





# Frequently asked questions about wind energy and noise

 Allegations and facts





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# Introduction

The energy transition has been accompanied by heavy public debate. And in recent years numerous initiatives, both for and against wind energy, have been set up. A plethora of statements has been made on the Internet, in forums and at lectures about wind turbines and their possible effects on humans, animals and the environment. A wide range of opinions can be found on the aspect of infrasound in particular. Many people are now confused and have a lot of questions they want answered.

In this brochure, we have addressed questions that we have been repeatedly asked in the past. And we have tried to provide answers in an intelligible form that are based on scientifically proven facts and figures. The provincial health authority of Baden-Württemberg has reviewed the statements and supports them.

You can find these statements as well as further information on the Internet at [www.lubw.de](http://www.lubw.de), in the theme portal Renewable Energy, area of Wind Energy.

# 1. Wind energy and sound energy

## QUESTION

It is claimed that wind turbines convert more than half of the wind energy into sound waves, and that modern wind power plants therefore cause noise in the megawatt range. The rotor blades of wind turbines are supposedly among the most effective producers of audible sound and infrasound in the industry. Is that true?

## ANSWER

Wind turbines certainly do not convert a large part of the energy from the wind into sound or infrasound. First and foremost, they transform the kinetic energy of the wind into electricity – however, only up to a certain extent, as their efficiency is limited. In practice, modern wind turbines can feed no more than half of the energy of the wind that blows through the area of the rotor blades into the power grid as electricity. The rest remains as kinetic energy in the wind itself.

A sound power of one megawatt (1,000,000 watts) corresponds to the noise emission of a rocket engine. So if the allegations were to be true, modern wind turbines would be louder than rocket engines. However, what is true is that, like many other technical plants, wind turbines produce both audible sound as well as infrasound. Yet they generally emit relatively little noise. Viewed over the entire frequency range, a typical wind turbine emits sound power to the amount of several watts and is thus a million times below the claimed values. The infrasound generated by wind turbines is low compared to cars or planes. The acoustically effective output of the audible sound is between 20 and 50 milliwatts – and thus even billions of times lower than claimed.





## 2. Measurements of the BGR

### QUESTION

The Bundesanstalt für Geowissenschaften und Rohstoffe (BGR – Federal Institute for Geosciences and Natural Resources) has conducted highly sensitive measurements of infrasound. According to their calculations, the infrasound of conventional wind turbines reaches the value of background noise with a frequency of a few Hertz (Hz) [1] only at a distance of about 10 km. Is that not proof of the fact that infrasound caused by wind turbines acoustically pollutes our environment and that normal measuring devices are unsuited?

### ANSWER

The BGR is the operator of three infrasound measuring stations in the Antarctic, in the Bavarian forest and near the city of Bremen. These are part of the international monitoring system to ensure compliance with the Nuclear Test Ban Treaty. Each system consists of at least four individual measuring sensors, which are several hundred meters apart, and can register smallest pressure signals in the order of a billionth unit of air pressure. The convergence of all measurement data gives the system properties comparable to a directional antenna so that it can be used to ascertain the bearing of signals.

The high sensitivity of such a monitoring system is required in order to actually detect a nuclear weapons test. Of course, infrasound originating from other sources can also be registered. In the year 2004 the BGR conducted field measurements at a free-standing wind turbine near Hannover over several weeks. One of the results of the investigation was that the emitted infrasound waves could mathematically still be determined at a distance of more than 10 km [2]. Such findings are of great importance for the operator. Because, the primary objective is to ensure undisturbed registrations of even the weakest signals at very low frequencies of well below a few Hertz. Regardless of that, noise emissions down to frequencies of 0.5 Hz can be accurately registered with commercially available high-quality infrasound microphones.

Measurements by the LUBW [3] show that infrasound is caused by a large number of different natural and technical sources. It is an everyday part of our environment that can be found everywhere. And wind turbines make no considerable contribution to it.

### 3. Noise prevention regulations

#### QUESTION

It is claimed that the technical noise prevention regulations (TA Lärm, 1998) do not take into consideration recent scientific findings for the acoustic assessment of wind turbines. Is it correct that these regulations also do not provide protection from infrasound and low-frequency noise from wind turbines?



#### ANSWER

Like other technical plants, wind turbines produce noise in a wide sound range. This also includes low-frequency noise and infrasound. The impact of these noise emissions has to be tested in specific licensing procedures in accordance with the Federal Immission Control Act. In this case the Act refers to the TA Lärm [4]. This represents the central assessment basis for noise in Germany emitted by commercial or industrial facilities. It was amended most recently in 1998. However, this does not mean that it no longer complies with the technical-scientific state of the art. Because, the TA Lärm does in fact also take into account infrasound and low frequency noise. Special measurement and assessment procedures are specifically provided for this frequency range, which are laid down in DIN standard 45 680 [6], as well in the associated supplementary sheet 1 "Messung und Beurteilung tieffrequenter Geräuschimmissionen in der Nachbarschaft – Hinweise zur Beurteilung bei gewerblichen Anlagen". This is where sound waves with frequencies down to 8 Hz are taken into

consideration, i.e. even a large part of infrasound. Measurements at wind turbines that included frequencies below 8 Hz consistently show that the contained infrasound, even at close ranges between 150 m and 300 m, is well below the human threshold of perception [6].

## 4. Vibrations in the body

### QUESTION

It is claimed that the human body is a vibration-prone system. Low-frequency sound from wind turbines could therefore cause resonance phenomena in the human organism. This in turn could represent a health hazard. Is that true?

### ANSWER

The human body is a system that is prone to vibration: At high levels, low-frequency sound can cause vibrations in the human body, for example when standing in front of a bass speaker at a rock concert. However, neither are wind turbines such strong sources, nor are significant mechanical vibrations transferred into the ground under the wind turbine. In fact, the mechanical vibrations at a distance of only a few hundred metres generally have a level similar to common background vibrations. At a distance of several hundred metres from a wind turbine, such resonance effects can be completely ruled out, as the sound intensity is a million times too low. The allegation that wind turbines cause resonance effects in the human body, and as a result pose a health risk, is therefore not correct.



## 5. Psychosomatic effects

### QUESTION

You can occasionally come across the allegation that residents living in the proximity of wind turbines often suffer from psychosomatic symptoms such as frustration, insomnia, fear, fatigue, ear pressure, headaches, nervousness and lack of concentration. These symptoms are supposedly caused by low-frequency noise and infrasound coming from wind turbines. Is that true?

### ANSWER

There is no secure evidence from which these allegations can be derived. In fact, it can be shown that these claims essentially go back to a single study conducted by the English University of Salford, which was published in the year 2011. The report titled "Proposed criteria for the assessment of low frequency noise disturbance" [7] contains an analysis of subjective noise complaints. It points out that more than half of the people who complained about low-frequency noise had the symptoms of frustration, insomnia, fear, fatigue, ear pressure, headaches, nervousness and lack of concentration.

However, this does not mean that these people were really burdened by low-frequency noise more than the average. It also does not mean that these widespread complaints really can be causally attributed to low-frequency noise.

The data base for this report is common noise complaints, as they have been brought forward to the environmental agencies for many decades. The researchers were only able to ascertain an above-average burden through low-frequency sound in a small proportion of those with complaints. A specific reference to wind turbines is not given: Noise from wind turbines is not actually mentioned in the report on more than 100 pages.

## 6. Infrasound experiment London

### QUESTION

It is said that in an experiment with 700 participants, scientists discovered that a significant share of 22 % of those surveyed had feelings like anxiety, uneasiness, extreme sadness, irritability in combination with nausea or fear, and felt pressure on the chest in the presence of infrasound. This result supposedly shows clearly that infrasound in the inaudible subliminal range, as is the case in the vicinity of wind turbines, causes acute health problems. Is that true?

### ANSWER

Such an experiment was in fact carried out in May 2003 by British scientists within the scope of the project "Experiment: Dialogue between art and science" in the London Purcell Room concert hall. The 700 participants were not only exposed to music, but also to an infrasound sinus sound of 17 Hz and a sound level of 90 dB [8]. 22 % of the audience judged the performance with infrasound to be unpleasant and experienced fear, a depressed mood and discomfort. The perceptibility threshold in accordance with DIN 45 680 for this frequency is 77 dB. The sound level in this experiment was thus clearly higher and no longer in the inaudible subliminal range. The sound intensity was energetically about 10,000 times as high as in the vicinity of a wind turbine. For comparison, please refer to the measurement results in [3].

The infrasound in this experiment was only difficult to perceive because loud music was playing at the same time. However, a relatively high proportion of the audience could nevertheless correctly answer the question as to whether the infrasound was turned on or off. These complementary explanations make clear that the experiment does not show that infrasound causes acute health problems in the inaudible subliminal range. Furthermore, the conditions of this experiment are completely different from those in the vicinity of wind turbines.

# 7. The "wind turbine syndrome"

## QUESTION

It is alleged that Dr. Pierpont demonstrated in the United States that infrasound from wind turbines can trigger the so-called wind turbine syndrome in humans. This then manifests itself through twelve main symptoms: sleep disorders, headaches, tinnitus (ringing in the ears), ear pressure, dizziness, spinning sensation, nausea, blurred vision, heart palpitations, irritability, concentration and memory problems, and panic attacks – coupled with the feeling that the internal organs are pulsating or trembling. Is that true?

## ANSWER

In March 2006 Dr. Nina Pierpont contacted people who live near wind turbines and ascribe their health complaints to those wind turbines. She interviewed 23 people by phone and from them received information about the symptoms of another 15 people. Based on that, she created a new clinical picture and called it "Visceral Vibratory Vestibular Disturbance" (also referred to as "wind turbine syndrome"). She describes it with the above twelve main symptoms. Dr. Pierpont published her results in 2009 in an almost 300-page English-language book titled "Wind Turbine Syndrom – A Report on a Natural Experiment" [9]. The content of the book has by now spread across the world, and when campaigning against wind energy, Dr. Pierpont is often called upon as an "expert".

However, upon closer inspection one can see that the study was conducted on the basis of only 23 phone calls without accompanying medical examinations or acoustic measurements. According to the experts of the Hessian fact check infrasound [6], this is merely a medical case description, which allows no conclusions to be made with regards to causal links



between wind turbines and the described symptoms on a population level. The study has so far not been published in specialist media and is not recognized in the professional world. However, it does provide points of reference for further surveys involving large samples, in which the measurement of infrasound and

low-frequency sound should be combined with a survey of local residents. Conclusion: The so-called "wind turbine syndrome" does not exist as a medically recognized clinical picture.



## 8. Stimulation of brain waves

### QUESTION

It is claimed that certain brainwaves can be stimulated and modulated by subliminal low-frequency sound. This proves that wind turbines pose a health risk. Is that true?

### ANSWER

The statements come from an article that was circulated in 2008 under the title "Infraschall von Windkraftanlagen als Gesundheitsgefahr" ("Infrasound from wind turbines as a health risk") [10]. One of its findings was as follows: "It could be proven experimentally that certain brain oscillations can be stimulated and modulated by low-frequency sound, meaning that an artificially induced unstable emotional state can be brought about."

The authors refer to a report about a medically unsatisfactory and ultimately aborted study of one individual. The actual scientific issue of the study was defined only in general terms. The test person was informed each time she was subjected to sound that was "not audible" but supposedly "harmful to health". The emotional response of the patient was

then reflected in the brain waves. In order to avoid the influence of negative expectations, such tests are usually blinded, i.e. the subjects and, if necessary, even the assistants of the experiment, are given no information about the experimental conditions and their timing. Furthermore, when it comes to acoustic research, another essential aspect is the measurement of the sound level. However, this was not taken into consideration here.

The report was not published in any journal. There is also no evidence that it was actually written as a contribution to a scientific debate. Therefore no generally valid statements about infrasound and a possible health risk from infrasound caused by wind turbines can be derived from the report.

## 9. Distances and WHO

### QUESTION

It is said that the World Health Organization (WHO) has called for a minimum distance of 2,000 m to inhabited buildings for wind turbines. Sometimes the WHO is quoted as requiring a distance of 1,500 m, 3,000 m or 10 x the wind turbine height. What is correct?

### ANSWER

In answer to a request by the LUBW, the WHO informed in a letter dated 22.03.2013 that it has neither published regulations specifically for noise from wind turbines nor published recommendations for distances between wind turbines and residential areas. The often stated minimum distances from wind turbines to built-up areas as supposedly recommended by the WHO do not exist. General instructions for the protection against noise at night are given in the WHO publication "Night Noise Guidelines for Europe" from the year 2009. As a precautionary level to avoid health-relevant effects, also for particularly sensitive individuals such as children or sick people, an outside level of 40 dB(A) is stated for the night. This corresponds to the immissions value of the TA Lärm for general residential areas.



# 10. Precautionary distance of 700 m

## QUESTION

Some people criticize that the precautionary distance of 700 m between wind turbines and residential areas in order to protect against noise pollution, as stipulated in the Baden-Württemberg wind energy decree from 09.05.2012, is too low to provide protection from noise coming from turbines. Is this criticism justified?



## ANSWER

The precautionary distance of 700 m from residential areas in accordance with no. 4.3 of the wind energy decree [11] is a guideline for regional planning and land-use planning. At this distance the outside level at night is normally kept below 40 dB(A). The recommended guideline value of 700 m is useful and sufficient as a means of regulating appropriate land-use planning. However, the statutory regulations of the Federal Immission Control Act or the TA Lärm are also applicable for the approval of a wind turbine and thus for the establishment of specific necessary distances. Each individual case is checked within the framework of the approval procedure. This is where evidence regarding noise immisions from the wind turbine and the effects of noise in the vicinity must be submitted. Such case by case assessments can lead to higher as well as lower distances.

# 11. Distance regulation in Great Britain

## QUESTION

It is claimed that a minimum distance of 3,000 m to residential areas is statutory for wind turbines in Great Britain. At the same time, it is also being demanded that this provision be adopted for Baden-Württemberg. What is the legal situation in Great Britain?

## ANSWER

To this day there is no legal minimum distance that is required between wind turbines and residential areas. Bills on minimum distances between wind turbines and residential buildings have already been introduced in the Houses of Parlia-



ment three times: For the first time in the session 2008-2009 on the initiative of the House of Commons and then twice in the House of Lords. The last initiative took place during the 2012-2013 session under the title "Wind Turbines (Minimum Distance from Residential Premises) Bill", and was proposed by the late Lord Reay. The law was to have been valid in England and Wales. On 14.05.2012 the first reading of the law took place in the House of Lords, which is the first of a total of ten formal legislative steps. The matter has rested ever since. Thus statutory provisions do not exist in Great Britain to this day.

## 12. Stimulation of the inner ear

### QUESTION

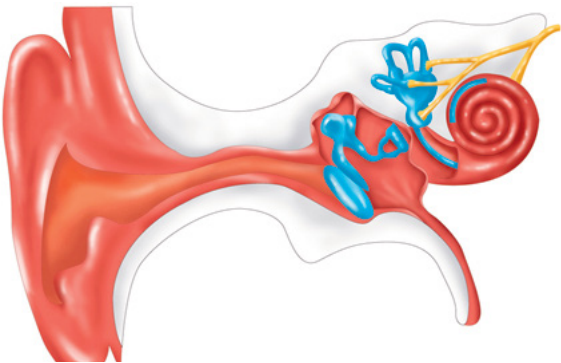
According to Prof. Alec Salt (Washington University, St. Louis, United States), inaudible infrasound, particularly by wind turbines, can be harmful to health. The outer hair cells of the inner ear are sensitive to infrasound below the threshold of perception and supposedly send out nerve impulses. The brain is then said to unconsciously perceive these nerve impulses. Is that true?

### ANSWER

The work by Prof. Alec Salt on wind energy is scientifically controversial and has already been widely criticized as it is largely speculative and not verifiable. The work always comes to the conclusion that wind turbines can be harmful to health. Prof. Salt uses previous studies on guinea pigs exposed to strong infrasound as a basis for his suppositions. According to his own statements [12], he was able to measure comparatively strong electric pulses in the inner ear of guinea pigs on the outer hair cells. This is supposedly proof that low-frequency noise greatly stimulates the ears of guinea pigs. Prof. Salt suggested that these findings could be transfera-

ble to humans. However, according to the experts of the Hessian fact check infrasound [6] these results cannot be transferred directly to humans. Furthermore, the possible health effects are also unclear, as effects that can be measured need not necessarily lead to adverse health effects.

Prof. Salt assumes that symptoms such as pulsation, discomfort, stress, uncertainty, balance problems, dizziness or nausea may be connected to the inaudible infrasound from wind turbines. Such effects can in fact be observed for very high infrasound levels. However, it is neither proven nor plausible that low-frequency noise on the level of natural sounds can cause such symptoms. Any relevance of the results by Prof. Salt for the risk assessment of wind turbine noise can currently not be seen.



## 13. Study on the quality of sleep

### QUESTION

The radiologist Dr. Michael A. Nissenbaum (Fort Kent, Maine, USA) believes that noise from wind turbines within a radius of 1.5 km has a negative impact on the quality of sleep and health. Is that true?

### ANSWER

In their case-control study "Effects of industrial wind turbine noise on sleep and health" [13], Nissenbaum, Hanning and Aramini examined the influence of wind turbines on the health issues of the inhabitants of two rural regions in Maine (USA). The participants who lived at distances of

between 375 and 1,400 m (case group) and 3.3 km and 6.6 km (control group) from the wind turbines were required to fill out questionnaires relating to the quality of sleep, daytime fatigue and general physical and mental health. The authors came to the conclusion that the case group did not sleep as well, was sleepier during the day and had a poorer mental health than the control group. The study by Nissenbaum is cited around the world as scientific evidence that wind farms cause health problems.



The investigated situation is not comparable to the situation in Germany. About half of the people in the case group lived very close to wind turbines, the shortest distance to a wind turbine being 375 m. According to the authors, these individuals were exposed to outdoor levels of up to 52 dB(A). At such noise levels impairments are generally to be

expected. In Germany, a reference level of 40 dB(A) may not be exceeded in general residential areas at night. In fact, a reference level of 35 dB(A) even applies in purely residential areas at night. This has led to much greater distances to residential areas.

A closer look at the study makes clear that the data show virtually no statistical correlation between sleep quality and distance. Both the people in the (small) case group as well as in the (small) control group generally did not sleep very well. There is a wide spread of people with good, average and poor sleep. A look at the statistical mean shows that both groups complain about similar daytime fatigue.

# 14. Nocebo effects

## QUESTION

It is said that people close to wind turbines often suffer from so-called "nocebo effects". What does that mean?

## ANSWER

The placebo-nocebo effect is an impressive example of how the mind interacts with the body. Placebo effects are positive effects ascribed to taking dummy medication without active ingredient or being given sham treatment. They lead to positive changes of subjective well-being and objectively measurable physical features. The positive expectations regarding the treatment as well as the conditioning are considered the most important prerequisites for the occurrence of the placebo effect. Placebos can cause the exact effects that patients expect. The greater the expectations, the greater the effect. A syringe with saline solution can successfully relieve pain if the patient believes that the syringe contains a strong pain reliever. Such effects can be attributed to the symbolic importance of curative treatment.

However, if the negative effects of a placebo outweigh the positive effects, it is referred to as a nocebo. The nocebo effect was discovered when negative effects, which the doctor had previously referred to or were listed in the package insert, occurred after the administration of preparations without any active ingredient. The nocebo effect is essentially based on negative expectations and conditioning. It is most clearly seen through sickening fear of supposed dangers. The symptoms experienced by those affected mostly take on the form of complaints attributed to psychosomatic causes, such as nausea, headaches, fatigue, insomnia or drowsiness. In addition, objective symptoms can also be diagnosed, such as skin rash, raised blood pressure and increased heart rate. A collection of impressive nocebo effect examples can be found in issue 04/2013 of the *Süddeutsche Zeitung* magazine [14].

Scientists of the University of Auckland followed up on the question as to whether the concern that inaudible infrasound is harmful to health might actually be the cause of precisely those symptoms that are linked to the postulated "wind turbine syndrome" (see question 7) [15]. In the respective study, 54 participants were divided into a case group and a control group. The case group was conditioned through a video with

reports on suffering relating to wind turbines in order to develop a negative expectation. The control group, on the other hand, watched a video in which scientists explained why infrasound does not cause such symptoms. All subjects were then exposed to ten minutes of infrasound significantly below the hearing threshold and ten minutes of supposed infrasound (i.e. silence).

The control group displayed no symptomatic changes. The participants felt the same during the exposure to the infrasound as they did before. The case group, which had negative expectations due to the video, reported an increase in symptoms during the exposure. The case group showed a significantly higher amount of symptoms and more intense symptoms compared to before – regardless of whether the group was exposed to infrasound or supposed infrasound (i.e. silence). In addition, the participants complained of exactly the symptoms they had seen beforehand. The study shows to what extent conditioning and negative expectations can enhance the amount and intensity of perceived symptoms. It is therefore an indication for the fact that the health problems attributed to infrasound can be explained by nocebo effects.



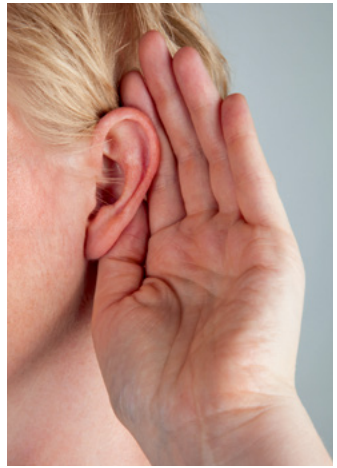
## 15. Sensitive people

### QUESTION

It is sometimes said that certain sensitive individuals are actually able to perceive infrasound below the perception threshold according to DIN 45 680. These people are supposedly affected by wind turbines. Is that true?

## ANSWER

Some people do in fact have a very low perception threshold for low frequencies. They can hear or perceive low-frequency noise better than would be expected given the hearing threshold in accordance with DIN 45 680 [5]. The human hearing threshold can vary greatly from one person to another. It varies particularly at the upper and lower end of the audible spectrum more than in the middle of the spectrum. The individually variable



hearing thresholds are statistically spread around a mean value. A good illustration of this distribution of the hearing threshold can be found in publications by Kurakata [16] [17] [18] and is summarized in the DIN ISO 28 961 standard [5].

The hearing threshold of the currently valid DIN 45 680 standard lies between the P25 and the P30 auditory threshold by Kurakata. That means that roughly 25 to 30 percent of people can hear or perceive more than defined by the hearing threshold in accordance with DIN 45 680. In the new draft of this standard, a hearing threshold that is about 3 dB lower is taken as a basis and described as perception threshold in the area of infrasound. This perception threshold corresponds to the P10 auditory threshold at 10 Hz. At 100 Hz, where the range of low-frequency noise ends, even the P1 threshold is slightly undercut. Therefore less than one percent of people hear better at this frequency than is defined by the hearing threshold of the new standard.

The infrasound from wind turbines is tens of decibels below the hearing threshold of the old as well as the new DIN 45 680 standard [5]. Furthermore, scientific studies on hearing threshold distribution also provide no evidence that people with a very low perception threshold can actually hear or perceive the infrasound from wind turbines in their vicinity. Adverse effects or impairments through infrasound coming from wind turbines are therefore not to be expected even for sensitive people. For additional information please refer to question 16.

## 16. Great need for research?

### QUESTION

It is said that when it comes to infrasound and low-frequency sound from wind turbines, a great deal of research is still required. Is that true?

### ANSWER

Some wind energy opponents claim, with reference to the Umweltbundesamt (UBA – Federal Environment Agency) or the Robert Koch Institute, that there is still a great need for research in the area of infrasound from wind turbines. That is why they are calling for a delay of the development of wind energy until enough study results are available.

In its information bulletin "Geräuschbelastung durch tieffrequenten Schall, insbesondere durch Infraschall im Wohnumfeld" ("noise burden through low-frequency sound, especially through infrasound in residential areas") [19], the UBA sees a "distinct lack of environmental medical study results on the subject of infrasound and low-frequency sound". However, the terms wind energy or wind power are not mentioned once. An inquiry directed at the UBA yielded the answer that these statements do not relate to wind turbines. The assessment of the UBA in fact generally refers more to the entire area of low frequency noise and infrasound. As examples, the UBA mentions things like air conditioners and pumps. A number of serious studies that have dealt extensively with the issue of wind energy and infrasound are already available. The study situation is good enough to enable a substantiated evaluation of the issue. A number of important considerations are summarized in the following.





**Infrasound measurements at wind turbines:** Scientifically conducted acoustic measurements in the vicinity of wind turbines consistently produce the result that infrasound from wind turbines is measurable in their immediate vicinity, but is well below the human perception threshold [6]. From a distance of about 700 m onwards, no real difference can be measured between the wind turbine switched on and the wind turbine switched off. Also, near motorways and highways or at forest sites, the infrasound of a wind turbine is no longer measurable against the background noise. The results provided by the infrasound measuring project conducted by the LUBW [3] are consistent with these findings. Thus, the infrasound from wind turbines is not a special problem.

**Wind energy and health:** So far there is no scientific evidence that infrasound that is clearly below the threshold of perception, as is emitted from wind turbines, causes any health problems. Nevertheless, the operation of wind turbines is associated with an audible noise level, which at very short distances can cause a considerable nuisance. However, given the proper planning and sufficient distance to residential buildings, wind turbines generate no significant noise disturbance. A range of studies on the topic of "wind energy and health" has been compiled by the University of Sydney [20]. The Canadian health authority "Health Canada" has conducted a large-scale study. A summary of the results is available online [21].

**Conclusion:** With respect to wind turbines, no fundamental lack of metrological and environmental medical study results on the subject of infrasound and low-frequency sound can be seen. Nevertheless, this does not rule out that individual aspects or details could be further examined. Irrespective of wind turbines, experts generally still see additional need for research in the area of infrasound and low-frequency noise. This is where both technical as well as natural sources of infrasound should be taken into consideration. In addition, the interaction of low-frequency and audible noise should also be considered, and be examined with respect to an environmental medical and environmental psychological perspective. The research paper on wind energy and infrasound by the Hessian Ministry of Economics, Energy, Transport and Regional Development provides a good overview of this topic [6].

# 17. Wind energy in Denmark

## QUESTION

The editor Daniel Wetzel published an article in the newspaper DIE WELT on 02.03.2015 by the title of "Macht der Infraschall von Windkraftanlagen krank?" ("Does the infrasound from wind turbines make you sick?") [22]. It was claimed in the article that due to the fear of negative health effects, wind turbines are hardly being built anymore in Denmark. A state investigation was ongoing, but German authorities would supposedly understate the problem. Furthermore, the impression was given that the non-audible sound of the wind turbines was making the animals in an adjacent mink farm crazy, so that these were biting each other to death. What can be made of these statements?

## ANSWER

The Ministry of the Environment, Climate and Energy Baden-Württemberg submitted the above-mentioned article to the Danish Embassy in Berlin with a request for comment. On 27.04.2015 it then communicated a reply by the Danish Energy Agency, which



is assigned to the Danish Ministry for Climate, Energy and Building. It is made clear in it that the statements made in the WELT article cannot be confirmed. The following four points are recompiled from the authorized German translation by the Danish embassy[23]:

- The development of wind power is not stagnating. In 2014, onshore wind turbines with a capacity of 106 MW were constructed and wind turbines with a total capacity of 29 MW dismantled. There was a decline in the development compared to 2013, which can – among other things – be attributed to changing tariff provisions since 01.01.2014.
- A study on the relationship between wind turbine noise and effects on health was initiated in early 2014. Some municipalities are waiting until the results of the study are available before they continue planning, but many municipalities are still planning to continue the development of wind power.

- Based on the existing scientific information, there is no evidence that wind turbines have a negative impact on health. That is why the Danish Ministry for Climate, Energy and Building has announced that the planning of wind turbines can be continued during the study period.
- The competence centre for agriculture and fur animals in 2011 indicated that reports of negative effects for the production of mink – even at a distance of only 200 meters to wind turbines – were not available.

**Background information:** Denmark relies heavily on wind energy. In 2014, more than 39 percent of the nation's electricity consumption was provided by approx. 4,700 wind turbines. However, the proportion of wind energy can no longer be increased at will without new user concepts (e.g. heating with electricity) or better distribution on a European level (net development, European electricity market for renewable energies). Thus the wind power output in 2014 varied between 0 and more than 130 percent of nationwide electricity demand.

Instead of additional construction, Denmark is currently seeing more of a conversion of wind turbines (repowering). This is where many small wind turbines are being replaced by a few large ones. It is thus that the number of small wind turbines (less than 500 kW) dropped by approx 2,300 units between the years 2000 and 2013. However, the installed output itself has more than doubled in the same period of time due to the additional construction of approx. 1,300 medium to large wind turbines (500 kW or more). According to current planning by the Danish Government for the years 2012 to 2020, large wind turbines with a total capacity of 1,800 MW will be newly constructed on land while at the same time older turbines with a total capacity of 1,300 MW will be decommissioned.

## 18. ICD code infrasound?

### QUESTION

One often hears that the federal joint committee of all health insurance companies has determined the code ICD-10-GM T75.2 as a precautionary measure for billing the treatment of health problems caused by infrasound from wind turbines. What is this all about?

### ANSWER

This information is simply not true. Upon request, both the Gemeinsame Bundesausschuss (G-BA – joint federal committee) in Berlin as well as the responsible Deutsches Institut für Medizinische Dokumentation und Information (DIMDI – German institute for medical documentation and information) in Cologne confirmed what is also evident when looking at the current version 2015 of the ICD-10-GM code: The referred-to health code T75.2 bears the title "damage through vibration" and encompasses symptoms and clinical pictures such as the so-called jackhammer syndrome, the Raynaud Syndrome after long-lasting operation of heavily vibrating machines, such as power saws, but also dizziness through infrasound. This position has already been in the list for more than 20 years. The entry was made before the widespread construction of wind turbines, thus by no means as a "precautionary measure" due to possible damage to health caused by infrasound from such facilities.

The International Statistical Classification of Diseases and Related Health Problems (ICD) is a globally recognized diagnostic classification system in the medical field. It is published by the World Health Organization (WHO). In Germany, doctors participating in contract-medical healthcare and physician-managed facilities are obliged to encode diagnoses in accordance with ICD-10 German Modification (GM). The ICD-10-GM version 2015 issued by the DIMDI is binding for the encoding in Germany.

# 19. Study by the PTB

## QUESTION

The Physikalisch-Technische Bundesanstalt (PTB – national metrology institute, a scientific and technical higher federal authority) examined the limits of hearing in the area of infrasound in 2015. One of the results is that one can actually hear infrasound. In a press release, the PTB addressed the concerns of parts of the population and the question of whether wind turbines are possibly harmful to people. So if the PTB is asking itself that question, are the concerns not justified?

## ANSWER

In 2015 the PTB issued a press release on a new study regarding the effect of infrasound and ultrasound on humans. Press and broadcasting services pounced on these reports using headlines such as "Buzzing in the head" or "Humans hear deeper than imagined". The PTB itself began its press release on 10.07.2015 with the question: "Are wind turbines harmful for humans?" The interest by the media was therefore understandable.

However, in the meantime the PTB has further clarified its statements. An announcement on 11.08.2015 [24] stated: "All measurements were taken in laboratory conditions with synthetic infrasound signals and healthy test persons. No sound signal was used that came from a wind turbine or simulated such a sound [...] The auditory thresholds and loudness values are in their entirety consistent with data from literature [...]"



Since the acoustic stimulation in our experiments was not derived from the actually measured sound fields of wind turbines, the results cannot be transferred to a specific situation on location."

The main focus of the PTB project was the analysis of the brain activity of 18 to 25-year-old subjects under the influence of sound using magneto encephalography (MEG) and magnetic resonance imaging (MRI). For this purpose, individual low-frequency tones were fed directly into the ear canal of the test persons. The measurement of brain activity showed that infrasound down to 8 Hz can be heard if the sound pressure is high enough. For 2.5 Hz, the average hearing threshold of the 18 subjects that had normal hearing was determined to be 120 dB. This is in accordance with known studies from the 1970s and 1980s.

As was shown by the LUBW measurement project "Low-frequent noise incl. infrasound from wind turbines and other sources" and other national as well as international analyses, the real infrasound impact of wind turbines does not even come close to reaching the levels used in the laboratory of the PTB. At 2.5 Hz the levels are around 60 dB below that, i.e. a millionth of the sound pressure of the hearing threshold.

## 20. Wind energy in Australia

### QUESTION

It is alleged that the acoustician Steven Cooper found a special infrasound pattern (wind turbine signature, WTS) for wind turbines in Australia. This supposedly explains health disorders such as insomnia, headaches, palpitations or pressure in the head. Is that true?

### ANSWER

Based on the complaints of six residents from three houses, the wind farm operator Pacific Hydro from Melbourne assigned the acoustician Steven Cooper to conduct research on the respective cause. The wind farm consists of 29 wind turbines that were built in the west of a peninsula directly by the sea. The houses in question are located at a distance of 650 m to 1600 m east of the wind farm. The task at hand was to examine whether the residents' complaints were related to specific wind conditions and noise immissions.

The comprehensive final report was published on the website of the wind farm operator. No link between the occurrence of the health disorders and the noise level curve can be found in it. The noise level of environmental noise from wind and the sea could not be distinguished metrologically from the wind farm noise. A shutdown of the wind turbines was virtually impossible to detect in the noise curves. No infrasound above the audible threshold was detected in any of the houses. In the area of infrasound, the narrowband spectrum showed some patterns typical for wind turbines, i.e. the blade passing frequency and its harmonics. The author suggested that the occurrence of this pattern could possibly be related to the complaints, and recommends further studies on the matter. However, this assumption is not supported by test results.

Due to criticism from the expert community, the author and the contracting company carried out an evaluation of their own study (Joint Statement). In it they refer to it as non-scientific. In fact, the study did not serve the investigation of health impacts. No licensing requirements relating to noise were checked, and the results would not suggest or justify any adaptations of regulations. The study merely constitutes a new approach to assess the acoustic environment and includes a number of unverified hypotheses.

# Appendix: Explanations and literature

- [1] Hertz (Hz) is the unit of measurement for frequency and refers to the number of vibrations per second.
- [2] Bundesanstalt für Geowissenschaften und Rohstoffe, Internet [www.bgr.bund.de](http://www.bgr.bund.de), enter into search box: "Der unhörbare Lärm"
- [3] LUBW Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg: "Tieffrequente Geräusche inkl. Infraschall von Windkraftanlagen und anderen Quellen", 2016  
Internet [www.lubw.de/servlet/is/257896](http://www.lubw.de/servlet/is/257896)
- [4] Sechste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zum Schutz gegen Lärm – TA Lärm) from 26.08.1998, GMBI Nr. 26/1998, pg. 503 ff.
- [5] DIN 45 680 "Messung und Bewertung tieffrequenter Geräuschimmissionen in der Nachbarschaft", Edition 1997-03, Beuth Verlag  
DIN 45 680 "Messung und Bewertung tieffrequenter Geräuschimmissionen", Draft 2013-09, Beuth Verlag  
DIN ISO 28 961 "Akustik – Statistische Verteilung von Freifeld-Normalhörschwellen", Edition 2010-06, Beuth Verlag
- [6] HA Hessen Agentur GmbH on behalf of the Hessisches Ministerium für Wirtschaft, Energie, Verkehr und Landesentwicklung: "Faktenpapier Windenergie und Infraschall", May 2015, Internet [http://www.energieland.hessen.de/pdf/Faktenpapier\\_Windenergie\\_und\\_Infraschall\\_2015.pdf](http://www.energieland.hessen.de/pdf/Faktenpapier_Windenergie_und_Infraschall_2015.pdf)
- [7] A. Moorhouse, D. Waddington, M. Adams: "Proposed criteria for the assessment of low frequency noise disturbance", Acoustics Research Centre, University of Salford, Manchester, 2011
- [8] Decibel (dB) is the unit to define sound pressure levels, i.e. the magnitude of noise.
- [9] N. Pierpont: "Wind turbine syndrome: a report on a natural experiment", K-Selected Books Sante Fe, NM, ISBN 978-0-9841827-0-1



- [10] E. Quambusch, M. Lauffer: "Infraschall von Windkraftanlagen als Gesundheitsgefahr", ZFSH/SGB – Zeitschrift für die sozialrechtliche Praxis, 08/2008
- [11] Windenergieerlass Baden-Württemberg, Gemeinsame Verwaltungsvorschrift des Ministeriums für Umwelt, Klima und Energiewirtschaft, des Ministeriums für Ländlichen Raum und Verbraucherschutz, des Ministeriums für Verkehr und Infrastruktur und des Ministeriums für Finanzen und Wirtschaft from 09.05.2012, Ref. 64-4583/404, GABl. 2012, pg. 413
- [12] A. N. Salt, J. A. Kaltenbach: "Infrasound from Wind Turbines could affect Humans", Bulletin of Science, Technology & Society 31(4), 2011, pp. 296-302
- [13] M. A. Nissenbaum, J. J. Aramini, Chr. D. Hanning: "Effects of industrial wind turbine noise on sleep and health", Noise & Health, Volume 14:60, 2012, pp. 237-43
- [14] W. Bartens: "Das falsche Signal", Süddeutsche Zeitung Magazin, issue 04/2013
- [15] F. Crichton, G. Dodd, G. Schmid, G. Gamble, K. J. Petrie: "Can Expectations produce Symptoms from Infrasound associated with Wind Turbines?", Health Psychology, Vol 33(4), 2014, pp. 360-364
- [16] K. Kurakata, T. Mizunami: "The Statistical Distribution of Normal Hearing Thresholds for Low-Frequency Tones", J. Low Freq. Noise Vib. Act. Contr., 27, 2008, pp. 97-104
- [17] K. Kurakata, T. Mizunami: "Statistical distribution of normal hearing thresholds under free-field listening conditions", Acoust. Sci. Tech., 26, 2005, pp. 440-446
- [18] K. Kurakata, T. Mizunami: "Percentiles of normal hearing-threshold distribution under free-field listening conditions in numerical form", Acoust. Sci. Tech., 26, 2005, pp. 447-449

- [19] "Geräuschbelastung durch tieffrequenten Schall, insbesondere durch Infraschall im Wohnumfeld", Umweltbundesamt, Fachgebiet I 3.4, Information from 08.02.2013
- [20] S. Chapman, T. Simonetti: "Summary of main Conclusions reached in 17 Reviews of the Research Literature on Wind Farms and Health", 2012  
Internet <http://canwea.ca/pdf/WindHealthReviews.pdf>
- [21] Health Canada: "Wind Turbine Noise and Health Study: Summary of Results", Internet [www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-oliennes/summary-resume-eng.php](http://www.hc-sc.gc.ca/ewh-semt/noise-bruit/turbine-oliennes/summary-resume-eng.php)
- [22] D. Wetzel: "Macht der Infraschall von Windkraftanlagen krank?", Die Welt, online edition from 02.03.2015, Internet [www.welt.de/wirtschaft/energie/article137970641/Macht-der-Infraschall-von-Windkraftanlagen-krank.html](http://www.welt.de/wirtschaft/energie/article137970641/Macht-der-Infraschall-von-Windkraftanlagen-krank.html)
- [23] Danish Energy Agency: "Hintergrundmaterial: Infraschall von Windkraftanlagen", Internet <http://www.lubw.de/documents/10184/61110/danish-energy-agency.pdf>
- [24] C. Koch, T. Sander-Thömmes: "Aussagekraft der Ergebnisse des EARS-Projekts für Windkraftanlagen", Internet [www.ptb.de](http://www.ptb.de), enter "Aussagekraft EARS-Projekt" in the search box



