

**Critical Analysis and Scientific Review of the
Report produced by the University of Tartu
in October 2025, titled:**

***Health effects of wind turbines: A systematic review
of studies published in peer-reviewed scientific
journals over the last fifteen years—Development
of a methodology for interpreting the results of
scientific studies on the potential health effects of
wind farms and other energy production
technologies in the Estonian context***

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International Acoustics Research Organization

IARO is an international group of researchers with a mission to investigate acoustical environments, especially with respect to features that affect humans and animals, and to publish the results. IARO holds the ethics approval for the CSI-ACHE, the Citizen Science Initiative into Acoustical Characterisation of Human Environments, the results of which are publicly disseminated.

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ANNEX A: English Translation of the TU report

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EXECUTIVE SUMMARY

1. On 6 October, 2025, IARO scientists were contacted by Citizens Initiative Estonia [a non-profit organization], with the request to provide an assessment of a report commissioned by the Ministry of Environment of Estonia, and produced by the University of Tartu (TU Report).
2. This IARO Critical Analysis Report is not an “oppositional document” to the TU Report. Rather, it has been prepared as a pedagogical document.
3. It is hoped that the authors of the TU Report, whom we view as fellow scientists, take this IARO Critical Analysis Report as an educational tool, contributing to their “Review Study Phase I,” rather than some gratuitous “attack document.”
4. The study documented by the TU Report has clearly been conducted properly in terms of how an analysis of published papers and reports should be undertaken, when those participating are not experts in the subject matter.
5. IARO Scientists have the distinct impression that these Estonian authors were pre-conditioned to believe that wind power plant sound emissions have no effect on public health.
6. This is further justified by the Recommendations made which are unfounded, skewed from reality, and not “evidence-based,” as promised by the authors of the TU Report.
7. Given the content of the Recommendations proffered by the TU Report, it seems probable that the Authorship of the TU Report has unwittingly succumbed to the unscientific practices promoted by governments and international special interest groups.
8. In the opinion of IARO Scientists, this study can only be regarded as, yet another, artificially constrained review of papers, with outcomes predetermined by politically generated questions, resulting in a report of low scientific standard.

A. INTRODUCTION

I. Background

9. On 6 October, 2025, IARO scientists were contacted by Citizens Initiative Estonia [a non-profit organization], and were requested to provide an assessment of a report commissioned by the Ministry of Environment of Estonia and produced by the University of Tartu (henceforth referred to as the TU Report).
10. For this purpose, IARO scientists received an English translation of the TU Report, included in this IARO Report as Annex A. References to page numbers of the TU Report correspond to those in this English version, provided in Annex A.
11. The TU Report states that it is related to Phase I of a Review Study titled: “Health effects of wind turbines: A systematic review of studies published in peer-reviewed scientific journals over the last fifteen years.” Within this context, the study of the TU Report is, more specifically, titled: *Development of a methodology for interpreting the results of scientific studies on the potential health effects of wind farms and other energy production technologies in the Estonian context.*
12. Figure 1 shows the Purpose of this Study as stated in the TU Report.

Purpose of the study

The aim of the study was to systematically analyse the evidence published in the scientific literature over the last fifteen years (2010–2025) on the health effects of wind turbines.

Research questions:

1. What are the main conclusions of existing studies on the health effects of wind turbines?
2. What is the overall quality of the existing evidence? Is there evidence in the scientific literature that wind turbines have a negative impact on human health?
3. If wind turbines have negative health effects, what health effects are associated with wind turbines?
4. If wind turbines have negative health effects, what role do environmental factors such as noise, infrasound, shadow flicker, visual aspects, psychological factors (including general attitudes towards wind turbines, people's beliefs and perceptions of wind turbines), vibration and electromagnetic fields in causing these health effects?
5. If wind turbines have health effects, under what conditions are these health effects more likely to occur (e.g. at what distance from the turbine, with powerful or tall turbines, etc.)?
6. Are certain population groups more vulnerable to the potential health effects of wind turbines?
7. What evidence-based recommendations can be made to policymakers, industry stakeholders and affected communities to protect human health?

Figure 1. Description of the Purpose of the Study of the TU Report and its Research Questions (p. 12)

II. Goal

13. To provide a scientific review of the TU Report, within the context of The Scientific Method, Evidence-based Medicine and Critical Analysis.

III. Disclaimer

- a. The report provided herein has one, and only one, agenda; that of pure scientific inquiry.
- b. The authors of this report are not party to anti-technology sentiments and do not harbour anti-wind-energy sentiments.

- c. In no way can or should this scientific review be construed as a document arguing for or against the implementation of wind power plants, or any other type of infrastructure or industrial complexes that generate acoustic pollution.
- d. IARO members and authors of this report hold no financial interest in the SAM Technology.

IV. International Acoustics Research Organization, IARO

14. The International Acoustics Research Organization represents a group of scientists who, collectively, hold over 300 years of scientific experience in the field of infrasound and low frequency noise, and its effects of human health. Since 2016, IARO researchers have been recording and analysing acoustical data in and near homes located in the vicinity of onshore wind power plants, in the following countries (alphabetical): Australia, Canada, Denmark, England, France, Germany, Ireland, New Zealand, Northern Ireland, Portugal, Scotland, Slovenia, and The Netherlands. Prior to 2016, all IARO scientists were already working either in acoustics alone or in acoustics and health. All research conducted by IARO is part of the Citizen Science Initiative for Acoustic Characterization of Human Environments (CSI-ACHE).

V. Acronyms and Variables Used in IARO Reports

15. Table 1 lists the acronyms and variables used in IARO Reports.

Table 1. Acronyms and Variables that may appear in IARO Reports

dB	Decibel unweighted	(measure of sound pressure level)
dBA	Decibel A-weighted	(measure of sound pressure level)
dB(C)	Decibel C-weighted	(measure of sound pressure level)
dB(G)	Decibel G-weighted	(measure of sound pressure level)
Hz	Hertz	(units for measure of frequency)
ILFN	Infrasound and Low Frequency Noise	(≤200 Hz)
IWT	Industrial Wind Turbine	
LFN	Low frequency noise	(20-200 Hz)
SPL	Sound Pressure Level	
WHO	World Health Organization	
WPP	Wind Power Plant	
WTAS	Wind Turbine Acoustic Signature	

B. ORGANIZATION OF THIS REPORT

I. Sequential approach to various aspects

16. Given the Authorship of the TU Report, the tone of this IARO Report is meant to be educational and not oppositional—IARO Scientists consider they are addressing fellow scientists.
17. The “Stated Purpose of the Study” and the “Research Questions” will be discussed first, in Section C.
18. A brief, science-based, educational approach is provided regarding ‘health effects,’ using annoyance as an example, in Section D.
19. A brief, science-based, educational approach is provided regarding the use of the A-weighting filter, and its appropriateness for measuring ‘wind turbine noise’ in Section E.
20. Section F demonstrates the fallacy of the notion ‘what you can’t hear, can’t hurt you,’ which wholly biases the TU Report.
21. Section G examines if Scientists have the luxury of accepting conclusions of meta-analyses or systematic reviews at face-value.
22. Section H discusses three topics that the Authors of the TU Report may find important for their own knowledge base.
23. Section I documents the Conclusions of this IARO Critical Analysis Report.

II. To the Authorship of the TU Report

24. With this Critical Analysis of the TU Report, in no way do IARO Scientists wish to offend or insult the authors of the TU Report, who are considered to be fellow scientists.
25. It is clear that a genuine effort has been made, within the context of systematic reviews, to adequately select published scientific papers, under the self-imposed exclusion criteria.
26. It has also become clear, however, that the Authors of the TU Report are unfamiliar with the deep complexities and intricacies of this particular subject, both in terms of acoustics and of biological sciences—This is entirely understandable, but errors (especially those arising from unfamiliarity with a particular subject) must be raised where they are made!

27. As mentioned above (Parag. 14), IARO Scientists have been individually dedicated to studying the health effects caused by infrasound and low frequency noise for many decades, and from many different perspectives (biological, clinical, signal analysis, instrumentation, occupational and environmental settings, animal exposures, among others).
28. IARO Scientists hope that the authors of the TU Report view this IARO Report as an educational tool, contributing to their "Review Study Phase I," rather than some gratuitous "attack document."
29. Please see Section H: A Candid Conversation among Scientists.

C. PURPOSE AND RESEARCH QUESTIONS UNDERLYING THE TU REPORT

I. Purpose of the TU Report Study

The aim of the study was to systematically analyse the evidence published in the scientific literature over the last fifteen years (2010–2025) on the health effects of wind turbines (p.12). (See Fig. 1)

30. While it is understood what is meant, this purpose is very badly worded, given the scientific credentials of the TU Report's Authorship.
31. Medical Sciences classifies agents of disease into 4 categories: biological, chemical, physical and psychosocial.
32. In which category, then, would "wind turbines" be inserted, since they are allegedly producing health effects? The wind turbines do not cause health issues; the emissions from wind turbines may cause health issues.
33. IARO scientists would suggest the following re-wordings for scientific accuracy:

"...on the health effects associated with the proximity of wind turbines to residential areas,"

Or

"...on the health effects claimed to be associated with wind turbine emissions,"

Or

"The aim of the study was to systematically analyse the evidence published in the scientific literature over the last fifteen years (2010–2025) on the purported health effects due to wind power plant operations."

34. This issue is not a trivial matter, as it may seem to some.
35. Instead, it reflects a deep misunderstanding of the matter at hand pertaining to the fundamental principles of Medical Sciences.
36. After all, the foremost concern here is the health of Estonian Citizens, is it not?

II. Research Questions

37. Throughout the Research Questions, it is apparent that wind turbines are (erroneously) interpreted as an agent of disease.
38. This greatly curtails the expansion of questions into a more scientific realm. As all scientists are aware, asking the right question is of fundamental importance.¹

Question 1: *What are the main conclusions of existing studies on the health effects of wind turbines?* (p.12, see Fig. 1)

39. This seems like an innocuous and purposeful question, but a closer inspection already reveals bias: is it presumed that the “health effects of wind turbines” are specific and exclusive to wind turbines—they are not!
40. Other industries can have similar emissions that bring about the same “health effects” as those allegedly developed by residents neighbouring wind power plants.
41. The agent of disease is not the wind turbine but its various emissions and, yes, one of those emissions is acoustical in nature.
42. Again, to the uninitiated this may seem a trivial point, more related to semantics—It is not!
43. Imagine the following question:

What are the main conclusions of existing studies on the health effects of automobiles?

44. Is this a question that, taken alone, makes any sense?

Question 2: *What is the overall quality of the existing evidence? Is there evidence in the scientific literature that wind turbines have a negative impact on human health?* (p.12)

45. The “overall quality of existing evidence” is evaluated by reading the Methodology Section of each and every selected paper to ascertain if the conclusions reached are supported by the methodology used (see Section G).
46. Are the Authors of the TU Report qualified to evaluate whether the methodologies imposed by law to “measure noise” are fit-for-purpose when human health is a concern?

¹ Back in the late 1800’s, the question was posed: “Is Light a particle OR a wave.” This question reduced physical reality to a dichotomy, not open to the possibility that Light can be BOTH. Hence the fundamental importance for proper Scientists to ask the pertinent and insightful questions.

47. Or have the Authors of the TU Report, instead, blindly relied upon the “noise measuring” methodologies as per legislated stipulations?
48. Many authors, unfamiliar with the matter at hand, do rely upon legislated methodologies.
49. However, given the stated “Purpose of the Study” and the scientific background of the authorship, can the Authors of the TU Report be afforded this luxury? (see Section E)
50. On the other hand, when the selected paper is referring to the evaluation of health endpoints, do the Authors of the TU Report have the expertise in Medical and Clinical Sciences to evaluate whether or not the selected health endpoint is pertinent and relevant? (See Section D)
51. The same can be pointed out regarding the second part of Question 2, *“Is there evidence in the scientific literature that wind turbines have a negative impact on human health?”* Whether there is or not, is the Authorship of the TU Report qualified to critically analyse the methods applied in these studies? (see Sections D and E)

Question 3: *If wind turbines have negative health effects, what health effects are associated with wind turbines? (p.12)*

52. This question trickles down from the prior questions. Again, it is not “wind turbines” that have negative health effects (unless the wind turbines themselves are becoming sick), but emissions from wind turbines that can act as agents of disease upon biological organisms.
53. Nevertheless, it is understood that the object of this question is to determine what kind of health effects have been documented as related to living in the proximity of wind power plants.
54. Do the Authors of the TU Report have the necessary expertise to evaluate the robustness of the methodologies used in papers that report health endpoints as related to residential proximity to wind power plants? (See Sections D, G and H-I)

Question 4: *If wind turbines have negative health effects, what role do environmental factors such as noise, infrasound, shadow flicker, visual aspects, psychological factors (including general attitudes towards wind turbines, people's beliefs and perceptions of wind turbines), vibration and electromagnetic fields in causing these health effects? (p.12)*

55. Let us dissect this question: “[W]hat role do environmental factors such as

noise, infrasound—a potential acoustical physical agent of disease,

shadow flicker—a potential optical physical agent of disease,

visual aspects—a potential optical physical and/or psychosocial agent of disease,

psychological factors—a potential psychosocial agent of disease,

vibration—a potential vibratory physical agent of disease and

electromagnetic fields—a potential electromagnetic physical agent of disease.

56. Perhaps, laid out like this, the Authors of the TU Report might realize why this question is entirely inappropriate...unless it is broken up into 6 distinct questions, each warranting its own independent study and (very) complex evaluation.
57. For example, “shadow flicker” is a term that only appeared after the advent of wind energy—before, it was called the stroboscopic effect.
58. Therefore, as the Authors of the TU Report would certainly agree, a proper investigation into “shadow flicker” must include prior studies (at least a glimpse into them) on the stroboscopic effects on humans (for example, such as those related to military helicopter pilots). Similar prior studies would be needed for each of the other environmental factors.

Question 5: *If wind turbines have health effects, under what conditions are these health effects more likely to occur (e.g. at what distance from the turbine, with powerful or tall turbines, etc.)?* (p.12)

59. Again, the wording of this question does not do justice to the scientific credentials of the TU Report’s Authors. While it is understood what is being asked here, its formulation is most unscientific.
60. Suggested rewording of Question 5:

Question 5 (suggested rewording):

If it can be demonstrated that “health effects” develop in residents neighbouring wind power plants, what external physical conditions (e.g. distance to turbine(s), type and specifications of turbine(s), etc.) become significant factors for the onset and/or development of these “health effects”?

61. It is hoped that this rewording is self-explanatory.

Question 6: *Are certain population groups more vulnerable to the potential health effects of wind turbines?* (p.12)

62. This is a very interesting question to have at such an initial stage of the study.
63. Is it intended to point out that population groups known to be vulnerable, such as the elderly, the chronically ill, infants and children, and pregnant women, should be

approached as separate populations to determine if they are (also) more vulnerable to “health effects of wind turbines,” if they exist?²

64. Given the vast experience of IARO Scientists, it seems that this question is most likely based on the prior supposition that some people ‘are more sensitive’ than others to the “health effects of wind turbines.” (See Section H-II).

Question 7: *What evidence-based recommendations can be made to policymakers, industry stakeholders and affected communities to protect human health? (p.12)*

65. This final question is, in and of itself, quite unscientific. “Evidence-based recommendations”—Are there any other type?
66. And yet, having read the Recommendations of the TU Report (and having pointed out their failings), it is now realized that, indeed, non-evidence-based Recommendations are, regrettably still (see Section H-III) a possibility from authors with significant Scientific Credentials.

² If the TU Report were to include animal studies, then perhaps this question could refer to different types of animal populations. Cows, sheep, rabbits and mink all react very differently when in the vicinity of wind power plants. Perhaps some are more vulnerable?

D. WHAT IS A NOISE-INDUCED HEALTH EFFECT?

67. As stated by the World Health Organization:

An adverse effect of noise is defined as a change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences.³

68. 'Annoyance' is commonly (yet erroneously) considered as a "health effect."

69. Duly, the TU Report covers this subject. Here are some examples:

Several of the studies included in this review (Appendix 2, Table 4) investigated the extent to which one specific characteristic of wind turbine noise, amplitude modulation (AM), contributes to annoyance (Ioannidou et al., 2016; Lee et al., 2011; Schaffer et al., 2016, 2018). In addition, these studies also examined the effect of noise frequency distribution and source origin on annoyance. (p. 21)

A review article (McCunney et al., 2014) also concluded that wind turbine noise plays only a minor role in causing annoyance compared to other factors that influence people's willingness to experience annoyance in relation to wind turbines. Pohl et al. (2018) also found that noise-related annoyance was influenced to a small extent by the distance to the nearest wind turbine and the intensity of the sound, but was most influenced by the extent to which people felt that the wind turbine planning process had been conducted fairly and transparently. (p. 33)

In summary, the relationship between wind turbines and disturbance depends on several factors, such as expectations/knowledge of the health effects of wind turbines, perceived fairness and transparency of the planning process, economic benefits, visual aspects and noise. It is likely that a combination of all these factors causes annoyance, and reducing just one factor (e.g. noise) may not reduce annoyance. (p. 36)

70. Annoyance is also included in the Recommendations Section of the TU Report:

³ World Health Organization. (1999) Guidelines for community noise. Stockholm University & Karolinska Institute: Stockholm, Sweden. pp. 21. <https://www.who.int/publications/i/item/a68672>

We recommend that developers and researchers explore ways to reduce AM depth in order to reduce the annoyance of wind turbine noise (p.46). [AM = Amplitude Modulation]

71. Are the Authors of the TU Report acquainted with the formal definition of annoyance?
72. In the 2017 edition of Mosby's Medical Dictionary,⁴ there were zero entries for the word 'annoyance.'
73. In the 2018 edition of the Medical Dictionary published by the British Medical Association,⁵ there were also no instances of the word 'annoyance.'
74. In the 2020 edition of the Oxford Medical Dictionary,⁶ one single entry is found for this word:

Glare n. the undesirable effects of scattered stray light on the retina, causing reduced contrast and visual performance as well as annoyance and discomfort.

75. Within the context of noise nuisance, perhaps the best definition for 'annoyance' is (still) the one given in 2000 by the European Commission Noise Team:

Annoyance is the scientific expression for the non-specific disturbance by noise, as reported in a structured field survey. Nearly every person that reports to be annoyed by noise in and around its home will also experience one or more of the following specific effects: Reduced enjoyment of balcony or garden; When inside the home with windows open: interference with sleep, communication, reading, watching television, listening to music and radio; Closing of bedroom windows in order to avoid sleep disturbance. Some of the persons that are annoyed by noise also experience one or more of the following effects: Sleep disturbance when windows and doors are closed; Interference with communication and other indoor activities when windows and doors are closed; Mental health effects; Noise-induced hearing impairment; Hypertension; Ischemic heart disease.⁷

⁴ O'Toole MT et al. (Eds). (2017) Mosby's Medical Dictionary. 10th Ed. Elsevier: St Louis, MI, USA.

⁵ British Medical Association. (2018) Medical Dictionary. 4th Edition. Dorling Kindersley: London, UK.

⁶ Martin E, Law J. (Eds) (2020) Concise Colour Medical Dictionary. 7th Ed. Oxford University Press: Oxford, UK.

⁷ European Commission. (2000) The Noise Policy of the European Union—Year 2. Towards improving the urban environment and contributing to global sustainability. European Commission Noise Team: Luxembourg. <https://www.europeansources.info/record/the-noise-policy-of-the-european-union-year-2-1999-2000-towards-improving-the-urban-environment-and-contributing-to-global-sustainability/>

76. This comprehensive definition of 'annoyance' clearly establishes it as a legitimate measure to be used within the realm of Psychoacoustic studies.
77. But it is far from being an appropriate health endpoint within the context of an "adverse effect of noise," as defined by the World Health Organization (see Parag. 67).
78. Do the Authors of the TU Report have the necessary expertise to identify this issue, or will it be 'business as usual'?⁸
79. For the edification of these Authors, in papers that have been excluded from their selection, annoyance has been linked to morphological changes in the auditory cilia and some medical professionals view self-reported 'noise annoyance' in their patients as a symptom of excessive prior noise exposure. (See Section H-II)
80. For the further edification TU Report's Authors: The International Classification of Diseases (ICD-11), published by the World Health Organization, has specific codes for infrasound-induced vertigo—NF08.2Y (see Figure 2).

⁸ The exclusion criteria should have included all papers that have used 'annoyance' as a *bona fide* health endpoint.

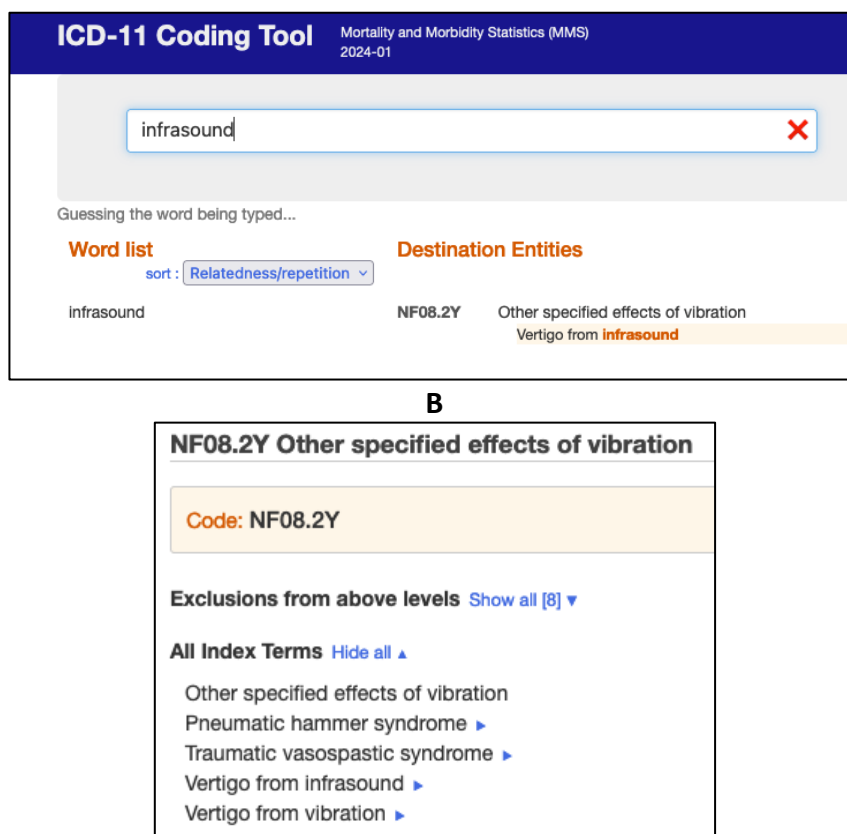


Figure 2. Results of the search for “infrasound” in the WHO ICD-11 (coding tool option).⁹ **(A)** One instance of infrasound appears—Code NF08.2Y, covering infrasound-induced vertigo, under the heading of “other specified effects of vibration.” **(B)** Index terms covered by this Code differentiate between infrasound- and vibration-induced vertigo.¹⁰

⁹ World Health Organization. (2024) International Classification of Diseases-11 (ICD-11). https://icd.who.int/ct/icd11_mms/en/release

¹⁰ World Health Organization. (2024) International Classification of Diseases-11 (ICD-11). <https://icd.who.int/browse/2024-01/mms/en#621374492%2Fother>

E. WHY CURRENT NOISE MEASURING METHODOLOGIES ARE NON-APPLICABLE FOR WIND TURBINE NOISE

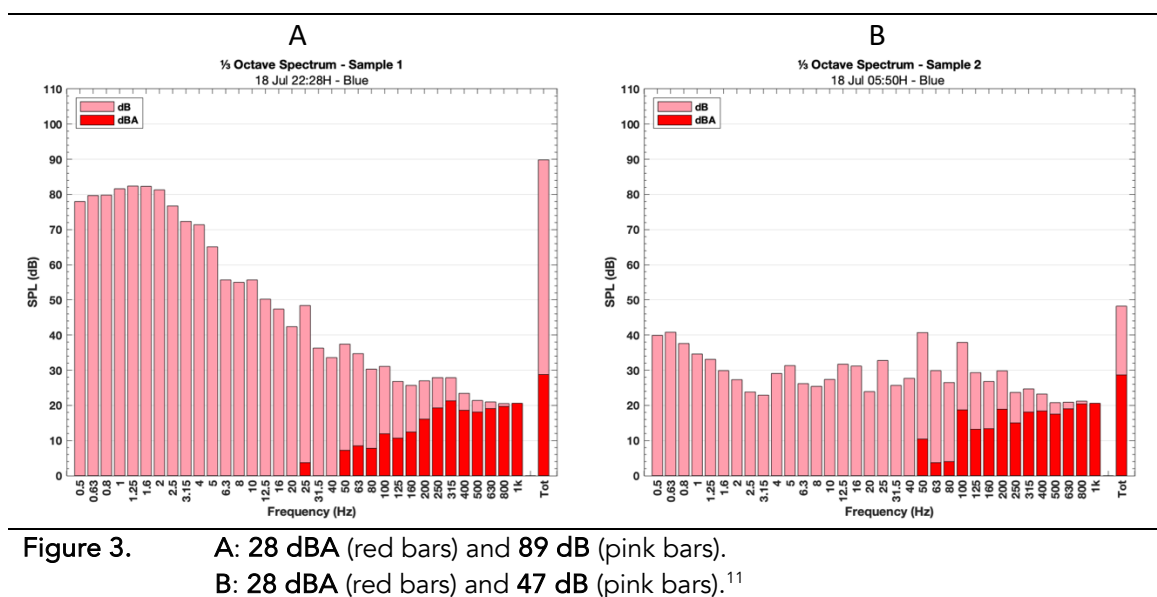
81. In its Recommendations section, the TU Report states the following:

For living and sleeping areas, we recommend setting a limit for wind turbine noise of 30 dB(A) during the day and 25 dB(A) at night, similar to the existing limits for traffic noise and noise from technical equipment. (p. 48).

82. Presumably, then, a value of 28 dBA would, more or less, comply with this recommendation.

83. Which value of 28 dBA would the Authors of the TU Report consider acceptable in the following field-data situation, shown in Fig. 3:

84. The 28 dBA in Fig. 3A or the 28 dBA in Fig. 3B?



¹¹ Data from urban field measurements (no wind turbines), published in a paper that was excluded from the TU Report selection of papers. Pereira-Sousa P, Alves-Pereira M, Bakker H. (2025). Dose-Response Relationship in Occupational Noise Exposures: The Distorted Quantification of Dose that Misinforms the Medical Community. SHO 2025 – International Symposium on Occupational Safety and Hygiene. Proceedings Book. DOI: https://doi.org/10.24840/978-989-54863-7-3_0125-0132

85. Do the Authors of the TU Report understand that noise measured in dBA cannot differentiate between these two, significantly different, acoustic environments?
86. Hence, the recommendation transcribed in Para. 81 is entirely skewed from the matter at hand.
87. This type of information was known by the World Health Organization in 1999:

A noise measure based only on energy summation and expressed as the conventional equivalent measure, LAeq, is not enough to characterize most noise environments. It is equally important to measure the maximum values of noise fluctuations, preferably combined with a measure of the number of noise events. If the noise includes a large proportion of low-frequency components, still lower values than the guideline values below will be needed. When prominent low-frequency components are present, noise measures based on A-weighting are inappropriate.¹² [Emphasis added.]

88. In the TU Report, Fig. 1 is a very informative graph showing the frequency response curves of the different frequency-weighting filters that are imposed on noise measurements by legislated stipulations. This graph is reproduced here in Fig. 4.

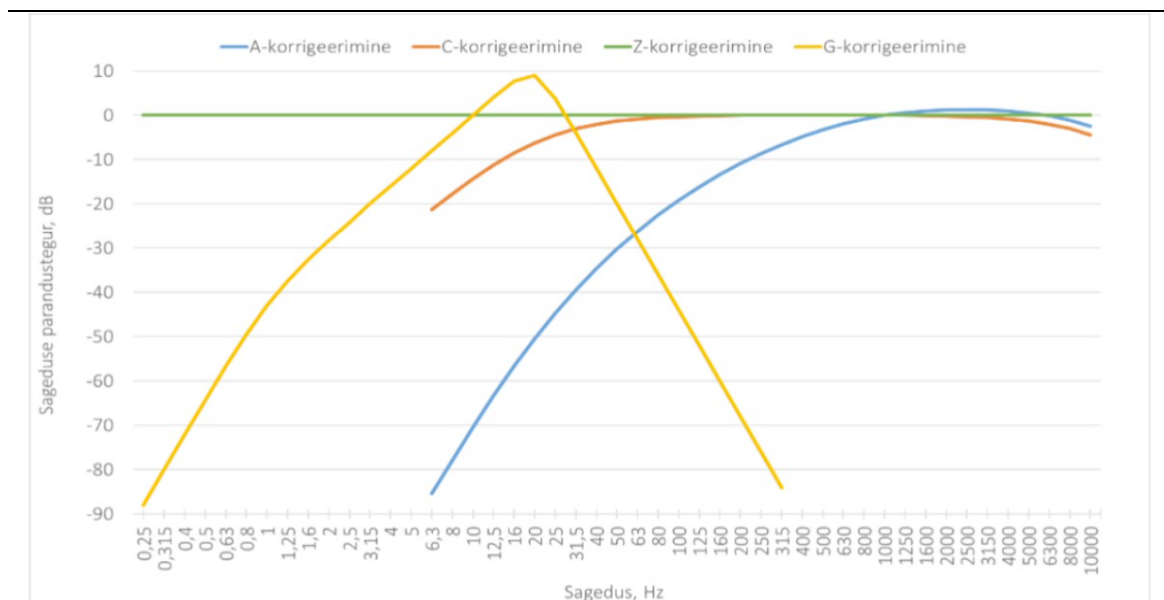


Figure 4. Frequency response curves for A, C and G the frequency-weighting filters and for the absence of filter, Z. (p. 8, TU Report)

¹² World Health Organization. (1999) Guidelines for community noise. Stockholm University & Karolinska Institute: Stockholm, Sweden. pp. xiii. <https://www.who.int/publications/i/item/a68672>.

89. Do the Authors of the TU Report realize that the application of any of these different filters (A, C and G) means that profound assumptions are being made, namely:
- 1) what you can't hear can't hurt you (see Section F), and
 - 2) annoyance is a *bona fide* health endpoint (see Section D)?
 - 3) noise only affects humans via the auditory pathway (see Section F).
90. Do the Authors of the TU Report realize that, for the purposes of the matter at hand, the act of "measuring noise" constitutes the quantification of the dose of the agent of disease?
91. Do the Authors of the TU Report understand that the Y axis of their Figure 1 indicates that the application of frequency weighting filters means that the measurements no longer reflect physical reality?
92. Does this begin to explain why legislated methodologies are scientifically irrelevant for measuring the types of environments where noise has significant lower frequency components, such as those generated by wind power plants?
93. Does this also suggest why a high-quality scientific investigation should ignore legislated methodologies in favour of evidence-based methodologies?
94. Real, scientific-grade information on the medical dose of noise is not obtained, if legislated procedures are applied, i.e., the mandatory use of A, C or G frequency-weighting filters. (See Fig. 3)

F. 'WHAT YOU CAN'T HEAR, CAN'T HURT YOU'

95. Is this what the Authors of the TU Report have been told? *What you can't hear, can't hurt you?*
96. The significant difference between the two 28-dBA environments shown in Fig. 3 will be summarily dismissed by those who believe this fallacy.
97. The Authors of the TU Report will be told that the real physical presence of the 47 and 89 dB difference (i.e., no filter is applied) is irrelevant for human health because it is occurring below the human auditory threshold.
98. Will these Authors, then, also believe that only environmental factors that can be readily perceived by all people are relevant for consideration in human health? In the same way that radioactivity is (not) readily perceived or carcinogenic chemicals are (not) readily perceived?
99. See Fig. 5, which shows an abstract of a paper from 1978 (!)¹³

Infrasound and sound: Differentiation of their psychophysiological effects through use of genetically deaf animals

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The effects of steady-state acoustic stimulation on resistance to fatigue, as shown by reduction of swimming time, was studied on three sublines of mice, one of which is genetically deaf. High frequency (500–10000 Hz) reduce swimming time from 25% to 50% in mice with normal hearing at a 60–80-dB threshold, but have no effect on deaf mice. Low frequencies and infrasounds (6–50 Hz) reduce swimming time in all mice similarly, even deaf animals, but the threshold is higher (160–115 dB). The use of genetically deaf animals therefore permits elimination of the auditory component; differentiation of the effects of air-borne from those of mechanical vibrations are thus possible.

PACS numbers: 43.80.Jz, 43.80.Lb, 43.28.Dm

Figure 5. Busnel RG, Lehmann AG (1978). Infrasound and sound: Differentiation of their psychophysiological effects through use of genetically deaf animals. *Journal of the Acoustical Society of America*¹⁴ (see text).

¹³ Certainly, way beyond the scope of the TU Report's systematic review...being from 1978 and because it involves animals.

¹⁴ Busnel RG, Lehmann AG (1978). Infrasound and sound: Differentiation of their psychophysiological effects through use of genetically deaf animals. *Journal of the Acoustical Society of America*, 63(3): 974-977. <https://pubmed.ncbi.nlm.nih.gov/670562/>

100. In this 1978 study, genetically-deaf mice were used as study subjects, and infrasound had a deleterious effect on their performance. *What you can't hear can't hurt you?*
101. How, then, to explain the more recent scientific results shown in Figs. 6A and 6B, where an acoustic phenomenon, presumed to be inaudible to humans (below 20 Hz) was able to distress the residents during a sleepless night, to the point of compelling them to take medication?¹⁵

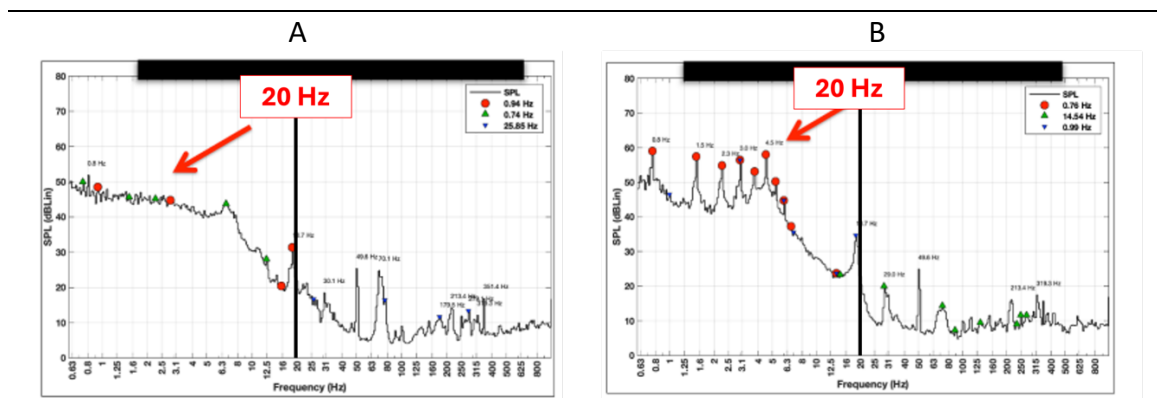


Figure 6.

A: Residents near wind power plants slept peacefully— 26 dBA and 67.3 dB,
 B: Same residents could not sleep and needed medication—26.5 dBA and 69.9 dB¹⁶

102. *What you can't hear, can't hurt you...*doesn't really work very well, does it? Not for mice in 1978, nor for humans in 2023.
103. For the edification of the Authors of the TU Report, the sequence of peaks seen in Fig. 6B is called a *wind turbine acoustic signature*. Mathematically, it is a harmonic series whose fundamental frequency corresponds to the blade pass frequency of the corresponding wind turbine (see Fig. 7B in Section G).
104. Wind turbine acoustic signatures become invisible when legislated noise measuring methodologies are applied.

¹⁵ The residents, authors of the diary providing this information, were not privy to any acoustical information that was being simultaneously recorded. Data presented here in Figure 6 are the result of post-processing analysis. Please see Footnote 16 for the full, peer-reviewed report on this case.

¹⁶ This paper was excluded from the selection of papers considered by the TU Report, as it is a Case Report. Bakker HHC, Alves-Pereira M, Mann R, Summers R, Dickinson P. (2023) Infrasound exposure: High resolution measurements near wind power plants. In: Suhanek M, Kevin Summers J. (Eds) Management of Noise Pollution. IntechOpen: London. DOI: 10.5772/intechopen.109047

G. LUXURIES NOT AFFORDED TO SCIENTISTS—A GLIMPSE OF THE TEDIOUS WORK REQUIRED TO UPHOLD SCIENTIFIC RIGOUR.

105. Scientists do not have the luxury of taking the conclusions of meta-analyses (or systematic reviews or literature reviews) of pre-existing papers, for granted or at face-value.
106. In contrast to laypersons, policy- and decision-makers, industry stakeholders and the general public, Scientists must evaluate the methodology of each and every paper included in a review.
107. A tedious exercise for sure, but a necessary one if scientific rigour is to be upheld.
108. How else can one scientifically vouch for the conclusions offered by the author of the meta-analysis, systematic review or literature review?
109. As a demonstrative exercise, let us explore an 11-year-old paper, quoted several times in the TU Report:

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., Stansfeld, S., 2014. Auditory and non-auditory effects of noise on health. Lancet 383, 1325–1332.

110. This same reference justified the following statements, made by the Authors of the TU Report on page 7:

A decibel indicates how much louder the sound is than the reference value. In air, the reference value is an air pressure of 20 micropascals (20 μ Pa or 2×10^{-5} Pa), which is considered to be the human hearing threshold at a frequency of 1000 Hz – this is the quietest sound that the average person can still hear at this frequency. (p.7)

111. And on page 32:

Disturbance can also act as a mediating factor between other health effects, including influencing the development of more serious conditions such as cardiovascular disease through stress (p. 32)

112. And, under the heading “**Audible noise** [sic] generated by wind turbines and clinically manifested health effects,” (p. 40), the TU Report makes another statement justified by this same, 2014 reference:

Disturbance and sleep disturbances caused by audible noise may contribute to the development of diagnosable diseases (p. 40).¹⁷

113. Returning to the original 2014 reference, it states:

In this Review, we summarise knowledge and research related to noise exposure and both auditory and non-auditory health effects. (...)

These noise exposures have been linked to a range of non-auditory health effects including annoyance (Miedema & Oudshoorn, 2001¹⁸), sleep disturbance (Muzet, 2007¹⁹), cardiovascular disease (van Kempen & Babisch, 2012²⁰; Sorensen et al., 2012²¹) and impairment of cognitive performance in children (Stansfeld & Matheson, 2003²²).²³ [The original numbered references were replaced with citations.]

114. Scientific 'work' involves reading each of these 5 references that are quoted in this 2014 review if and only if scientific rigour is to be maintained.

115. (It should be recalled that scientific rigour is not necessarily in the purview of laypersons, policy- and decision-makers, industry stakeholders and the general public.)

116. Just by reading the titles of these 5 papers we see that one is a meta-analysis, which eliminates it from this immediate consideration.

117. Let us look into the other four.

¹⁷ This last assertion is a truism (at least since the times of Ancient Rome) as it is referring to audible noise! Strictly speaking, no reference would have been needed.

¹⁸ Miedema HME, Oudshoorn CGM. Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environ Health Perspect.* 2001; 109:409–16. <https://pubmed.ncbi.nlm.nih.gov/11335190/>.

¹⁹ Muzet A. Environmental noise, sleep and health. *Sleep Med Rev.* 2007; 11:135–42. <https://pubmed.ncbi.nlm.nih.gov/17317241/>

²⁰ van Kempen E, Babisch W. The quantitative relationship between road traffic noise and hypertension: a meta-analysis. *J Hypertens.* 2012; 30:1075–86. <https://pubmed.ncbi.nlm.nih.gov/22473017/>

²¹ Sørensen M, Andersen ZJ, Nordsborg RB, et al. Road traffic noise and incident myocardial infarction: a prospective cohort study. *PLoS One.* 2012; 7:e39283. <https://pubmed.ncbi.nlm.nih.gov/22745727/>

²² Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. *Br Med Bull.* 2003; 68:243–57. <https://pubmed.ncbi.nlm.nih.gov/14757721/>

²³ Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, Stansfeld S. (2014) Auditory and non-auditory effects of noise on health. *Lancet* 383: 1325–1332. <https://pubmed.ncbi.nlm.nih.gov/24183105/>

118. Miadema & Oudshoorn (2001): *"Here we model the distribution of annoyance responses as a function of the noise exposure" for road, rail and air traffic noise. "Day–night level (DNL) and day–evening–night level (DENL) were used as noise descriptors."*
119. Wind turbine noise is not considered in the Miadema & Oudshoorn paper.
120. Annoyance, which Miadema & Oudshoorn used as a health endpoint, is not a *bona fide* health outcome (see Section D).
121. The noise parameters used to characterize "noise exposure" are inconsequential for the matter at hand (see Section E).²⁴
122. Muzet (2007) is classified as a "Clinical Review" and uses sleep as a measure of a health—a *bona fide* health endpoint.
123. However, noise environments of the papers used by Muzet in his Clinical Review are still characterized in dBA, and wind turbine noise is not considered—this excludes any real scientific relevance to the matter at hand.
124. Sorensen *et al.* (2012), not a review paper, and a very scientifically robust health endpoint was chosen—ischemic heart disease (see Section D).
125. Sorensen *et al.* (2012) stated: *"Exposure to long-term residential road traffic noise was associated with a higher risk for MI, in a dose-dependent manner."* [MI=Myocardial Infarction, i.e., ischemic heart disease.]
126. As with the Miadema & Oudshoorn study, the 'day–evening–night level,' or Lden, was used to quantify the noise environment (see Section E and footnote 24), and wind turbine noise was not considered.
127. Stansfeld & Matheson (2003), yet another review, based on 86 references...
128. The tediousness of this exercise is an integral part of the Scientific process.
129. To finalize this Section, a last assertion is transcribed from the Introduction of the TU Report:

However, reviews of wind turbine noise conducted to date have not confirmed a link between wind turbine noise and clinically apparent health effects (Karasmanaki, 2022; Schmidt and Klokke, 2014; Teneler and Hassoy, 2023; van Kamp and van den Berg, 2021, 2018). (p. 4)

²⁴ Although not explicitly indicated, the use of the Lden or DENL noise parameter implies the application of the A-frequency-weighting filter (see Section E, Figs. 3 and 4).

130. These five references, offered as (evidence-based?) justifications for this assertion, are all meta-analysis, systematic reviews or literature reviews.
131. Does this mean that the Authors of the TU Report vouch for the position taken by the author(s) of each one of these five reviews, and therefore guarantees that all the papers cited in reviews uphold the author(s)' position? Can they vouch for the methodologies of all the papers when they have not seen them?
132. Of course not!
133. However, unlike others, Scientists, do not have the luxury of merely depending on the conclusions reached by the authors of these types of review papers, because they could include papers of dubious scientific integrity.
134. This is a part of what the scientific process is all about, is it not?
135. On page 26 of the TU Report, the following is stated:

The study concluded that wind turbine infrasound does not disturb people's sleep, does not cause symptoms of 'wind turbine syndrome', does not impair measured cardiovascular health indicators, and does not impair people's mental well-being (Marshall et al., 2023). The results of the study can be considered well-proven. (p.26)

136. Annex B provides a critical analysis of the Marshall et al. (2023) paper prepared by IARO Scientists in 2024.
137. On page 33 of the TU Report, the following is stated:

An experiment conducted in Finland showed that the audible sounds of a wind farm were more disturbing than the sounds of the ocean (Maijala et al., 2021).

138. Would the Authors of the TU Report care to know the scientific reason for why this is so?
139. Here is a comparison between ocean noise and wind turbine noise, as measured without the methodologies imposed by legislation:

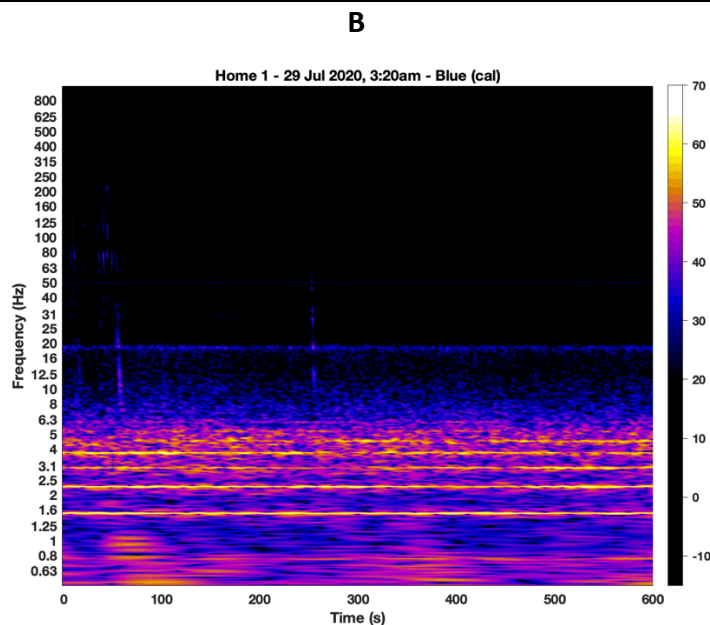
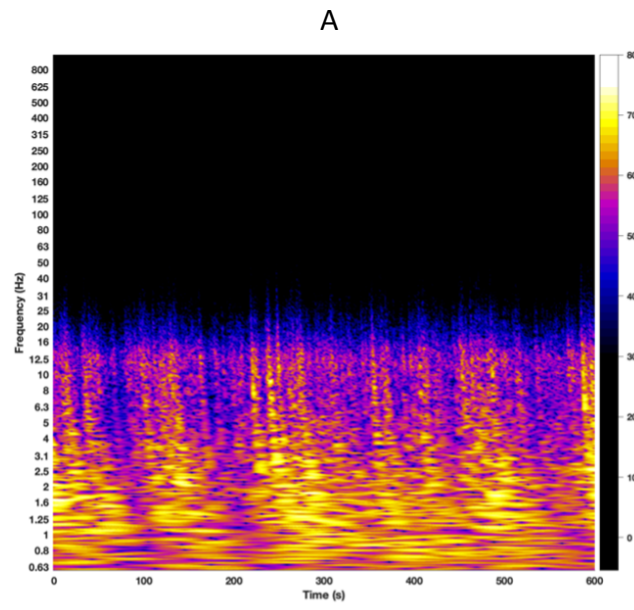


Figure 7. Characterization of acoustic environments (i.e., noise measurements) without the legislated-imposed methodologies. **A.** Beach, Rømo Island, Denmark, 13 Dec 2016 at 01:10H. **B.** Wind turbines acoustic signature, present in the acoustic environment corresponding to the night when residents could not sleep and were compelled to take medication—See Fig 3B in Section F.

140. All this important information becomes invisible when legislated methodologies are imposed.
141. Annex C provides a critical analysis of the Maijala *et al.* paper prepared by IARO Scientists in 2024.

H. A CANDID CONVERSATION AMONG SCIENTISTS

142. Since the Authors of the TU Report are considered by IARO as fellow-scientists, an uncommon decision has been taken to speak directly to these Authors through this Critical Analysis Report.
143. This was deemed all the more appropriate since IARO Scientists have been informed that this Team of Estonian Scientists will proceed with more studies to monitor the development health effects among residents neighbouring wind power plants.
144. If this TU Report is any indication of the avenues of research that will be followed (particularly given its appalling Recommendations), then IARO's position is simple—what a waste of time, money and brainpower!

I. The 'nocebo effect' narrative

145. As part of the Recommendations, the TU Report states:

The results of our study show that several factors other than wind turbine noise affect disturbance, and that noise reduction alone may not be sufficient to mitigate disturbance. Just as important as noise restrictions in preventing disturbance may be informing residents about the nocebo effect, the absence of negative expectations regarding the health effects of wind turbines, and understanding the positive characteristics of wind turbines (Crichton et al., 2015, 2014b, 2014a; Crichton and Petrie, 2015b, 2015a; Tonin et al., 2016).

146. By advocating this 'nocebo effect narrative,' the Authorship of the TU Report is taking a position that is absolutely indefensible in terms of Science.
147. The Authors of the TU Report, as Scientists, should be aware that a nocebo effect cannot be proven, as it is impossible to eliminate all environmental factors that might be a cause but are unmeasured.²⁵ The Authors should be asking, where is the evidence for a nocebo effect?
148. Given the scientific credentials of the Authors of the TU Report, they should, instead, be inquiring into the studies that justified attributing the label of 'nocebo effect' to the collection of symptoms, self-reported people by all over the world.

²⁵ The nocebo effect can never be proved, it can only fail to be disproved.

149. This collection of symptoms is not specific to people who live in the proximity of wind power plants, but it is specific to people who live in infrasound-contaminated homes (whatever the source).
150. Are all these cases supposed to be the result of some collective psychosomatic disorder?
151. For the edification of these Estonian Scientists, the 'nocebo effect' is, in Clinical Medicine, considered to be of psychosomatic origin (or aetiology), falling under the category of pathology caused by psychosocial agents of disease (see Parag. 31).
152. Under the rules of Evidence-based Medicine, to claim that a collection of symptoms is a 'nocebo effect,' then, objective medical examinations must have been prescribed and no organic aetiology for the symptoms was found.
153. Has the TU Report's Authors found a scientific justification for labelling this collection of symptoms as a 'nocebo effect'?
154. Moreover, if, as Scientists, these Authors truly insist on standing by the 'nocebo effect narrative,' then they must be prepared to explain all the effects seen in animals living in proximity to wind power plants, such as:

Exposed cows in France registered a dramatic fall in milk output.²⁶

Exposed cows in Korea are reported to have many cases of foetal death.²⁷

In Poland, there was a negative effect on the stress parameters and productivity of exposed geese.²⁸

In England, higher cortisol levels were found in exposed badgers and "these high levels may affect badgers' immune systems, which could result in increased risk of infection and disease in the badger population."²⁹

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- 26 Mulholland R. (2015) French farmer sues energy giant after wind turbines 'make cows sick.' The Telegraph, 18 September. <https://www.telegraph.co.uk/news/worldnews/europe/france/11875989/French-farmer-sues-energy-giant-after-wind-turbines-make-cows-sick.html>.
- 27 Se-hwan B. (2018). Wind turbines destroy local farming village. Rapid expansion of wind power facilities raises health and environmental concerns. The Korea Herald, 20 March. <http://www.koreaherald.com/view.php?ud=20180320000768>
- 28 Mikolajczak J, Borowski S, Marc-Pienlowska J, Odrowaz-Sypniewska G, Bernacki Z, Siodmiak J, Szterk P. (2013) Preliminary studies on the reaction of growing geese (Anser anser f. domestica) to the proximity of wind turbines. Polish Journal of Veterinary Sciences, 16(4):679-86. DOI: 10.2478/pjvs-2013-0096
- 29 Agnew RCN, Smith VJ, Fowkes RC. (2016) Wind turbines cause chronic stress in badgers (meles meles) in Great Britain. Journal of Wildlife Diseases, 52(3): 459-67. DOI: 10.7589/2015-09-231

In a Polish study, the meat quality of exposed pigs decreased significantly.³⁰

In Spain, a rabbit farm saw a 50% decrease in production after the WPP was installed. Exposed rabbits developed “problems of stress, infertility, death and behavioural changes,”³¹ and “a disproportionate increase in mortality rates.” This farm has since been closed down.³²

Exposed frogs in Japan, “collected from paddy fields with wind power generators exhibited a faster call rate, higher salivary concentrations of corticosterone, and lower innate immunity (...) [This] can alter the disease epidemiology of local populations by regulating the balance between reproduction and immunity.”³³

Exposed horses in Portugal developed flexural deformities and blood vessel walls revealed the characteristic, collagen-based thickening.^{34, 35}

In Denmark, a mink farm was forced to close due to greatly increased aggressiveness, stillbirths and birth defects.³⁶

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- 30 Karwowska M, Milolajczak J, Dolatowski ZJ, Borowski S. (2015) The effect of varying distances from wind turbine on meat quality of growing-finishing pigs. *Annals of Animal Sciences*, 15(4):1043-54. DOI: 10.1515/aoas-2015-0051.
- 31 Ephe. (2023) [Union of Peasants of Castile and Leon denounces the ruin of one of the best farms in Spain by a wind farm] *El Di rio.es*, 9 May. (In Spanish) https://www.eldiario.es/castilla-y-leon/union-campesinos-castilla-leon-denuncia-ruina-mejores-granjas-espana-parque-eolico_1_10189253.html
- 32 Fern ndez, JI. (2023) [A rabbit farm's fight against a wind farm: “We are in ruins”]. *El Espa ol*, 9 May. [Article in Spanish] https://www.elespanol.com/castilla-y-leon/economia/el-campo/20230509/lucha-granja-conejos-parque-eolico-ruina/762423940_0.html
- 33 Park JK, Do Y. (2022) Wind turbine noise behaviourally and physiologically changes male frogs. *Biology*, 11, 516. DOI: 10.3390/biology11040516
- 34 Castelo Branco NAA, Costa e Curto T, Mendes Jorge L, Cavaco Fa sca J, Amaral Dias L, Oliveira P, Martins dos Santos J, Alves-Pereira M. (2010) Family with wind turbines in close proximity to home: follow-up of the case presented in 2007. *Proceedings of the 14th International Meeting on Low Frequency Noise, Vibration and Its Control*. Aalborg, Denmark, 9-11 June, 31-40.
https://www.researchgate.net/publication/290444702_Family_with_wind_turbines_in_close_proximity_to_home_follow-up_of_the_case_presented_in_2007
- 35 Costa e Curto TM. (2012) [Acquired flexural deformity of the distal interphalangeal articulation in foals]. Master’s Thesis. Faculty of Veterinary Medicine, Technical University of Lisbon. [Thesis in Portuguese]
<https://www.repository.utl.pt/handle/10400.5/4847>
- 36 Rapley, B. (2018). *Conversation for a Small Planet Vol. 3-Biological Consequences of Low-Frequency Sound*. Bouncing Koala Press, Palmerston North, New Zealand. (Chapter 8-Death in Denmark) Available from consultant@smart-technologies.co.nz.

155. Is it the position of the Authors of the TU Report that the adverse health effects observed in these animals, living in the proximity of wind power plants, are also caused by a 'nocebo effect' (i.e., psychosocial factors)?
156. Or is this one of the reasons why animal studies were excluded from the selection of papers chosen for this systematic review?

II. The questionnaire approach

157. In order to construct an appropriate questionnaire for people who live in proximity to wind power plants, yet another concept must be understood, regarding Medical Sciences and Physical Agents of Disease:

The health effects of physical agents of disease are cumulative.

158. This means the overall, prior noise exposure time (whatever the source!) is a parameter that must be considered, if a *bona fide* study based on questionnaires is desired.
159. This is true for vibration exposures, electromagnetic radiation exposures (where personal dosimeters are applied to actually quantify the cumulative exposure) and for noise exposures.
160. Stratification of study and control populations, as per prior noise exposures (severe, moderate and mild) must be made before any statistically valid study of health effects developed by citizens living in proximity to wind power plants can be properly obtained.
161. 'Increased sensitivity' can, therefore, merely be synonymous with significant, prior noise exposure, such as foetal exposures and/or prior occupational or residential exposures.
162. This particular topic has been extensively discussed elsewhere.³⁷

³⁷ The exclusion criteria applied by the Authorship of the TU report eliminated this paper from consideration. Alves-Pereira M, Rapley B, Bakker H, Summers R. (2019) Acoustics and Biological Structures. In: Abiddine Fella ZE, Ogam E. (Eds) *Acoustics of Materials*. IntechOpen: London. DOI: 10.5772/intechopen.82761.

III. Another ‘Scientific Authorship’ of another “Wind Turbine Health Impact Study” ...

163. In 2012 (13 years ago!), the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health commissioned an Expert Independent Panel to conduct a “Wind Turbine Health Impact Study.”
164. IARO Scientists invite the Estonian Authors of the TU Report to read the Charge given to this Scientific Panel, shown in Figure 8.

The Panel Charge

The Expert Panel was given the following charge by the Massachusetts Department of Environmental Protection (MassDEP) and Massachusetts Department of Public Health (MDPH):

1. Identify and characterize attributes of concern (e.g., noise, infrasound, vibration, and light flicker) and identify any scientifically documented or potential connection between health impacts associated with wind energy turbines located on land or coastal tidelands that can impact land-based human receptors.
 2. Evaluate and discuss information from peer-reviewed scientific studies, other reports, popular media, and public comments received by the MassDEP and/or in response to the *Environmental Monitor Notice* and/or by the MDPH on the nature and type of health complaints commonly reported by individuals who reside near existing wind farms.
 3. Assess the magnitude and frequency of any potential impacts and risks to human health associated with the design and operation of wind energy turbines based on existing data.
 4. For the attributes of concern, identify documented best practices that could reduce potential human health impacts. Include examples of such best practices (design, operation, maintenance, and management from published articles). The best practices could be used to inform public policy decisions by state, local, or regional governments concerning the siting of turbines.
 5. Issue a report within 3 months of the evaluation, summarizing its findings.
- To meet its charge, the Panel conducted a literature review and met as a group a total of three times. In addition, calls were also held with Panel members to further clarify points of discussion.

Figure 8. Charge given to the Expert Independent Panel by the Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health³⁸

³⁸ Expert Independent Panel. (2012) Wind turbine health impact study. Massachusetts Department of Environmental Protection and the Massachusetts Department of Public Health.
<https://www.mass.gov/files/documents/2016/08/th/turbine-impact-study.pdf>

165. How much does it differ from the Charge given to the Authors of the TU Report by the Ministry of Environment of Estonia?
166. In Annex D, please find the full Response from one of IARO's Scientists to this 2012 Expert Independent Panel.
167. For the benefit of the Authors of the TU Report, excerpts taken from this Response are offered to our fellow Estonian Scientists in Fig. 9:

Loaded dice

In a way, this Panel was charged with the task of rolling loaded dice. Peer-reviewed studies investigating the impact on human health of WT noise exposure practically do not exist. Those that claim to study just that, fail when objective clinical outcomes are non-existent end-points. Hence the Panel's charge, more than difficult is quite near impossible.

(p.4, Annex D)

In conclusion

The Panel's charge is not an enviable one since it is nearly impossible to carry out. The health impacts on populations living in the vicinity of WT are, simply put, not documented.

Health impacts *are not* scientifically evaluated through questionnaires and surveys. Instead, objective clinical data are required which, in this case, do not exist.

The authorities who requested this Report (MassDEP and MDPH) will most likely not find it very useful *if their priority is the health of populations living near WT*. However, if other agendas exist, this Report may become relevant.

(p.9, Annex D)

Figure 9. Excerpts from the Response to the Massachusetts Independent Expert Panel (Full Response Report is provided in Annex D).

I. CONCLUSIONS

- 168.** The systematic review documented in the TU Report has clearly been conducted properly in terms of how an analysis of published papers and reports should be undertaken when those participating are not experts in the subject matter.
- 169.** The exclusion criteria applied to the selection of scientific papers for the study, blinds the Authors of the TU Report to a broader understanding of the matter at hand.
- 170.** Given the non-evidence-based Recommendations proffered by the TU Report, it seems probable that the Authors of the TU Report have unwittingly succumbed to the unscientific practices promoted by governments and international special interest groups.
- 171.** In the opinion of IARO Scientists, this study can only be regarded as, yet another, artificially constrained review of papers, with outcomes predetermined by politically generated questions, resulting in a report of low scientific standard.