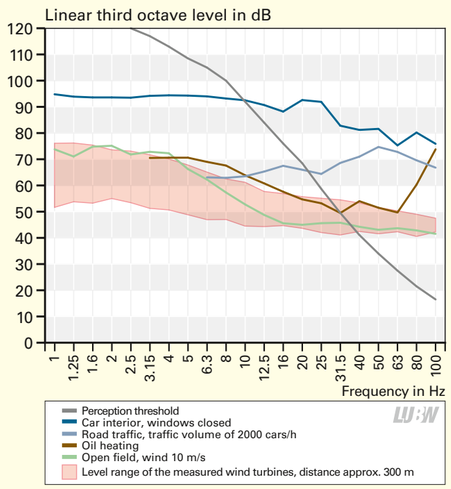


Comparison of noise levels within a passenger car, near a road, on an open field, and from an oil heating with the level range of the measured wind turbines as well as the human perception threshold

CONCLUSION

Infrasound and low-frequency noise are an everyday part of our technical and natural environment. Compared with other technical and natural sources, the level of infrasound caused by wind turbines is low. Already at a distance of 150 m, it is well below the human limits of perception. Accordingly, it is even lower at the usual distances from residential areas. Effects on health caused by infrasound below the perception thresholds have not been scientifically proven. Together with the health authorities, we in Baden-Württemberg have come to the conclusion that adverse effects relating to infrasound from wind turbines cannot be expected on the basis of the evidence at hand.

The measurement results of wind turbines also show no acoustic abnormalities for the frequency range of audible sound. Wind turbines can thus be assessed like other installations according to the specifications of the TA Lärm (noise prevention regulations).

It can be concluded that, given the respective compliance with legal and professional technical requirements for planning and approval, harmful effects of noise from wind turbines cannot be deduced.

FURTHER INFORMATION

Detailed information on the measuring project is included in the document „Low-frequency noise incl. infrasound from wind turbines and other sources – Report on the results of the measurement project 2013-2015“. It can be downloaded in the LUBW online shop at www.lubw.de/servlet/is/262445.

Further information about wind energy and infrasound can be found in the leaflet „Windenergie und Infraschall – Tieffrequente Geräusche durch Windenergieanlagen“, which the LUBW has issued in cooperation with the public health authorities of Baden-Württemberg, and the publication „Fragen und Antworten zu Windenergie und Schall – Behauptungen und Fakten“. Both publications are in German language and can be downloaded or ordered using the search field on the LUBW home page www.lubw.de.

PICTURE CREDITS

Title page: goodluz / fotolia.com
All other pictures: LUBW

Issue: September 2016 (1st edition)

Comparative table of results

	Level in dB(G)
Wind turbines (at wind speed of 2-15 m/s)	
Turbine off, 120-190 m distance	50-75
Turbine on, 120-190 m distance	55-80
Turbine off, 650-700 m distance	50-75
Turbine on, 650-700 m distance	50-75
Road traffic	
Inner city (measured on balcony)	50-75
Inner city (measured in living quarters)	40-65
Inner city (traffic noise measuring station Karlsruhe)	65-75
Inner city (traffic noise measuring station Reutlingen)	70-80
Motorway (A5 near Malsch), 80 m distance	75
Motorway (A5 near Malsch), 260 m distance	70
Noise in passenger car (windows closed, 130 km/h)	105
Noise in minibus (windows closed, 130 km/h)	100
Urban environment	
Museum roof	50-65
City square	50-65
Interior	45-60
Rural area (at wind speed of 10 m/s)	
Open field (130 m from forest)	55-65
Edge of forest	50-60
Forest	50-60
Sources of noise in residential buildings	
Washing machine (all operating phases)	50-85
Heating (oil and gas, full load)	60-70
Refrigerator (full load)	60
Sea surf (literature source Turnbull/Turner/Walsh)	
Beach (25 m distance)	75
Rock cliff (250 m distance)	70

LUBW

LUBW

Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg

Low-frequency noise incl. infrasound from wind turbines and other sources

Results of the measurement project 2013-2015

Publisher:

LUBW Landesanstalt für Umwelt,
Messungen und Naturschutz Baden-Württemberg
Postfach 10 01 63 · 76231 Karlsruhe
www.lubw.baden-wuerttemberg.de
windenergie@lubw.bwl.de

Baden-Württemberg

THE ISSUE AT HAND

In addition to the usual audible sound, the noise coming from wind turbines also contains low frequencies including infrasound. Sound below the audible range, i. e. with frequencies of less than 20 hertz (Hz), is called infrasound. Noise is defined as low-frequency noise if substantial parts of it are in the frequency range below 100 hertz (Hz). Infrasound is thus a part of low-frequency sound.

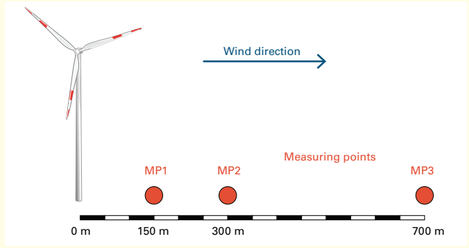
Our hearing is very insensitive to low frequencies. However, in the context of the development of wind power utilization, fears are often expressed that wind power plants might produce a great amount of infrasound. But how much infrasound do wind turbines really produce? This is the question the LUBW examined in an extensive measurement project. This leaflet summarizes the main results of the survey.

THE MEASUREMENT PROJECT

The acoustic examinations were carried out in the years 2013 through 2015 in cooperation with the company Wölfel Engineering GmbH & Co. KG in the vicinity of six wind turbines by different manufacturers and of different sizes. Additional vibration measurements were also carried out at one wind turbine. In order to appropriately classify the data collected, low-frequency sound from other sources was also measured and evaluated: effects of an urban road outside and inside a residential building, near a motorway, at two LUBW measuring stations for road traffic noise, as well as inside driving cars. Measurements without direct source reference were taken in the city centre of Karlsruhe. Furthermore, noise from technical home appliances, such as washing machine,

Evaluation of noise

Depending on the issue, the frequencies of sound are weighted differently. A-weighting is customary and expressed as dB(A), which roughly corresponds to human auditory perception. However, for the range of infrasound, so-called G-weighting, expressed in dB(G), is used. The G-weighting is focused at 20 Hz: The contributions of sound between 10 Hz and 25 Hz are strongly incorporated into the level, the contributions above and below only slightly. Unweighted levels (linear levels) are normally used for frequency analysis and the comparison with the perception threshold. In this case, all frequencies are weighted equally. The Figures in this leaflet show unweighted third octave spectra or narrow-band spectra.



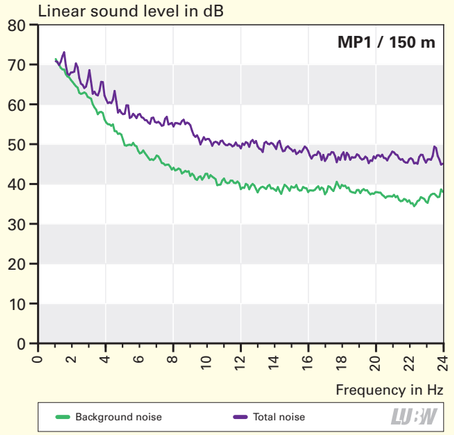
Exemplary measuring arrangement (not to scale)

refrigerator or heating, were also analysed in the way that they occur indoors. Additional measurements of natural infrasound in an open field, at the edge of a forest and in a forest rounded off the measurement programme.

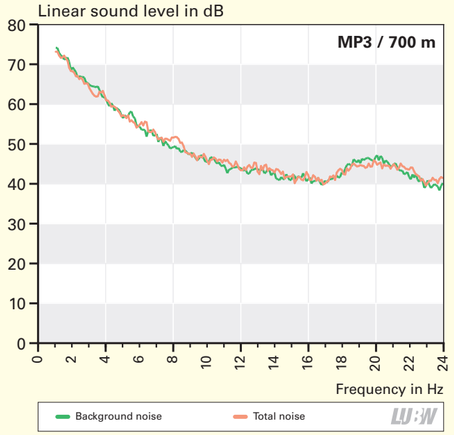
WIND TURBINES

Depending on the respective local conditions, the measurements at the six wind turbines were carried out at distances of approx. 150 m, 300 m and 700 m. The turbines covered a power range from 1.8 to 3.2 megawatts. It turned out that the infrasound coming from wind power plants can be detected by measurement rather well in the vicinity of the power plants. In addition to the noise of the wind turbine, sound generated by wind in the vicinity as well as wind-induced sound at the microphone are also generally picked up. In the narrowband spectrum, a typical sawtooth pattern can be seen below 8 Hz. This is due to the uniform movement of the rotor blades, which appears as a fundamental oscillation with harmonic waves (see Figure top of page 4).

With values of between 45 and 75 dB (unweighted), the infrasound third octave levels measured around the wind turbines are well below the human perception threshold as defined by DIN 45680 (draft 2013) even at close distances of around 150 m. The measured values show a wide range of variation. This is due to different environmental conditions and the varying noise components of the wind. At a distance of 700 m from the wind turbines, it was observed that when the turbine is switched on, the measured infrasound level did not increase notably or only to a limited



Background noise (turbine off) and total noise (background noise plus noise of the wind turbine) at a distance of 150 m at 6.5 m/s wind speed



Background noise (turbine off) and total noise (background noise plus noise of the wind turbine) at a distance of 700 m at 6.5 m/s wind speed

extent. At this distance, the infrasound is mainly induced by the wind and not generated by the power plants (see Figure bottom of page 4).

The vibrations caused by the wind turbine being examined were already minimal at a distance of less than 300 m. The readings were well below the reference values in accordance with DIN 4150 Part 2. This standard applies for the assessment of vibrations that affect people in buildings. At distances required in the vicinity of residential areas for noise protection reasons alone, no relevant effects can thus be expected for residential buildings.

ROAD TRAFFIC

As expected, the measurements of noise from traffic showed a clear correlation between noise and traffic density. The higher the volume of traffic, the higher was the low-frequency noise level. Contrary to the situation with wind turbines, the levels caused by road traffic also occur directly near residential buildings. The G-rated infrasound levels near residential buildings were between 55 and 80 dB(G). Increased level values were observed mainly in the frequency range between 30 and 80 Hz. These noise components are well above the perception threshold in accordance with DIN 45680 (2013 draft). The measured low-frequency noise from road traffic is significantly louder than in the vicinity of wind turbines (see Figure on page 7). The infrasound and low-frequency noise levels dropped at night.

Much higher levels occur in the interior of a medium-sized car driving at 130 km/h. This does not actually concern an immission in an open environment, but it is an everyday situation, which many people are often exposed to for longer periods of time. The infrasound here is greater by several orders of magnitude than in the vicinity of wind turbines (see Figure page 7).

CITY CENTRE

The measurements in the city centre of Karlsruhe showed G-weighted infrasound levels that were mostly between 55 and 65 dB(G). At times, values above 70 dB(G) were even reached.

In the evenings, the G-level declined steadily. In the frequency range between 25 and 80 Hz, relatively high third octave levels of up to 60 dB (unweighted) were observed. These are probably due to traffic noise in the wider vicinity. G-levels of between 45 and 60 dB(G) were measured indoors.

TECHNICAL EQUIPMENT IN RESIDENTIAL BUILDINGS

The measurement of appliances in a residential building showed the highest G-weighted infrasound levels with up to 85 dB(G) during the spin cycle of washing machines. In some frequency ranges, the levels reach the human perception threshold in accordance with DIN 45680 (2013 draft). The linear third octave levels caused by an oil heating were between 50 and 75 dB (see Figure page 7).

RURAL ENVIRONMENT

The noise situation with the wind blowing in an open field, at the edge of a forest and in a forest is similar to that in the vicinity of a wind turbine. At a wind speed of 10 m/s in the open field, the measurements of 55 to 65 dB(G) on the open field showed slightly higher G-weighted infrasound levels than at the edge of the forest and in the forest, where 50 to 60 dB(G) were measured. This can be explained by the lower wind speed at the edge of the forest and in the forest. For audible sound, the noise level rises at the edge of the forest and in the forest compared to the open field. This is due to the rustling of leaves (see Figure page 7).

COMPARISON OF DIFFERENT SOURCES

The Figure on page 7 again illustrates the breadth of the linear third octave level for the respective wind turbines at a distance of approx. 300 m (red band). For comparison, the measurement results for the sound of traffic and nature as well as an oil heating system are also shown. What becomes apparent is the large distance between the turbine noise and the human perception threshold in the infrasound range.