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Final report

Informational concept on infrasound and its effects

From:

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Abstract: Informational concept on infrasound and its effects

The object of this project is to deepen the concepts and connections regarding the perceived risk of infrasound, the underlying information processing processes and the acceptance of wind turbines (WT) based on a review of the state of research (literature analyses) as well as to investigate those concepts and connections by means of empirical surveys. In this context, the research is guided by questions about the understanding of infrasound and the emotions associated with it, as well as the mechanisms that lead to such emotions. Based on these findings, the transferability of the understanding of and emotions about infrasound and its effects on the acceptance of WTs is investigated. Furthermore, on the basis of these results a concept is developed, which informs the population appropriately about infrasound and its effects (partly using the example of WTs).

Kurzbeschreibung: Aufklärungskonzept zu Infraschall und dessen Wirkungen

Gegenstand dieses Vorhabens ist es, Konzepte und Zusammenhänge zum wahrgenommenen Risiko von Infraschall, den zugrundeliegenden Informationsverarbeitungsprozessen und der Akzeptanz von Windenergieanlagen (WEA) im Rahmen der Aufarbeitung des Forschungsstandes (Literaturanalysen) zu vertiefen sowie anhand von empirischen Erhebungen zu untersuchen. Hierbei sind die Fragen nach dem Verständnis von Infraschall und den damit verbundenen Emotionen sowie die Mechanismen, die solche Emotionen entstehen lassen, forschungsleitend. Ausgehend von diesen Erkenntnissen wurde exemplarisch der Übertragbarkeit des Verständnisses und der Emotionen zum Infraschall und dessen Auswirkungen auf die Akzeptanz von WEA nachgegangen. Weiterhin wurde auf Grundlage dieser Ergebnisse ein Konzept entwickelt, welches die Bevölkerung sachgerecht über Infraschall und dessen Wirkungen (zum Teil exemplarisch am Beispiel WEA) informiert.

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ANIMA	Aviation Noise Impact Management through novel Approaches
ANOVA	Analysis of Variance
APA	American Psychological Association
BASE	Bielefeld Academic Search Engine
CI ('s)	Citizens' initiative(s)
CC licence	Creative Commons Licence
dB	Decibel
df	Degrees of freedom
DIN standard	Standard laid down by the German Institute for Standardisation
DVD	Digital Video Disc
EEG	Electroencephalogram
EFA	Exploratory factor analysis
EMF	electromagnetic fields
EU	European Union
Fax	Faximile
F-value	Specification for the ratio of two variances (in ANOVA)
GmbH	Limited liability company
Hz / kHz	Hertz / Kilohertz
ICBEN	International Commission on Biological Effects of Noise
ISO standard	International standards developed by the International Organization for Standardisation
kW	Kilowatt
LANUV NRW	State Agency for Nature, Environment and Consumer Protection North Rhine-Westphalia (Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein- Westfalen)
L_{den}	Day-evening-night level
M	Mean value
MANOVA	Multivariate Analysis of Variance
MAXQDA	Software for qualitative data and text analysis
MDiff	Difference between two mean values in group comparison
Min. / Max.	Minimum / Maximum
N / n	Number
NGO	Non-profit organisations
NIMBY	Not in my backyard
p	Significance level
pdf	Portable Document Format
PECO system	Population, Exposure, *Comparator*, *Outcomes*
PEOS system	Population, Exposure, *Outcomes,* Study Design
PSS	Perceived Stress Scale, measures the personal experience of stress
Pubmed	"Public Medicine" medical database
R^2	Coefficient of determination / coefficient of determination
S. / p.	Page

Sc.	Scenario
SD	Standard deviation
SWR	Südwestrundfunk
Tel	Phone
UBA	German Environment Agency
WEAs/WTs	Wind turbine/s
WHO	World Health Organization
WP	Work package

Summary

Infrasound is the term used to describe airborne sound waves that lie in a frequency range of 1 to 16 or 20 Hz (Leventhall 2013). Depending on the individual hearing threshold, which can vary significantly between individuals (Kurakata & Mizunami 2008), infrasound waves can be perceived. Infrasound can be heard if it is only "loud" enough or via senses other than hearing, such as pressure sensation. Increasingly, i.e. when the frequency falls significantly below 20 Hz, "hearing" of the sound is limited to volume perception, and tonal sensations are lost (Koch 2017).

Original studies conducted according to scientific standards, and systematic reviews published in peer-reviewed scientific journals report a lack of consistent evidence of health effects of infrasound beyond noise annoyance and reported sleep disturbances (Freiberg et al. 2019; Van Kamp & Van den Berg 2017, 2020). Most publications consider the effects of infrasound emitted by wind turbines (WTs). With increasing numbers of WTs in Germany, the number of complaints received from concerned residents is increasing, also with regard to the health effects of infrasound emitted by WTs.

The object of this project is to deepen the understanding of people's cognitions and emotions regarding infrasound and its effects, the underlying information processing and the association between these cognitions and emotions and the acceptance of WT. For this, reviews of the state of research (literature analyses) are carried out and qualitative as well as quantitative surveys conducted. In this context, the research is guided by questions about the understanding of infrasound and the emotions associated with it, as well as the mechanisms that lead to such emotions. Based on these findings, the transferability of the understanding of and emotions about infrasound and its effects on the acceptance of WTs is investigated. Furthermore, on the basis of these results a concept is developed, which informs the population appropriately about infrasound and its effects (partly using the example of WT).

The first indications of how infrasound is cognitively conceptualized in the population come from the UBA research project on the effects of infrasound (Krahé et al. 2020). When asked about the spontaneous association with the term "infrasound", the majority of the study participants recognized that it is the low frequency range, which is less audible but instead physically perceptible and that this perception (pressure, vibration) can also be associated with discomfort. In some cases, however, infrasound was also experienced as audible, with further statements also indicating that the understanding of high-frequency (ultra) sound and infrasound (or low-frequency sound) are mixed up. The subjects suspected mainly negative effects. In a laboratory experiment, the participants were exposed to several infrasound emissions, each lasting 30 minutes. Negative physiological effects could not be detected in these situations (Krahé et al. 2020).

The assessment of "subjective risk" (Slovic 2010), i.e. the perception of risk in the general population, takes place in situations that are characterized, among others, by involuntariness, unfamiliarity or controllability by others. That is, risks are not judged by non-experts on the basis of (objective) probabilities ("risk as analysis"), nor solely on the basis of what people think about a risk, but also and especially on the basis of what affects or emotions they associate with it (risk as feelings; Slovic and Peters 2006; Slovic et al. 2004). Higher risks are associated with lower benefits. Associated with this, activities or events that are associated with positive affects are perceived as less risky and vice versa (Slovic and Peters 2006). Applied to infrasound in the context of WT, it can be assumed that the more negative emotions and attitudes towards WT are, the more they are perceived as a health risk, and also the less their benefits are perceived (and vice versa). Furthermore, risk perception may be maintained especially when individuals seek out the information that confirms their own attitudes (selective exposure; Festinger 1957)).

The perception of environmental risks such as "infrasound" and the presumed health risks posed by WT are associated with the acceptance of WT. Acceptance means "a positive evaluation that can go hand in hand with both active actions, such as support or commitment to the turbine, and passive actions, such as endorsement without active action." (Emig & Kastner 2020, p. 212). This includes a negative evaluation of WT, which is equated with low positive evaluation (Emig & Kastner 2020).

In order to explain the non-acceptance of WT by people living in the neighbourhood, the so-called NIMBY effect ("not-in-my-backyard") is often hastily mentioned. NIMBYism, i.e. the rejection of a local, neighbourhood-oriented construction of (sustainable) technologies, does not help to explain the negative attitude towards e.g. WT (Devine-Wright 2009; Rau et al. 2011). This is partly because NIMBYism rarely occurs in this very undifferentiated form (Wunderlich 2012). Instead, the rejection is due to rather specific local reasons. Devine-Wright (2009) understands opposition to the erection of new technologies such as WT in the neighbourhood as a form of "place-protective action" (p. 426), in which an assessment of new turbine projects is made in terms of emotional attachment to the home/neighbourhood/place of residence ("place attachment") and identity processes associated with the place of residence ("place identity").

The presented background regarding "infrasound" shows the complexity of this topic. The empirical research work in this project is divided into two project parts. First, a literature analysis and a qualitative study (telephone interviews) were used to gather the concepts and associations presented here with regard to cognitions and emotions about infrasound and its perceived health effects. Building on this, in a second part a further literature analysis and a quantitative survey were carried out, which aimed at examining the cognition and emotion about infrasound, but in particular the transferability to the acceptance of WT.

The literature reviews conducted in this research project are methodologically 'scoping reviews'. This type of review is conducted to provide an initial orientation on the state of research and to establish preliminary definitions or approaches for further work (Von Elm et al. 2019).

The literature search on cognition and emotion regarding infrasound and its effects revealed that infrasound was often examined in connection with WT. A separate consideration of infrasound without a focus on its emitting sources could not be found in this search. The nine included articles give an insight into the few findings on cognitions and emotions and related perceptions and ideas of the topic of infrasound. Overall, the scientific publications identified mainly fears or concerns with regard to the health effects of infrasound as emotions about infrasound. Concerning the development of these emotions, the role of expectations and media information is emphasized.

The qualitative survey in this research work focused on identifying the emotions and cognitions related to infrasound and the mechanisms underlying these factors. For this purpose, a total of 43 telephone interviews were conducted with people from areas with WT, representatives of citizens' initiatives as well as people from an unexposed area and from an area with a dominant low-frequency sound emitting source. Based on the results of the literature review on cognitions and emotions about infrasound, a guideline for the qualitative survey was developed, which included guiding questions on cognition, emotion and the underlying mechanisms, an impulse discussion on infrasound and a role play to suitably inform about infrasound. As a result, the qualitative survey shows that less than half of the respondents are familiar with the term "infrasound". If the term is known, then mostly in connection with WT and road traffic (vehicles, roadway, etc.).

The associations with the term infrasound expressed in the qualitative survey vary, e.g. it was described as "sound you hear or perceive" or "not heard but perceived" or as dull and

subliminal. Only some of the participants from a study area with WT and from the citizens' initiatives saw health effects on humans, especially sleep disturbances. The respondents' own experiences with infrasound were mainly associated with the construction of (more) WT.

In the second part of this research project, the literature analysis on the scientific state of research on cognition and emotion about infrasound in connection with WT aims to obtain relevant factors for the acceptance of WT. Overall, the literature review shows that there are hardly any studies that explicitly consider the relationship between cognitions and emotions about infrasound and the acceptance of WT. The results of the included articles show that cognitions and emotions or concerns regarding infrasound and low-frequency sound have an influence on the acceptance and the assessment of the construction and operation of WT. Almost without exception, the cognitions and associated emotions relate to adverse health effects of infrasound and low-frequency sound. They are used to justify the rejection of the construction and operation of WT and thus the low acceptance of these installations. Publicly available information and media reports play an important role in this, whereby facts and false reports (fake news) are equally important according to the study by Borch et al. (2020).

Among other factors, the role of cognitions and emotions about infrasound in the acceptance of infrasound-emitting facilities was further investigated in this project with a quantitative survey of 340 people in areas with and without WT located in the residential environment.

Comparing the survey results of the sub-samples of the areas with different infrasound sources in the neighbourhood, it becomes apparent that they do not differ with regard to trust in technology and the degree of concern about climate change. Differences in the sub-samples can be found in the concerns regarding WT, the positive attitude towards WT, the acceptance of WT as well as in the assessment of the authenticity of WT stakeholders. Especially in areas with a higher acceptance of WT, a correspondingly lower level of concern regarding WT, an overall more positive attitude towards WT and a more positive assessment of the authenticity of WT stakeholders can be observed.

Following the approaches of Devine-Wright and Wiersma (2019) and Emig and Kastner (2020), personal, local and project-related variables influencing the acceptance of wind farms were investigated. The results show, that among person-related characteristics above all attitude-related and emotion-based characteristics have an influence on acceptance. On the other hand, socio-demographic characteristics do not contribute significantly to the acceptance of WT.

In terms of location, both the quality of time spent outdoors in the residential environment and the visual impact of WT on the residential environment play a role in the acceptance of WT.

As process-related or project-related factors influencing the acceptance of WT, the results of the group differences confirm that the authenticity of WT stakeholders, the development of positive attitudes, but also concerns regarding WT were identified as important determinants.

With the development of an informational concept on the topic of infrasound, the research project translated the scientific knowledge gained in this study into a communication plan that could be implemented in practice. For this purpose, a detailed communication strategy and a detailed plan for three communication measures was elaborated. The exemplary communication products designed are

- a brochure on infrasound;
- infographics and
- a school teaching trial for secondary level 1.

Zusammenfassung

Als Infraschall werden solche Luftschallwellen bezeichnet, die in einem Frequenzbereich von 1 bis 16 bzw. 20 Hz liegen (Leventhall 2013). Je nach individueller Hörschwelle, die zwischen einzelnen Menschen deutlich variieren kann (Kurakata & Mizunami 2008), können Infraschallwellen wahrgenommen werden. Infraschall kann gehört werden, wenn er nur „laut" genug ist bzw. über andere Sinne als das Hören, z. B. über das Druckempfinden. Zunehmend, das heißt wenn die Frequenz von 20 Hz deutlich unterschritten wird, beschränkt sich das „Hören" des Schalls auf die Lautstärkewahrnehmung, tonale Empfindungen gehen verloren (Koch 2017).

Nach wissenschaftlichen Standards durchgeführte Originalstudien und in wissenschaftlichen Peer-Review-Zeitschriften erschienene systematische Reviews berichten einen Mangel an konsistenter Evidenz von durch Infraschall ausgelösten Gesundheitseffekten, die über die Lärmbelästigung und berichtete Schlafstörungen hinausgehen (Freiberg et al. 2019; Van Kamp & Van den Berg 2017, 2020). In den meisten Veröffentlichungen werden die Wirkungen von Infraschall im Zusammenhang mit Windenergieanlagen (WEA) als emittierende Quelle betrachtet. Mit dem Ausbau der WEA in Deutschland steigt die Zahl der eingehenden Klagen besorgter Anwohnenden, auch hinsichtlich der gesundheitlichen Wirkungen von Infraschall welcher von WEA ausgeht.

Gegenstand dieses Vorhabens ist es, das Verständnis der Kognitionen und Emotionen zum Infraschall und dessen Auswirkungen, die Informationsverarbeitung dazu und den Zusammenhang zwischen diesen Kognitionen und Emotionen und der Akzeptanz von WEA zu vertiefen. Dies erfolgt anhand der Aufarbeitung des Forschungsstandes (Literaturanalysen) sowie anhand von qualitativen und quantitativen Erhebungen. Hierbei sind die Fragen nach dem Verständnis von Infraschall und den damit verbundenen Emotionen sowie die Mechanismen, die solche Emotionen entstehen lassen, forschungsleitend. Ausgehend von diesen Erkenntnissen soll exemplarisch der Übertragbarkeit des Verständnisses und der Emotionen zum Infraschall und dessen Auswirkungen auf die Akzeptanz von WEA nachgegangen werden. Weiterhin wird auf Grundlage dieser Ergebnisse ein Konzept entwickelt, welches die Bevölkerung sachgerecht über Infraschall und dessen Wirkungen (zum Teil exemplarisch am Beispiel von WEA) informiert.

Erste Hinweise zu der Frage, wie Infraschall in der Bevölkerung kognitiv konzeptualisiert ist, ergeben sich aus dem UBA-Forschungsvorhaben zur Wirkung von Infraschallimmissionen (Krahé et al. 2020). Gefragt nach der spontanen Assoziation mit dem Begriff „Infraschall" wurde von den Proband*innen mehrheitlich erkannt, dass es sich um den niedrigen Frequenzbereich handelt, der weniger hör- aber stattdessen körperlich wahrnehmbar ist und diese Wahrnehmung (Druck, Vibration) auch mit Unwohlsein verbunden sein kann. Zum Teil wird Infraschall aber auch als hörbar erlebt, wobei aus weiteren Äußerungen ebenfalls hervorgeht, dass hochfrequenter (Ultra-) Schall und Infraschall (beziehungsweise tieffrequenter Schall) verwechselt werden. Es wurden hauptsächlich negative Wirkungen vermutet. Die Proband*innen wurden in einem Laborversuch mehreren jeweils 30-minütigen Infraschallemissionen ausgesetzt. Dabei konnten in diesen Situationen negative physiologische Wirkungen nicht festgestellt werden (Krahé et al. 2020).

Die Einschätzung des „subjektiven Risikos" (Slovic 2010), also die Risikowahrnehmung in der Allgemeinbevölkerung, erfolgt in Situationen, die unter anderem durch Unfreiwilligkeit, Unbekanntheit oder Kontrollierbarkeit durch Andere gekennzeichnet sind. Das heißt, Risiken werden von Nicht-Fachleuten nicht anhand von (objektiven) Wahrscheinlichkeiten („*risk as analysis*") beurteilt und auch nicht allein danach, was die Menschen über ein Risiko denken, sondern auch und gerade danach welche Emotionen sie damit verbinden (*risk as feelings;* Slovic und Peters 2006; Slovic et al. 2004). Höhere Risiken werden mit niedrigerem Nutzen assoziiert. Verbunden damit werden Aktivitäten oder Ereignisse, die mit positiven Emotionen verbunden

sind als weniger riskant wahrgenommen und umgekehrt (Slovic und Peters 2006). Übertragen auf Infraschall im Kontext von WEA, kann vermutet werden, dass dieser umso mehr als Gesundheitsrisiko wahrgenommen wird, je negativer die Emotionen und Einstellungen zu WEA sind und auch je weniger ihr Nutzen wahrgenommen wird (und umgekehrt). Weiterhin kann eine Risikowahrnehmung insbesondere auch dann aufrechterhalten werden, wenn Personen die Informationen aufsuchen, die die eigene Einstellung bestätigen (selektive Auswahl neuer Informationen (Festinger 1957)).

Mit der Wahrnehmung von Umweltrisiken wie „Infraschall" und oft damit verbunden den von WEA ausgehenden vermuteten Gesundheitsrisiken geht die Akzeptanz von WEA einher. Akzeptanz meint „eine positive Bewertung, die sowohl mit aktiven Handlungen, wie der Unterstützung oder dem Engagement für die Anlage einhergehen kann, als auch mit passiven Handlungen, wie der Befürwortung ohne aktive Handlung." (Emig & Kastner 2020, S. 212). Darin eingeschlossen ist eine negative Bewertung von WEA, die mit geringer positiver Bewertung gleichgesetzt wird (Emig & Kastner 2020).

Zur Erklärung der Nicht-Akzeptanz von WEA bei Anwohnenden dieser Anlagen wird oftmals vorschnell vom sogenannten NIMBY-Effekt („*not-in-my-backyard*") gesprochen. NIMBYism, also die Ablehnung einer lokalen, nachbarschaftsnahen Errichtung (nachhaltiger) Technologien, trägt nicht dazu bei, die ablehnende Haltung z. B. gegenüber von WEA zu erklären (Devine-Wright 2009; Rau et al. 2011). Dies liegt unter anderem auch daran, dass NIMBYism in dieser sehr undifferenzierten Form selten vorkommt (Wunderlich 2012). Vielmehr ist die Ablehnung auf eher spezifische lokale Gründe zurückzuführen. Devine-Wright (2009) versteht die Opposition zu der Errichtung neuer Technologien wie WEA in der Nachbarschaft als Form der „place-protective action" (S. 426), in der eine Einschätzung neuer Anlagenprojekte in Bezug auf die emotionale Bindung an das Zuhause/die Nachbarschaft/den Wohnort („place attachment") und mit dem Wohnort verbundene Identitätsprozesse („place identity") vorgenommen wird.

Die bisherige Darstellung des Hintergrunds zum Thema „Infraschall" weist die Spannweite des Themenkomplexes in diesem Vorhaben auf. Die empirischen Forschungsarbeiten dazu sind in zwei Projektteile gegliedert. Zunächst wurden anhand einer Literaturanalyse und einer qualitativen Untersuchung (Telefoninterviews) die hier dargestellten Konzepte und Zusammenhänge in Bezug auf Kognitionen und Emotionen zum Infraschall und dessen wahrgenommenen Gesundheitswirkungen erfasst. In einem zweiten, darauf aufbauenden Teil, erfolgte eine weitere Literaturanalyse und eine quantitative Befragung, die zum einen die Kognition und Emotion zum Infraschall, insbesondere aber die Übertragbarkeit auf die Akzeptanz von WEA prüfen sollten.

Bei den in diesem Forschungsvorhaben durchgeführten Literaturanalysen handelt es sich methodisch um ‚Scoping Reviews'. Diese Art von Review wird vorgenommen, wenn es um eine erste Orientierung über den Forschungsstand geht und darum, für die weitere Arbeit vorläufige Definitionen oder Vorgehensweisen festzulegen (Von Elm et al. 2019).

Die Literatursuche zu Kognition und Emotion zu Infraschall und dessen Wirkungen ergab, dass Infraschall oftmals im Zusammenhang mit Windenergieanlagen untersucht wurde. Eine gesonderte Betrachtung von Infraschall ohne Vertiefung auf dessen emittierenden Quellen waren in dieser Suche nicht auffindbar. Die neun eingeschlossenen Artikel geben einen Einblick in die wenigen Befunde zu Kognitionen und Emotionen und damit verbundene Wahrnehmungen und Vorstellungen der Thematik Infraschall. Insgesamt ist festzustellen, dass die in der Literaturanalyse identifizierten wissenschaftlichen Publikationen im Wesentlichen Ängste beziehungsweise Befürchtungen im Hinblick auf die Gesundheitswirkung von Infraschall als Emotionen zum Infraschall nennen. Hinsichtlich des Zustandekommens dieser Emotionen wird die Rolle von Erwartungen und medialer Informationen hervorgehoben.

Die qualitative Erhebung in dieser Forschungsarbeit konzentrierte sich auf die Erfassung der Emotionen und Kognitionen im Zusammenhang mit Infraschall sowie den Mechanismen, die diesen Faktoren zugrunde liegen. Hierzu wurden insgesamt 43 telefonische Interviews mit Personen aus Gebieten mit WEA, Vertretern von Bürgerinitiativen sowie Personen aus einem unbelasteten Gebiet und aus einem Gebiet mit einer dominanten tieffrequenten Schall emittierenden Quelle durchgeführt. Anhand der Ergebnisse der Literaturanalyse zu den Kognitionen und Emotionen zum Infraschall wurde ein Leitfaden für die qualitative Erhebung erstellt, welcher Leitfragen zu Kognition, Emotion und den zugrundeliegenden Mechanismen, eine Impulsdiskussion zum Infraschall sowie ein Rollenspiel zur Aufklärung über Infraschall enthielt. Im Ergebnis zeigt die qualitative Befragung auf, dass insgesamt weniger als der Hälfte der befragten Personen der Begriff „Infraschall" bekannt ist. Ist der Begriff bekannt, dann meistens im Zusammenhang mit WEA und dem Straßenverkehr (Fahrzeuge, Fahrbahn, etc.).

Die in der qualitativen Befragung geäußerten Assoziationen zu dem Begriff Infraschall sind unterschiedlich, z. B. wurde er beschrieben als „Schall, den man hört oder wahrnimmt" oder „nicht hört, aber wahrnimmt" oder als dumpf und unterschwellig. Gesundheitliche Auswirkungen auf den Menschen sah nur ein Teil der teilnehmenden Personen aus einem Untersuchungsgebiet mit WEA und von Bürgerinitiativen insbesondere Schlafstörungen. Eigene Erfahrungen mit Infraschall wurden von den Befragungspersonen hauptsächlich mit dem Aufstellen von (mehr) WEAs verbunden.

Die Literaturanalyse zum wissenschaftlichen Stand der Forschung zu Kognition und Emotion zu Infraschall in Verbindung mit WEA hat das Ziel, relevante Faktoren für die Akzeptanz von WEA zu erhalten. Insgesamt zeigt die Literaturanalyse, dass es kaum Untersuchungen gibt, die explizit den Zusammenhang zwischen Kognitionen und Emotionen zu Infraschall und der Akzeptanz von WEA betrachten. Die Ergebnisse der eingeschlossenen Artikel zeigen, dass Kognitionen und Emotionen beziehungsweise Sorgen in Bezug auf Infraschall und tieffrequenten Schall einen Einfluss auf die Akzeptanz und Bewertung des Baus und Betriebs von WEA haben. Die Kognitionen und damit verknüpften Emotionen betreffen fast ausnahmslos gesundheitlich nachteilige Wirkungen von Infra- und tieffrequentem Schall. Mit ihnen wird die Ablehnung von Bau und Betrieb von WEA und damit eine geringe Akzeptanz dieser Anlagen begründet. Eine wesentliche Rolle dabei spielen öffentlich zugängliche Informationen und Medienberichte, wobei Fakten und Falschmeldungen (*Fake News*) nach der Studie von Borch et al. (2020) gleichwertig nebeneinanderstehen.

Welche Rolle Kognitionen und Emotionen zum Infraschall neben anderen Faktoren für die Akzeptanz von Infraschall-emittierenden Anlagen hat, wurde im weiteren Verlauf des Forschungsvorhabens mit einer quantitativen Befragung von 340 Personen in Gebieten mit und ohne WEA in der Wohnumgebung erhoben.

Stellt man die Befragungsergebnisse der Substichproben der Gebiete mit unterschiedlichen Infraschallquellen in der Nachbarschaft einander gegenüber, so zeigt sich, dass diese sich bezüglich des Technologie-Vertrauens und der Ausprägung in der Besorgnis wegen des Klimawandels nicht unterscheiden. Gebietsunterschiede zeigen sich in den Befürchtungen bezüglich WEA, der positiven Einstellung zu WEA, der Akzeptanz von WEA sowie in der Einschätzung der Glaubwürdigkeit von WEA-Akteur*innen. Vor allem in Gebieten mit höherer Akzeptanz der WEA ist eine damit einhergehende geringere Ausprägung der Befürchtungen hinsichtlich WEA, eine insgesamt positivere Einstellung zu WEA und eine positivere Einschätzung der Glaubwürdigkeit von WEA-Akteur*innen feststellbar.

Den Ansätzen von Devine-Wright und Wiersma (2019) sowie Emig und Kastner (2020) folgend wurden personenbezogene, örtliche sowie projektbezogene Einflussvariablen auf die Akzeptanz von WEA untersucht. Betrachtet man den Einfluss personenbezogener Merkmale auf die

Akzeptanz so zeigt sich zum einen, dass vor allem einstellungsbezogene und emotionsgestützte Merkmale einen Einfluss auf die Akzeptanz haben. Zum anderen zeigt sich, dass soziodemografische Merkmale dagegen nicht wesentlich zur Akzeptanz von WEA beitragen.

Ortsbezogen spielen sowohl die Aufenthaltsqualität im Freien der Wohnumgebung als auch die visuelle Beeinträchtigung im Wohnumfeld durch die WEA eine Rolle für die Akzeptanz von WEA.

Als prozess- beziehungsweise projektbezogene Einflussfaktoren auf die Akzeptanz von WEA bestätigen sich die Ergebnisse der Gruppenunterschiede hinsichtlich dessen, dass die Glaubwürdigkeit von WEA-Akteur*innen, die Ausprägung positiver Einstellungen aber auch Befürchtungen hinsichtlich WEA als wichtige Determinanten identifiziert wurden.

Mit der Erarbeitung eines Aufklärungskonzepts zum Thema Infraschall wurde in dem Forschungsvorhaben die der Studie gewonnenen wissenschaftlichen Erkenntnisse in einen praktisch umsetzbaren Kommunikationsplan übersetzt. Dafür wurden eine ausführliche Kommunikationsstrategie und ein detaillierter Plan für drei Kommunikationsmaßnahmen ausgearbeitet. Bei den exemplarisch konzipierten Kommunikationsprodukten handelt es sich um

- eine Broschüre zum Infraschall;
- Infografiken sowie
- einen Schulunterrichtsversuch für die Sekundarstufe 1.

1 Introduction to the research project

In recent decades, the use of wind turbines (WTs) for the production of renewable energy has been steadily expanding. This expansion is accompanied by an increasing number of complaints about infrasound emitted by WTs. Complaints about the noise emitted by other sources of noise, such as air-source heat pumps, are also increasing, as are concerns about the negative effects of low frequency sound, including infrasound, emitted by these installations.

According to the international standard ISO 7196, infrasound refers to airborne sound waves that lie in a frequency range of 1 to 20 Hertz (Hz). By definition, infrasound lies in the frequency range below the hearing frequency range (DIN 1320), which in turn refers to the frequency range of distinct hearing in humans, which according to the DIN standard lies between 16 Hz and 16 kilohertz (kHz). This does not mean, however, that infrasound cannot be perceived. Studies on the health risk of infrasound are sometimes ambiguous. Low audibility, contradictory information and an unclear understanding and concept of infrasound can lead to an increased perception of risk. It is also known from risk perception research that some factors influence risk assessment. For example, the perceived risk is higher with lower familiarity, higher disaster potential, involuntariness, (in)controllability, lower understanding or knowledge, unequal distribution of risks, unclear, questionable benefits, etc. (Davis et al. 2003; Janmaimool & Watanabe 2014). In addition, information processing plays an important role in the conceptualisation of items with uncertain risk, such as heuristics. The perception of environmental risks such as "infrasound" and often associated health risks posed by WTs is accompanied by the acceptance of WTs. This in turn is shaped by factors such as attitudes, trust in those responsible, but also local economic impacts (Hübner et al. 2020).

The object of this project is, on the one hand, to deepen these concepts and connections by reviewing the state of research (literature analysis) and to investigate them based on empirical surveys. The understanding of infrasound and the emotions associated with it, as well as the mechanisms that give rise to such emotions, are the guiding questions of this research. Based on these findings, the transferability of the understanding of and emotions about infrasound and its effects on the acceptance of WTs will be investigated. These literature analyses as well as the implementation of the qualitative and quantitative surveys and their results are presented in the chapters 3 to 5. In a second step, a concept is developed on the basis of these results, which informs the population appropriately about infrasound and its effects, partly exemplified by the topic of WTs (Chapter 6). The implementation of the informational concept is carried out using three communication products: a brochure on infrasound, infographics and a school teaching trial for secondary level 1.

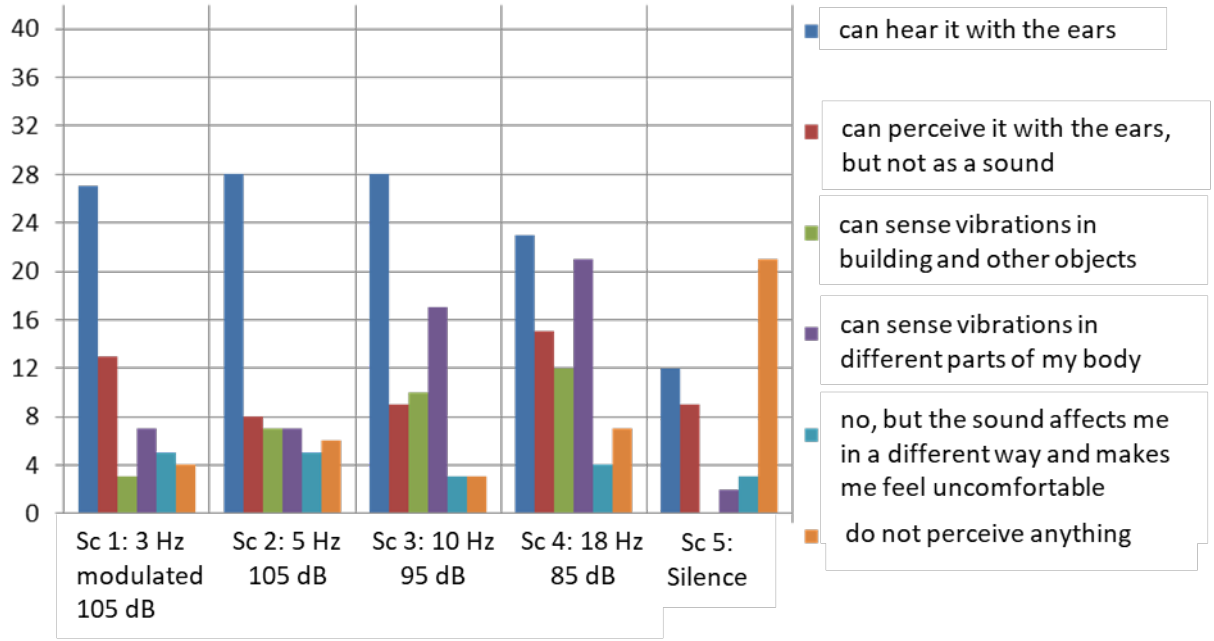
2 Background on infrasound

For some years now, people have been complaining about turbines that emit low-frequency noise or, in particular, infrasound (Eulitz et al. 2020; Krahé et al. 2020).

Low-frequency sound is noise with a frequency of 20 to 100 Hertz (DIN 45680:1997-03; Schmidt 2016) or up to 200 Hz (Leventhall 2004; Robert Koch Institute 2007). According to the international standard ISO 7196 (ISO 7196:1995-03), infrasound refers to airborne sound waves in the frequency range from 1 to 20 Hz. According to DIN 1320 (DIN 1320:2009-12), infrasound lies in the frequency range below the hearing frequency range, which in turn refers to the frequency range of distinct hearing in humans, which according to the DIN standard lies between 16 Hz and 16 kHz.

For both definitions, infrasound is below the human hearing threshold, but this does not mean that infrasound cannot be perceived. On the one hand, the individual hearing threshold varies greatly between people (Kurakata and Mizunami 2008), on the other hand, the hearing threshold depends on the frequency and the sound pressure level, i.e. infrasound can be perceived auditorily if it is only "loud" enough. In addition, perception also takes place via other senses than "hearing", e.g. via the sensation of pressure. This is exemplified by a survey result from another project of the German Environment Agency (UBA) on the noise effects of infrasound immissions (Krahé et al. 2020). In this study, the majority of respondents stated that they had heard recorded infrasound from 3 Hz to 18 Hz, but other forms of perception were also reported (e.g. "via the ear, but not perceptible as a noise" or "perceptible as vibrations on the body", see Figure 1).

Figure 1: Perception of 30-minute infrasound scenarios played in an experimental study



Source: Krahé et al. (2020), p. 99 (Figure 40)

As Koch (2017) puts it, humans can perceive acoustic signals down to at least a frequency of 2.5 Hz. Infrasound is detected by the ear, but the tonal sensation is increasingly lost, i.e. "hearing" is

limited to the perception of loudness (Robert Koch Institute 2007) if the frequency falls significantly below 20 Hz. The sensation becomes more discontinuous in character (Koch 2017; Moeller and Pedersen 2011). There are indications that infrasound near the hearing threshold triggers neuronal activities not only in the brain areas where auditory information is processed (in short: in brain areas responsible for hearing), but also in those areas where emotion control and control of the autonomic nervous system are located (Weichenberger et al. 2017).

2.1 Effects of infrasound

In parts of the population there is concern about the health effects of infrasound emitted by WTs. This concern may be fuelled by publications such as the book "The Wind Turbine Syndrome" (Pierpoint 2009). In this publication, which does not meet the standards of good scientific practice, Pierpont describes an interview study with 38 people from 10 households living in the vicinity of WTs, who reported a number of symptoms that occurred after the erection of the respective WTs: sleep disturbances (insomnia), headaches, tinnitus, dizziness, nausea, panic attacks and palpitations. According to Pierpont (2009), these symptoms are caused by low frequencies, infrasound and vibrations. The work of Salt and Hullar (2010) on the role of neurons involved in auditory perception may also contribute to this concern. The authors conclude that infrasound components in WT noise affect physiological processes in the ear. However, these studies, and thus their conclusions on the effects, are also strongly criticised because both studies have methodological weaknesses and were not conducted according to usual scientific quality standards. In Pierpont's case in particular, the selection of participants who only report on the presence of symptoms, the failure to take into account other households in the vicinity of the WTs and the lack of a survey of acoustic exposure can be classified as non-scientific work. The conclusions reached by Pierpont are thus not evidence-based.

On the other hand, studies carried out according to scientific criteria can also be misinterpreted, even if the subject of the study does not allow for an assessment of the effect of WTs on humans. In a frequently cited study by the Federal Institute for Geosciences and Natural Resources (2004), the disturbance impact of WTs on highly sensitive infrasound stations, which was carried out as part of the monitoring of the International Nuclear Test Ban Treaty (CTBT), was investigated. The results have so far been interpreted by wind energy critics in such a way that harmful effects of infrasound from WTs on humans can be derived from them. However, transferring the findings to people living in the vicinity of WTs is neither sensible nor scientifically permissible. Incorrect calculation of the results and omissions in the correction of that study further contributed to uncertainty about the effects of WTs on humans.

In contrast, findings from other laboratory-based studies show that acute exposure to infrasound from a few seconds (e.g. Maijala et al. 2020) up to half an hour per sound (Krahé et al. 2020) does not result in physiological reactions such as changes in heart rate, heart rate variability, skin conductance, blood pressure, waking EEG (electroencephalogram) and sense of balance. Furthermore, no differences were found between persons who had previously mentioned WT-related symptoms in a survey and those who had not (Maijala et al. 2020) or between persons who were (knowingly) pre-exposed to infrasound and those who were not (Krahé et al. 2020).

Moreover, reviews regularly summarise original work on the effects of infrasound and low frequencies, especially those emitted by WTs, in such a way that, apart from effects on noise annoyance, no other physical health effects could be consistently demonstrated (e.g., van Kamp

and van den Berg, 2020). Therefore, in its Environmental Noise Guidelines for the European Region (World Health Organization (WHO) 2018), the World Health Organization was able to provide a guideline value for the day-evening-night level L_{den} caused by WT noise only in relation to avoiding significant noise annoyance in the affected population. For other health effects, the certainty of evidence was not sufficient to be able to derive corresponding recommendations. The 118th German Medical Association (Deutscher Ärztetag) in turn summarises the findings in the opposite way: "Thus, the harmlessness of these sound immissions [immissions in the low-frequency and infrasound range] to health has not been proven at present." (Bundesärztekammer 2015, p. 353).

Due to these seemingly contradictory views in science on infrasound as a health risk as well as the prevalence of unscientific assumptions, it is reasonable to assume that this ambiguity of available information combined with the partly diffuse perception of this type of sound itself (see Figure 1) and its own unclear cognitive concept of the term "infrasound" can lead to an increased risk perception in the population (Slovic and Peters 2006).

2.2 Cognitive understanding of infrasound and its effects

First indications on the question of how infrasound is cognitively conceptualised in the population result from the UBA research project on the effects of infrasound immissions (Krahé et al. 2020). There, after the completion of a listening test, 42 people were asked, among other things, the following general open questions about infrasound:

1. What do you understand by the term "infrasound", what comes to mind spontaneously?
2. What do you think: what effects does infrasound have on people in your opinion?

The majority of the respondents recognised that it is the low frequency range that is less audible but instead physically perceptible and that this perception (pressure, vibration) can also be associated with discomfort. In some cases, however, infrasound is also experienced as audible, whereby further statements also show that high-frequency (ultra) sound and infrasound (or low-frequency sound) are confused. That infrasound has no effect on humans is assumed by 2 of the 42 persons. The others mention effects, mostly negative, especially psychological, cognitive (nervousness, restlessness, lack of concentration, fear, stress, danger instincts, thoughts of flight) and other complaints such as sleep disturbance and indisposition (dizziness). As many as 6 out of 42 people also mention physical complaints (cardiac arrhythmia, hearing problems, changes in the musculature, tumour formation).

Figure 2: Frequency of response categories to open questions on infrasound and its effects

Question "What do you understand by the term 'infrasound'?"

Characteristic	low frequency	deep-toned	perceptible	physical perception	audible	not audible	pressure and/or vibrations and/or discomfort	(negative) health effects
Number of mentions	10	8	2	8	6	9	8	2

Question "What do you think: what effects does infrasound have on people in your opinion?"

presumed effect	no effects	unspecified negative effect	neutral effect (depending on individual/ length/ intensity)	physical complaints	psychological and cognitive complaints	general disorder	other complaints (sleep disturbance, discomfort)
Number of mentions	2	4	3	6	12	6	10

Source: Krahé et al. (2020), p. 105 (Table 12 there) and p. 107 (Table 14 there).

When asked how they inform themselves about infrasound, the subjects of Krahé et al. (2020) most frequently mention the internet (33 of 79 mentions). The second most frequently mentioned sources of information are television and newspapers (13 mentions) followed by family, friends and acquaintances (12 mentions).

These mentions are significant insofar as the Internet seems to be the most frequently used source of information and it is a source with very different information of heterogeneous quality in terms of content, whose professional or scientific foundations are not always recognisable or verifiable. It can be assumed that the internet will be a central medium for information on infrasound and its effects in the context of WTs.

2.3 Risk perception of infrasound

Among experts or in the natural sciences, "risk" means a quantifiable probability of the occurrence of an event with adverse effects (injury, damage, loss) (Slovic 2010) - what is meant here is "objective risk". Hertel (2005), for example, defines risk as "a function of the probability of an effect affecting health and the severity of this effect as a consequence of the realisation of a hazard" (Hertel 2005, p. 4) [*citation translated by authors*]. In contrast, "subjective risk" (Slovic 2010) or "perceived risk" (Bundesinstitut für Risikobewertung 2008) is used to refer to the perception of risks by the population or laypersons.

The perception of a higher subjective risk occurs in situations that are characterised by the following aspects, among others:

- involuntariness,
- controllability by others,
- less familiarity,

- unequal distribution of risks,
- unclear, questionable benefits,
- low understanding/knowledge,
- uncertainty,
- horribleness/gruesomeness,
- irreversibility of negative effects,
- need for a credible, institutional response (trust required),
- personal involvement,
- ethically questionable or morally wrong conditions,
- anthropogenic causation (not of natural origin),
- identifiability with the victim (including the aspect of affecting family members, especially children (Janmaimool and Watanabe 2014)).
- and high disaster potential (Davies et al. 2003).

According to the psychometric approach to risk perception, it is the dimensions of dread and unfamiliarity on which risks are subjectively mapped in their extent (Slovic 1987).

This means that lay people do not judge risks on the basis of (objective) probabilities ("*risk as analysis*") and also not solely on the basis of what people think about a risk, but also and especially what emotions they associate with it and what affects it triggers (*risk as feelings;* Slovic and Peters 2006; Slovic et al. 2004). "Affect" here means the specific quality of "good" and "bad", which (1) is experienced consciously or unconsciously as an emotional state and (2) according to which the positive and negative quality of an external stimulus is delimited (Slovic et al. 2004). In this context, an affective reaction can be defined as an initial (violent), rapid, autonomous, associative reaction (Zajonc 1980). Affects help to decide quickly - without lengthy weighing of advantages and disadvantages - whether something is dangerous, risky or harmless. Used for decision-making, this is called "affect heuristics" (Slovic et al. 2004). From an evolutionary perspective, affects are essential for human survival. If the ability to form affect is lost, e.g. due to brain damage, this impairs the ability to make rational decisions (Damasio 1994).

Risk perception research shows that while high risks are often objectively associated with high benefits (e.g. riskier securities are associated with higher returns; safe investments, on the other hand, have lower returns), the subjective perception of risk is the opposite: higher risks are associated with lower benefits. Linked to this, activities/events associated with positive emotions are perceived as less risky and vice versa (Slovic and Peters 2006).

Applied to infrasound in the context of WTs, it can be assumed that the more negative the emotions and attitudes - in the sense of affectively evaluated opinions (Fishbein and Ajzen 1975) - towards WTs are, the more they are perceived as a health risk and the less recognized are their benefits (and vice versa).

Risk perception can also be maintained in particular when people seek out information that confirms their own attitude (selective choice of new information (Festinger 1957), or

confirmation bias (Nickerson 1998)). According to Osnabrügge et al. (1985), this corresponds to the basic motivation of humans to gain or retain control over events and conditions in the environment. This is accompanied by the phenomenon of evaluation bias, which states that preference-consistent statements, attitudes or behaviours are systematically evaluated better (Edwards and Smith 1996) than those that deviate from one's own preferences.

2.4 Importance of heuristics in information processing for the cognitive conceptualisation of infrasound

A number of cognitive-affective processes in human information processing can influence the risk perception of infrasound. These are characteristic "*biases*" in perception or cognitive processing or heuristics, i.e., conclusions, decision-making based on "rules of thumb" (Kahneman et al. 1982). These "biases" and heuristics occur primarily in situations of uncertainty, when information is missing, interactions are unknown or the linking of relevant information is not successful due to the complexity of a situation. The term "bias" is somewhat misleading here, as it connotes "inadequacy" or "error-prone information processing". Even if such distortions and rules of thumb can lead to incorrect problem solutions or distorted conclusions, heuristics can indeed be indispensable for quick decision-making or quick action (under time pressure or in dangerous situations) (Gigerenzer et al. 2011). The same applies to "perceptual distortions", which turn out to be ecologically/evolutionarily sensible perceptions when taking into account that perception serves the ability to act (Gibson 1982).

In addition to the above-mentioned *confirmation* and *evaluation* biases and the affect heuristic, further examples of such heuristics and biases are listed below, which may be relevant for the development of cognitive understanding and emotions about infrasound and, by extension, also for the acceptance of WTs:

- The *availability heuristic* (Kahneman et al. 1982), according to which information that is easier to recall from memory will have a stronger influence on judgement behaviour. The media presence of nuclear disasters (e.g. Fukushima, Chernobyl), for example, leads to a correspondingly high availability and thus to an increased risk perception (Shen et al. 2013). If infrasound is frequently reported in the media in connection with possible health effects and behavioural changes in humans and animals, and this is associated with WTs, then increased risk perception can also be expected here.
- The *severity effect* or disaster potential, according to which the probability of an event or its (negative) consequences is systematically overestimated due to the objectively given or subjectively perceived severity of the event or its consequences (Harris and Corner 2011). For example, the risk of an aeroplane crash is considered higher than the risk of a road traffic accident, whereas the statistical probability is exactly the opposite. Applied to infrasound, the health risk of infrasound would be estimated to be higher, the higher the severity of the (presumed) consequences of illness.
- *Status quo bias*: People are aversive to change (Kahneman et al. 1991) out of fear that the situation will get worse or things will no longer work ("*never change a running system*"). This is associated with loss aversion, according to which people strive more to avoid losses than to generate gains (Kahneman et al. 1991). The erection of a WT means a change in the familiar landscape and the acoustic noise situation, which - due to a lack of available information - is perceived as a loss or threat or - in the case of imminent erection and

commissioning - is feared. Media information on infrasound and its (presumed) health effects can reinforce this effect.

- *Conformity bias*: Behaviour that other present or relevant persons show or that one assumes they would show is also shown with increased probability, i.e. it forms a social norm for one's own behaviour (Asch 1956; Van der Linden 2015). If neighbours, family members, friends or acquaintances oppose WTs or understand infrasound as a health risk, then this understanding creates pressure to subscribe to these attitudes. This pressure is all the greater the more relevant the respective group in a situation (neighbourhood, family, circle of friends) is for a person and the more important the group in the situation is for one's own social identity (membership in groups and emotional evaluation of this membership) (Tajfel and Turner 1986).

2.5 Acceptance of WTs

The perception of environmental risks such as "infrasound" and often related to the presumed health risks posed by WTs goes hand in hand with the acceptance of WTs. Acceptance means "a positive evaluation, which can be accompanied both by active actions, such as support or commitment to the turbine, and by passive actions, such as endorsement without active action." (Emig & Kastner 2020, p. 212) [*citation translated by authors]*. This includes a negative evaluation of WT, which is equated with low positive evaluation (Emig & Kastner 2020).

Emig and Kastner (2020) see the WT as the acceptance object (what is accepted) and consider in their review the people who live permanently near a WT (the residents) as the acceptance subjects (who accepts). Based on Wüstenhagen et al. (2007), the authors distinguish between project-related acceptance (approval of a specific WT project), socio-political acceptance (general acceptance of the technology of WTs or the use of wind energy) and market acceptance (decision to purchase an energy generation system or green electricity) (Emig & Kastner 2020). The acceptance definition by Emig and Kastner (2020) is also used as a guiding framework in this project, as is their definition of the acceptance object. For the purposes of this project, acceptance subjects can be residents of (planned) WTs as well as the general population.

According to Hübner et al. (2020), the five essential factors of acceptance of WTs include:

1. *Economic effects on site*: Property value, energy costs, opportunity to participate in energy production, in leasing, if applicable, concession on energy purchase;
2. *Attitude to the* energy transition, to wind energy in general, to WT operation in the residential environment;
3. *Trust in those responsible* (operators, politics/administration at different levels);
4. *Perceived fairness* (distributive justice of burdens/benefits, procedural fairness of the decision-making processes for erecting and operating WTs);
5. *Impacts on people and nature*:
    - Adverse effects of wind energy noise (disturbance, annoyance, other health complaints),
    - Visual and other non-acoustic impacts of WTs (e.g. shadows cast, landscape appearance, obstacle marking, rotational movements, ice shedding).

In another way of categorising factors of project-related acceptance, the authors in Emig and Kastner (2020), following Devine-Wright (2005), distinguish between *contextual, local factors* (e.g. impairment of the landscape, distance to the WT); *physical factors* (e.g. noise, shadow

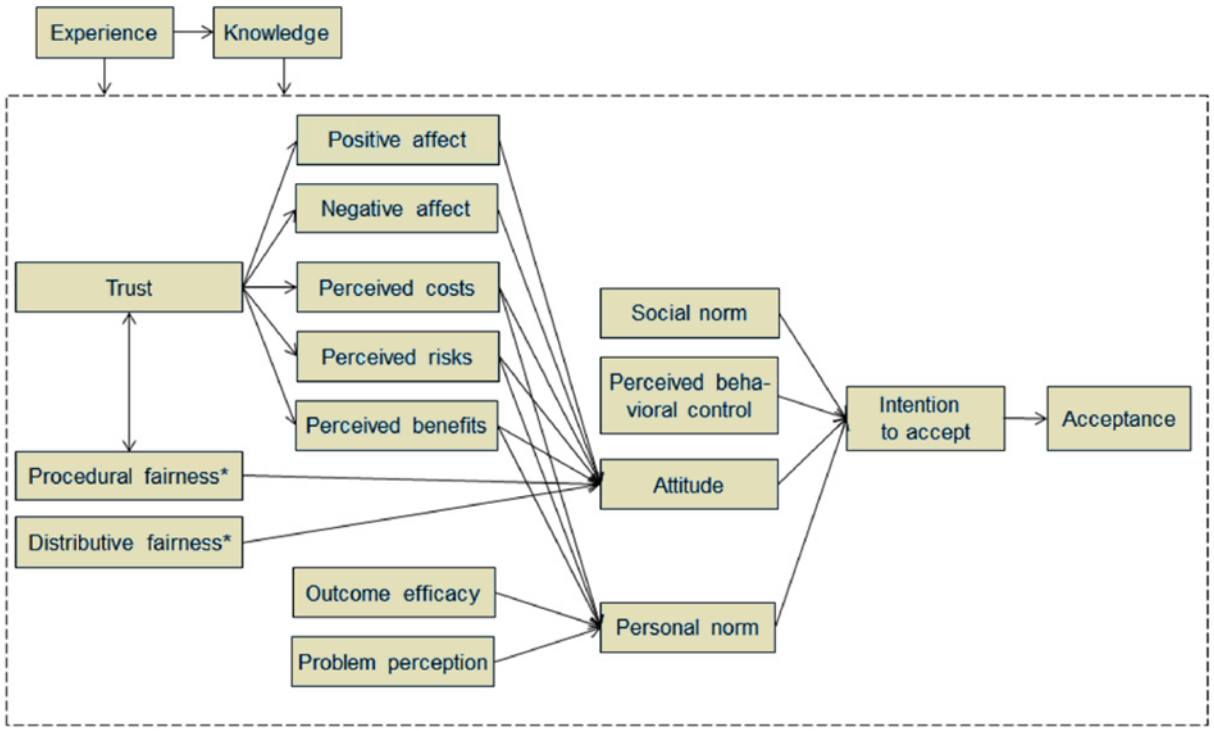
flicker), *personal attitudes* (to WT in general, risk assessment, level of information, environmental awareness, etc.), *socio-economic factors (*e.g. financial participation, length of residence), *political-institutional factors* (e.g. planning process, opportunities for participation, interest), *social-communicative factors* (including media reports, actions by citizens' initiatives) and *demographic factors* such as age, gender, education, income. These largely empirically determined acceptance factors can also be classified in a theory-based manner. Huijts et al. (2012) linked the theory of planned behaviour (Crichton and Petrie 2015a) with the norm-activity model (Schwartz and Howard 1981) for acceptance of sustainable energy technologies and included social context factors such as trust, perceived fairness, experience and knowledge (see Figure 3). Figure 3

Acceptance of WT, which is preceded by the intention to accept, would thus be a result of

- the own attitude, which is fed by the perceived costs, benefits and risks of operating WTs and the related negative and positive emotions, as well as the perceived procedural fairness of the turbine project and the distributive justice of costs and benefits,
- as well as the social and personal norm and perceived control.

According to the model, trust in those responsible influences affects and cognitions about costs, benefits and risks and is interrelated to the perceived fairness of the turbine planning process and the distribution of costs and benefits. One's own experiences and knowledge of specific turbine projects as well as of wind energy use in general and associated factors such as infrasound influence the acceptance process as a whole. For example, the less information is available about the operation of WTs and the (supposedly) associated risks (including infrasound), the more important is trust in those responsible and their authenticity (Huijts et al. 2012). Wüstenhagen et al. (2007) state, "Trust is a key issue in all facility siting issues" (p. 2687).

Figure 3: Framework model for the acceptance of renewable energy technologies



Source: Huijts et al. (2012), p. 530 (Figure 6 there).

The so-called NIMBY effect ("*not-in-my-backyard*") is often hastily used to explain the non-acceptance of WTs by local residents. NIMBYism, i.e. the rejection of local, neighbourhood-oriented construction of (sustainable) technologies, does not help to explain the negative attitude towards WTs, for example (Devine-Wright 2009; Rau et al. 2011). This is partly due to the fact that NIMBYism rarely occurs in this very undifferentiated form (Wunderlich 2012). In general, this effect falls short of the complex interplay of various factors, obscures any actual reasons of residents and, in its simplicity, prevents the discovery of other more promising solutions (Rau et al. 2011). Rather, rejection is due to more specific local reasons. Devine-Wright (2009) understands opposition to the installation of new technologies such as WTs in the neighbourhood as a form of "place-protective action" (p. 426), in which an assessment of new turbine projects is made in terms of emotional attachment to the home/neighbourhood/place of residence ("place attachment") and identity processes associated with the place of residence ("place identity"). Using group discussions and a quantitative survey on the construction of an offshore wind farm off the Welsh coast in two locations, Devine-Wright (2009) showed that a negative attitude emerged among respondents who perceived the contradiction between (restorative) nature and "enclosing" technology as a threat to place identity and attachment.

Rau et al. (2011) also see it as the duty of municipalities to involve their citizens in the planning and decision-making process at an early stage and to make it fair, transparent and sustainable. In this way, the justice aspect, especially distributive and procedural justice, is taken into account and the citizens' demand for more say and citizen participation is met.

Crichton and Petrie (2015a) state that expectations of the effects of WTs are created through media of all kinds and/or exchanges with close people. In a laboratory experiment, subjects were presented with both negative and positive audio-visual reports of infrasound gathered from the internet and then exposed to audible sounds as well as infrasound from WTs during each session. The results show that positive reporting of the health effects of noise from WTs can soften or even reverse negative expectations.

The previous presentation of the background to the topic of "infrasound" shows the complexity in this project. Therefore, the empirical research work was divided into two project parts. First, a literature analysis and a qualitative study (telephone interviews) were used to record the concepts and correlations presented here with regard to cognitions and emotions about infrasound and its perceived health effects. In a second part, building on this, a literature analysis and quantitative survey (questionnaire; *quantitative interview*) were carried out, which on the one hand was intended to examine the cognition and emotion about infrasound, but in particular the transferability to the acceptance of WTs.

3 Cognitions and emotions about infrasound and its effects

3.1 Literature analysis on the state of research

The literature reviews conducted in this research project are methodologically 'scoping reviews'. This type of review is conducted to provide an initial orientation on the state of research and to establish preliminary definitions or approaches for further work (Von Elm et al. 2019).

Another common type of literature review is the systematic review. It serves to answer clearly defined questions, e.g. "Does infrasound of a certain frequency and intensity lead to a statistically significant increase in physiological activities of the cardiovascular system, such as an increase in blood pressure or heart rate compared to a resting condition?" In addition to a review and interpretive evaluation of the literature, a systematic review can also quantify the evidence of an issue (e.g. the extent of a health risk or the effect of an intervention). In comparison, a scoping review deals with a broader question, such as the one envisaged in this research project (e.g. "What cognitions and emotions do people have about infrasound?") (see also Tricco et al. 2018).

A scoping review is carried out step by step and, if necessary, in several loops. The steps of a scoping review are (Von Elm et al. 2019):

- Objective, question(s) of the review;
- Inclusion and exclusion criteria of the literature selection;
- Procedure for literature search (subject databases, search strings);
- Presentation of the results:
  - Literature selection: Number/type of literature included, number of literatures excluded and reasons for exclusion,
  - extracted information from the included literature;
- Summary of and conclusion from the results.

The scoping review conducted here on cognitions and emotions about infrasound was also guided by these five steps, which are now described in more detail.

In *setting the objectives* of this scoping review, three questions guide the research:

1. *Cognition*: What ideas do people have about "infrasound", what do they understand by it?
2. *Emotion*: What emotions do people have about infrasound and its possible health effects?
3. *Mechanism*: What is the origin of these emotions, what mechanisms of emotion development towards infrasound can be identified?

The questions guiding the literature review were addressed using the PEOS system (Population, Exposure, *Outcomes*, Study Design) which itself is based on the PECO system (Population, Exposure, *Comparator, Outcomes*) (Freiberg et al. 2019; Morgan et al. 2018) (Table 1).

Table 1: Questions broken down according to the PEOS system

Topic	PEOS	Question
Cognitions, emotions (affects)	Population	In the general population, what effect does...
	Exposure	infrasound have as a physical exposure but also as a concept or as available information and its effects...
	Outcomes	on cognitions (subjective theories, mental models, beliefs) and emotions or affects (e.g. fear or concerns)?
	Study design	What study design was used to investigate this?
Mechanisms	Population	In the general population, ...
	Exposure	what mechanisms...
	Outcomes	of the origin of emotions about infrasound and its effects...
	Study design	were investigated with which study design?

For the selection of the literature, the criteria listed in Table 2 were defined and applied for the selection of the literature.

Table 2: Inclusion and exclusion criteria for the literature selection

	Inclusion criteria	Exclusion criteria
Population	General population, stakeholder groups (e.g. operators of WTs, members of citizens' initiatives, environmental/ supervisory authorities)	Animals
Exposure	Infrasound, information on infrasound (media, internet contributions/social media)	WTs (if infrasound is not addressed), other environmental pollution, sound of higher frequencies ("audible sound")
Outcomes	Cognitions (subjective theories, mental models, conceptions) and emotions (affects, affective reactions) about infrasound and its effects	Biopsychosocial infrasound effects on health, symptoms, effects on cognitions, brain activities, technical/acoustic measurement, calculation results
Study design	Longitudinal study, cross-sectional study, theoretical article, discussion paper	Comment responses to published articles, introduction to a journal

For the literature search, the following relevant *specialised databases* were used:

- EBSCO with the integrated subject databases APA PsycInfo (Abstracts), APA PsycArticles and PSYNDEX Literature with Psyndex Tests;
- Pubmed;

- BASE (Bielefeld Academic Search Engine).

Based on the questions about cognitions and emotions on the topic of infrasound and its possible health effects, the following search terms and their links were defined. English terms were chosen in order to be able to collect international literature.

> *(infrasound AND (cognition OR emotion OR affect OR subjective definition OR mental model OR mental concept OR cognitive concept OR comprehension OR framing OR (risk perception) OR (risk communication) OR acceptance OR understanding OR (acceptance of technology)).*

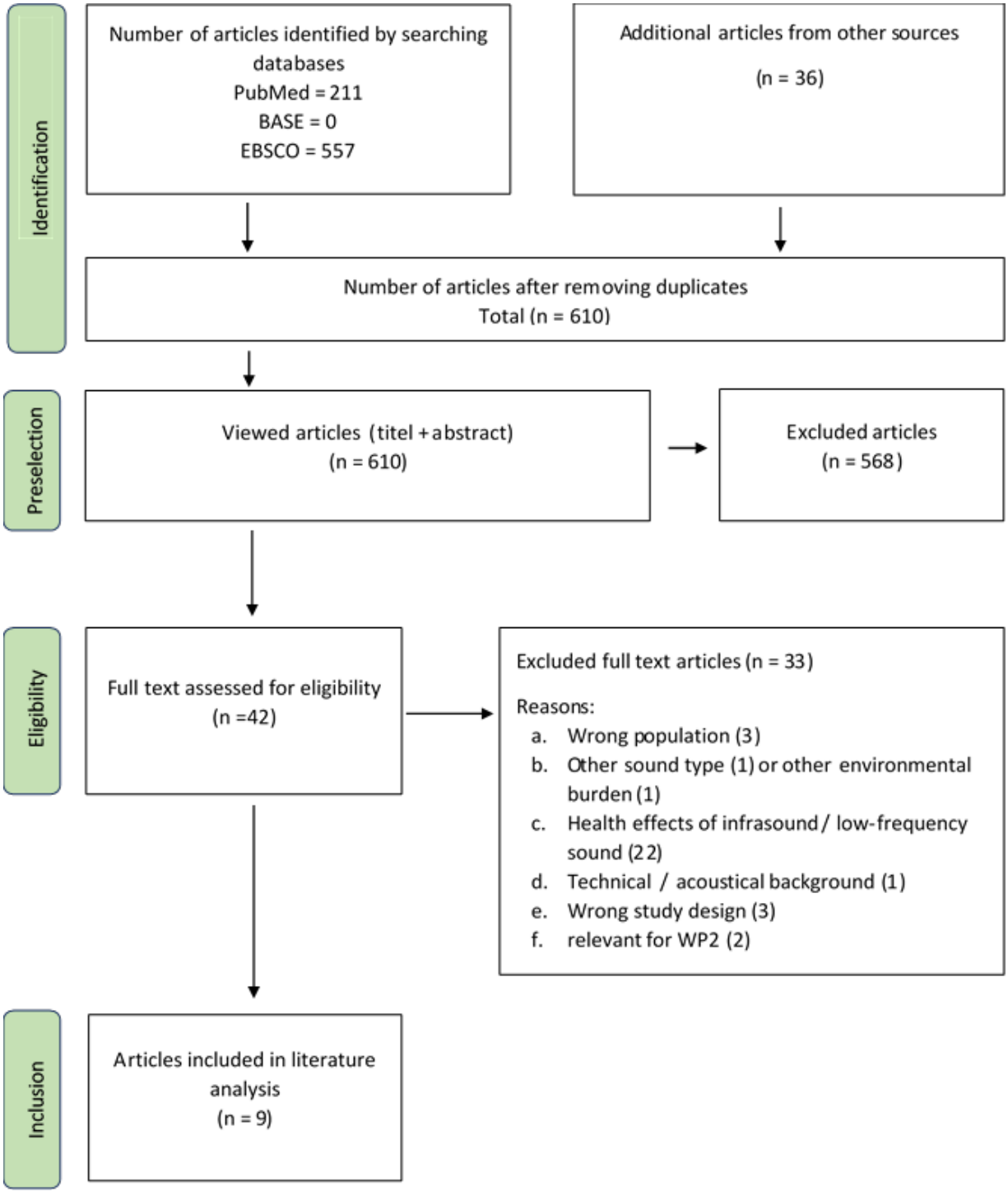
In the course of the first review of the found results, further term links were searched for:

> (*infrasound AND belief**),
> (*infrasound AND content analysis*),
> (*infrasound AND complaints*).

3.1.1 Results of the literature review

The selection of literature is described in the flowchart oriented on the PRISMA Statement (Moher et al. 2009; Tricco et al. 2018) (Figure 4). The BASE database did not yield any results with the above search string. The biomedical database PubMed returned 211 references, EBSCO 557 references. By checking references in the full texts, the feedback from colleagues and searching for further links in the course of the literature analysis, 36 additional references or articles were found.

Figure 4: PRISMA flowchart showing the process and results of the literature search WP1



Source: own representation, ZEUS GmbH

After merging all found articles into the Citavi literature management programme, duplicates were removed and 610 articles remained, which were subjected to a pre-selection based on their title and abstract. Subsequently, 42 articles could be checked for their suitability on the basis of their full text. This examination was carried out with the help of the previously defined inclusion and exclusion criteria (see Table 2). The literature search on cognition and emotion regarding infrasound and its effects revealed that infrasound was often studied in connection with WTs. A separate consideration of infrasound without a focus on its emitting sources could

not be found in this search. The included articles provide an insight into the few findings on cognitions and emotions and related perceptions and ideas of the topic of infrasound.

3.1.2 Extracted insights and findings

Bilski (2012) describes a literature review of factors influencing social perceptions of wind energy industry investments and presents results of measurements of WT noise (with A, C and G weighting), including infrasound, in the author's living environment in Poland. The measurements are intended to illustrate the importance of carefully recording infrasound. The author lists a number of factors that influence the perception of those affected by future WTs with regard to noise. Among other things, he mentions the lack of analyses/appraisals by independent institutions prior to WT investment as well as the lack of quality requirements for offices commissioned with noise measurements, especially with regard to the measurement of infrasound. The list of influencing factors itself, however, is made by the author without references, so that the list is to be understood less as an evidence-based result than as the author's conclusion from his literature analysis. Whether, for example, the lack of qualification for measuring infrasound is also perceived by the affected population itself and contributes to their formation of cognitions and emotions about infrasound remains unclear.

Chapman et al. (2014) conducted content analyses of submissions or complaints against the construction of a WT in Victoria, Australia, which were submitted to the responsible authority. They compared the collected data with information that was available in advance in local media and correspondence and at an event organised by a citizens' initiative against WTs, at which, among other things, a documentary video on the health effects of infrasound was shown. Furthermore, a Google search was carried out to find negative information on infrasound effects on the internet and their dissemination via social media in the region. In addition to the content, the rate of the respective website access was also collected during the internet search. The information provided in the complaints was categorised according to the extent to which it addressed direct health effects of WTs, annoyance and quality-of-life effects of audible WT noise, or health effects of infrasound. Chapman et al. report a significant increase in fears about negative health effects and other consequences of the planned WTs in the local media immediately after the citizens' initiative event date. They show that about one third of the media and event information on the local proposed new WTs, and furthermore just under one third of the WT-related websites identified referred to negative health effects of WTs. One fifth of the web pages name the *Wind Turbine Syndrome*, which according to Pierpoint (2009; see also Sect. 2.1), which includes symptoms attributed to low frequencies, infrasound and vibrations as causes. The proportion of local information related solely to infrasound could not be taken from the publication by Chapman et al. (2014). Almost all submissions (99% of 75 submissions from 53 households) identified general concerns about negative health effects of WTs, 77% health effects of WT noise. The publication by Chapman et al. (2014) does not indicate how many of the submissions referred to infrasound or low frequencies. The authors state that many of the submissions took up the media information on the health impacts of WTs in their arguments, in particular the information from the citizens' initiative event and from the documentary video. The information presented in the video was referred to in “many submissions” (Chapman et al. 2014, p. 3) as a study and the presented cases of effects attributed to WTs were understood as evidence of the negative health effects of WTs. These were considered serious, particularly with reference to the fact that residents featured in the video decided to move away. Chapman et al. (2014) fear a conformity bias in the sense that the citizens' initiative event triggers a targeted search for information on negative health effects of WTs, which then finds its way into objections to WT construction. Overall, they consider their findings to be a "*real world*" test of a nocebo effect, according to which negative information (here: on health effects of WTs) prepares

or fosters health complaints and concerns about them. The study makes clear that part of the information and corresponding concerns in the submissions refer to negative health effects specifically of infrasound, but without quantifying the infrasound-related effects. The inference to an effect of the local information on the submissions is made in the study via temporal and content-related correspondence of information and submissions and via the fact that explicit reference was made in submissions to the respective source of information of the argumentation. However, a causality in the strict, statistical sense is not proven.

Eltiti et al. (2018) re-analysed the data from two double-blind provocation studies to address the question of whether a nocebo effect can explain why people with environmental intolerances to electromagnetic fields (EMF) report symptoms despite the lack of scientific evidence linking these symptoms to actual exposure to electromagnetic fields. In the original study, subjects with and without environmental intolerances (related to EMF) were asked in two experiments to rate whether they believed a telecommunications station was ‘on’ or ‘off’. The two experiments included a sham exposure and other different EMFs (different telecommunication sources). These sources were combined with the sham exposure and the pairs were presented in different order. The participants indicated whether they considered the source to be 'on' or 'off' and at the same time gave an assessment of their subjective well-being. As expected by the authors, subjects with environmental intolerances (related to EMF) consistently reported significantly lower well-being when they believed the source was 'on'. However, the control subjects also reported more and more pronounced symptoms when they thought the EMF source was 'on' compared to 'off'. The authors attribute this to the fact that at the time of the study, there was a lot of media coverage on the topic and the studies. On the other hand, the participants were informed at the beginning of the experiments that potential negative health effects of EMFs were being investigated. The results of the re-analysis show that the symptoms listed by the participants cannot be attributed to the EMF exposures. Rather, the nocebo effect provides a plausible explanation for the fact that the symptoms are reported both in persons identified as EMF-sensitive and in the control subjects.

On the importance of expectations in the link between infrasound and health complaints, **Crichton et al. (2014a)** summarise evidence from the literature and their own findings in a review paper and argue for the nocebo expectancy theory, which states that health complaints can be triggered by the influence of negative expectations of harmful health effects themselves (Benedetti et al. 2007). For example, they argue that existing knowledge naturally influences how we describe experience, including symptoms attributed to exposure from WT noise. They further argue that environmental and health-related concerns about environmental risks can create negative expectations, causing people to focus more on bodily processes and symptoms to be attributed to sources of discomfort associated with the expectations. It is also argued that the presence of information about apparently harmful effects may be accompanied by a "scanning" of symptoms for those that are supposed to be related to expectations. The authors see the tenor of media reporting as a driver, among other things; according to the results of laboratory studies, expectations can positively or negatively influence symptoms and mood during exposure to WT noise, depending on whether positive or negative expectations are generated by consuming a report about infrasound. Visibility and audibility of the noise sources can also influence the magnitude of the annoyance response, as the stimuli are "in front of the eyes", i.e. permanently present, salient and processed. The article is characterised by the fact that evidence-based assumptions are formulated; there is no systematic review of the evidence.

Crichton et al. (2014b, 2015) looked at the role of expectations on the effect of infrasound on humans. In a laboratory study, they investigated the influence of positive and negative expectations about WT noise on annoyance response, mood (Crichton et al. 2014b) and reported symptoms (Crichton et al. 2015) from exposure to WT noise, also taking into account noise sensitivity. For this purpose, 60 healthy students were randomly assigned to one of two experimental conditions: the first group was shown a DVD about wind power with negative framing mentioning potential negative health effects, the second group was shown a DVD about wind power with positive framing mentioning any positive effects of infrasound. Afterwards, the test subjects were exposed to wind power sounds that realistically contained audible and non-audible infrasound components. For auditory and infrasound recordings in the listening test, frequency ranges and sound pressures were chosen that correspond to significantly exposed buildings in field studies (auditory sound 43 dB, infrasound 50.4 dB/9 Hz). During the listening tests, annoyance by the WT noise, mood (12 positive mood items such as relaxed, peaceful, happy; 12 items with negative mood attributes such as anxious, nervous, sad) and reported symptoms (e.g. headache, ear pressure, fatigue) were queried.

As a result, the noise annoyance judgements differed significantly between the groups specifically that subjects in the negative expectations group were significantly more annoyed by the noise than subjects in the positive expectations group (Crichton et al. 2015). In addition, noise sensitivity was found to influence annoyance in the negative expectancy group, but not in the positive expectancy group. For positive sentiment, there was no effect of noise sensitivity. However, there was a moderation effect of noise sensitivity from negative and positive expectation on negative mood. If subjects in the negative expectation group described themselves as more sensitive to noise, their mood during noise exposure was more negative than in subjects who were less sensitive to noise. Conversely, in the positive expectancy groups, more noise-sensitive subjects reported experiencing less low mood during noise exposure than subjects who rated themselves as less noise-sensitive. The results indicate that more noise-sensitive individuals appear to be more influenced in their mood by the direction of externally generated expectations than less noise-sensitive individuals. This finding is in line with the result of a laboratory-experimental investigation of cognitive aspects of noise sensitivity, according to which more noise-sensitive people generally pay more attention to their environment, thus noise sensitivity is based on a more general environment- and situation-related monitoring, which possibly also includes environmental information mediated by the media (Höger 2000).

Reported symptoms were asked before the beginning and during the exposure (Crichton et al. 2014b). Depending on the group membership, differences in the number and intensity of reported symptoms were found. In the negative expectation group, there was a significant increase in the number and intensity of symptoms compared to the positive expectation group, where a significant decrease was recorded.

The authors argue that the consumption of information about health effects can create symptom expectations that are reflected in reports of symptoms (Crichton et al. 2014b) and see a connection here with media reports, which, depending on the type of reporting, can create certain expectations about the effects.

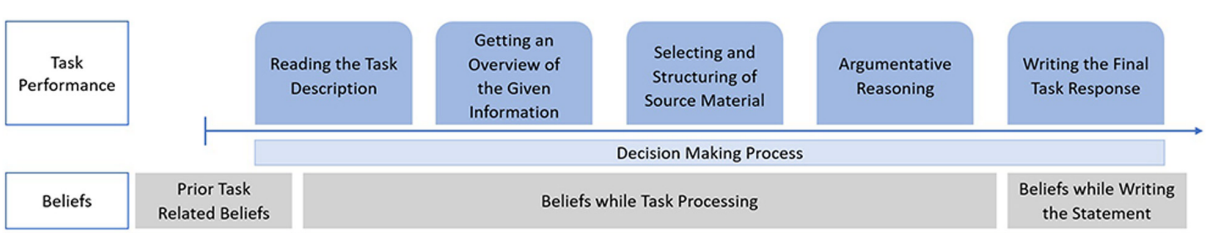
However, it should not be neglected here that the experience of infrasound in the laboratory is different from the experience of noise from WT in the immediate residential environment

meaning that further contextual factors relevant to the potential for disturbance play a role which, unlike in field studies, cannot be taken into account here.

In their review, **Knopper and Ollson (2011)** were not primarily interested in the health impacts of WTs. Rather, they wanted to highlight that people interested in the discussion about the health effects of WT use two types of sources to make informed decisions. One are scientific studies published in peer-reviewed journals. Secondly, popular literature and the internet are used as sources of information. Knopper and Ollson (2011) compared the found scientific literature, reports from public authorities and the most significant popular literature and analysed them with regard to (content-related) differences and, where applicable, similarities. They came to the conclusion that both types of information agree that WTs cause a sense of annoyance in certain people. However, the differences are clearly to be found in the reasons for the annoyance, i.e. that although scientific studies show a statistical correlation between annoyance and noise from WTs, the correlation between annoyance and other factors (attitude towards WTs, noise sensitivity and visuality) is stronger. Furthermore, the reported negative health effects in the scientific literature tend to be attributed to environmental stressors "that result in an annoyed/stressed state in a segment of the population" (Knopper and Ollson 2011, p. 1). In contrast, in the popular literature and on the internet, the self-reported effects of WTs are mainly related to the distance to the turbines. Furthermore, the underlying data of the popular literature are in most cases case descriptions of specific symptoms of affected persons, without control subjects, and the reported symptoms are attributed to infrasound without acoustic measurements being available.

Zlatkin-Troitschanskaia et al. (2020) build to some extent on the findings of Knopper and Ollson (2011) with their study. They investigated the role of opinion/conviction in a student sample when they were asked to draw critical conclusions between multiple and substantively conflicting sources of information on a particular topic. For this purpose, 30 students in the role of a member of the administration of a small town were asked to decide whether a WT should be erected or not. In order to be able to make this decision, each participant had the same 22 types of information at their disposal, on the basis of which the recommendation for or against the WT was to be justified in writing. Directly after this task, a subsample was asked about their decision and the decision-making process using a semi-structured cognitive interview. Since pre-existing opinions or beliefs on a topic play an essential role in critically distinguishing between claims and evidence-based facts, beliefs were elicited at three points in time (before, during the task, and the written recommendation) (see following Figure 5).

Figure 5: Framework concept on the role of critical reasoning in multiple and conflicting information sources



Source: Zlatkin-Troitschanskaia et al. 2020, p. 7

Zlatkin-Troitschanskaia et al. (2020) conclude that "the students' beliefs had an influence on their selection, critical evaluation and use of information as well as on their reasoning processes

and final decisions" (p. 1). For example, it was found that students who already made a decision at the beginning of the task based on their existing beliefs included significantly fewer sources in their written recommendation. Interestingly, students who already had their own beliefs at the beginning came to a completely opposite conclusion in their recommendation. In contrast to participants who did not yet have any preconceived opinions, information on the health impacts on people and animals living near WTs had a relevant influence on decision-making in the group of people who were already informed. In general, it was found that participants selected and analysed information based on the types of media and information, i.e. whether they considered the source or type to be reputable and relevant, rather than on the content or evidence described there. Most participants based their decision on the information that corresponded to their own beliefs, i.e. a rather biased selection and evaluation of the information provided. A critical examination of all information and evidence did not take place.

Langer et al. (2016) investigated the acceptance of wind energy in Bavaria, Germany, on the basis of a literature analysis and a total of nine qualitative expert interviews with representatives from the fields of wind energy project planning, politics/administration, citizens' initiatives, non-profit organisations (NGOs), and companies in the renewable energy industry. The authors distinguish personality traits (attitudes, knowledge, norms), perceived side effects, technical and geographical as well as process-related aspects as influencing factors. The literature analysis shows that in relation to infrasound, this primarily triggers fears in relation to negative health effects. In the expert interviews, visual appearance and infrasound were named as the main aspects of the area of "perceived side effects". Interviewees (from NGOs) stated that infrasound was not originally an issue and only came up recently (referring to the survey year 2015). It was assumed that the massive communication can lead to the development of fear. Another person from an NGO added that people would wrongly assume that higher WTs would also result in stronger environmental impacts and clarified this assumption using the example of infrasound: the higher the WT, the more infrasound it would produce, which would not be true.

Regardless of whether the statement "higher WT = more infrasound" is true or whether the change in sound intensity associated with the height of the WT is a perceptible change in infrasound, the statements speak for an attribute substitution (Kahneman and Frederick 2002). This means that the assessment of a target attribute that is difficult to assess (here: infrasound immission) is replaced by the assessment of a heuristic attribute that is easier to assess (here: height of the WT) (Pfister et al. 2017, p. 145). Here, the height of the WT (of the heuristic attribute) is mapped onto the intensity of the infrasound (scale of the target attribute) (Pfister et al. 2017).

3.1.3 Conclusions from the literature review

The similarities and differences identified by Knopper and Ollson (2011) in their comparison of scientific literature published in peer-reviewed journals and other sources of information (popular literature, internet, government reports) are instructive. Differences relate to the fact that different reasons are given for annoyance that can be triggered by WT noise. For example, the scientific studies show that annoyance is not solely influenced by WT noise, but to a greater extent by other factors, and that health effects are more likely to be attributed to the stress associated with annoyance, whereas the information in popular literature and on the internet relates health effects to distance from WTs and thus causally to WT operation. Differences in the

view of what a "study" is also become clear here. Publications in scientific peer-reviewed journals are those that have been subjected to a scientific evaluation procedure (peer-review) prior to publication and follow certain scientific standards - for example with regard to hypothesis derivation, sample sizes, selection of a suitable study design, as far as possible control of study conditions and selection of suitable statistical methods. Studies presented in the popular literature mostly include case descriptions of individuals with reported symptoms attributed to infrasound without any associated exposure assessment (e.g. by acoustic measurements).

For people seeking information about infrasound and its effects, the differences in the available information in terms of quality and significance for the evidence of infrasound effects may not be discernible or may only be discernible with difficulty, especially since access to scientific peer-reviewed publications and their readability is not always available or only available with difficulty. At the very least, the study by Zlatkin-Troitschanskaia et al. (2020) suggests that when searching for information, those are selected whose source or type of information is considered reputable or relevant. The challenge of disseminating scientific information on infrasound to the public is the tendency of people to make decisions based on information that corresponds to their beliefs and to select and evaluate information accordingly (Zlatkin-Troitschanskaia et al. 2020).

The nocebo expectancy hypothesis, which has been shown to be robust by results of experimental studies (see also e.g. Crichton et al. 2014b, 2015; Eltiti et al. 2018), suggests that health complaints or symptoms as well as fears of these symptoms can be triggered by expectations and media-mediated information about the health effects of environmental pollution such as infrasound or EMF. Conversely, positive expectations mediated by corresponding instructions/information can reduce reported health complaints (Crichton et al. 2014b, 2015). The nocebo effect does not mean, as is sometimes erroneously assumed, that health complaints are "imagined", but rather says something about the causes or influencing factors to which the health complaints can be attributed. With the help of the experimentally confirmed nocebo-expectation hypothesis, effects of expectations and information can be explained in non-experimental field studies (Chapman et al. 2014), even if these cannot themselves prove the causality of the influence of expectations and information on health complaints due to their study design.

Expectations and media information about the health effects of infrasound can also amplify noise annoyance from WT noise. Increasingly, studies on WT noise, but also on other sources such as aircraft noise, indicate that noise annoyance can be a mediator between noise exposure and further health impairments (Crichton et al. 2014a, b, 2015; Benz & Schreckenberg 2019; Freiberg et al. 2019; Baudin et al. 2020, 2021), so that the interplay of noise exposure, expectations, media information and noise annoyance (also through higher-frequency noise components) can promote fears of infrasound as a health risk.

Overall, it can be stated that the scientific publications identified in the literature analysis mainly mention fears or anxieties with regard to the health effects of infrasound as emotions. With regard to the development of these emotions, the role of expectations and media information is emphasised.

On the question of subjective theories, mental models or ideas about infrasound (cognitions), hardly any results were found, so that there seems to be a research gap that can be addressed with the planned qualitative telephone interviews and quantitative surveys. With regard to cognitions, it is worth mentioning that preconceived beliefs guide information search and evaluation (Zlatkin-Troitschanskaia et al. 2020) and that heuristics such as attribute substitution

(Kahneman & Frederick 2002; Pfister et al. 2017) support the cognitive classification of infrasound.

3.2 Qualitative survey on the understanding of infrasound

The qualitative survey in this research focused on capturing the emotions and cognitions related to infrasound and the mechanisms underlying these factors. In the following sections, the area selection, the recruitment of participants as well as the development of the guideline and the results and implications for the questionnaire development of the quantitative survey are presented.

3.2.1 Area selection

The area selection was based on the five defined study groups:

- Group 1 "WEA-Nord" ("WT-North"): People from regions with WT near the North German coast, possibly larger wind farms, e.g. Schleswig-Holstein, Lower Saxony;
- Group 2 "WEA-South" ("WT-South"): People from regions that have WT or smaller wind farms inland and are partly located on hills, e.g. in low mountain regions;
- Group 3 "Active against WT": People who are actively involved in a citizens' initiative on the topic of infrasound and, if applicable, WT at local and/or regional level;
- Group 4 "low-frequency sound sources": People from regions that have, for example, an increased proportion of air-source heat pumps, generally in urban areas;
- Group 5 "no exposure": Persons from regions largely without exposure to infrasound.

Criteria catalogues were developed for all groups (except group 3), which were intended to provide a comparable basis, especially between groups 1 WT-North and 2 WT-South, and also served as a stable basis for decision-making.

For the groups with WT sites, the height of potential WTs was set to a hub height of between 130 and 170 m, and the distance of the turbine to the residential area should be a maximum of 5 km. Here, in the case of an individual turbine the starting point of the distance measurement should be this turbine itself and in the case of wind farms a turbine located in the middle. For the qualitative survey, at least 100 residents should live within the 5 km radius around the turbine, and for the quantitative survey at least 700 to 1,000 people. This population density can be estimated with the help of the website https://atlas.zensus2011.de, which provides the number of people living there for a desired radius on the basis of a population survey and lists of the administrations (including residents' registration offices) with the cut-off date of 9 May 2011. This results in an approximate number of people living there.

When selecting suitable areas for WTs, biogas plants, air-source heat pumps (except for the group "low-frequency sound sources"), the proximity to busy roads (motorways, trunk roads) and large construction sites, as well as larger adjoining forest areas, etc., were all disruptive elements. These are disturbance elements that should be excluded as far as possible. However, if these were positioned at a sufficient distance so that they could not be perceived by residents, these areas also fell into the closer selection. Thus, it should be ensured that the WTs are decisive as an assessed infrasound source.

Another criterion related to the age of the WTs, with the turbines categorised as > 5 years or ≤5 years. The distinction by age was made because there are variations in height even within the specified hub height of 130 - 170 m, which depend on the age of the turbine.

The search for suitable regions for the two *WT groups* was carried out in two steps:

- On the one hand, an internet search was carried out, mainly using the website of the Federal Network Agency. The processing of the found turbines (parks) took place in tabular form and was based on the previously defined criteria. Technical data such as hub height (in metres, m) and gross output (in kilowatts, kW) as well as the year of commissioning were assigned to the individual turbines. The presence of possible disturbing elements was checked using an internet-based map study.
- On the other hand, people and institutions were contacted and asked for information on suitable sites. In particular, the enquiry at State-Agency for Nature, Environment and Consumer Protection North-Rhine Westphalia (LANUV NRW) was productive, as feedback from 30 cities and municipalities was received in this way. These responses were examined and led in two cases to their inclusion as study areas (Group 2 WT-South; Group 4 low-frequency sound sources, in this case air-source heat pumps).

Based on the internet research, two study areas in Lower Saxony were selected for group 1 "WT-North". These are the wind farm 489UN north of Ochtersum (hub height: 135 m, gross capacity: 3000 kW, commissioning 2017) and the wind farm Dornum (hub height: 135 m, gross capacity: 2350 - 3050 kW, commissioning 2014).

- The Ochtersum area includes the villages of Barkholt, Ost- and Westochtersum south of the WT and Fulkum and Epshausen north of the WT. According to the 2011 census data, 1,185 people live in these villages.
- The area of Dornum includes the villages of Roggenstede to the west of the WT, Schwittersum, Westeraccum and the southern part of Dornum (north-east of the WT) with a population of approx. 1,305. These two areas are located directly next to each other, which is why the radius for the individual telephone interviews in WP1 was chosen to be rather small in order to avoid overlapping.

The study areas Hilchenbach and Issum were selected for *group 2 "WT-South".*

- The Issum area includes the Vorster Feld, Oermter Berg and Oermter Feld wind farms, which are located south of the villages of Oermten and Sevelen and east of Hartefeld. As of 09.05.2011, the villages together had a population of 6,770. The three wind farms have hub heights of 135 m and 149 m and a respective gross output of 3000 kW; they were commissioned in 2017 and 2018.
- The Hilchenbach wind farm was selected based on feedback from the municipality (enquiry via LANUV NRW). The hub height is 138 m, the gross output is 2 kW and commissioning took place in 2007. According to feedback from the town of Hilchenbach, the wind farm receives a high level of acceptance from the population; the well-used "wind hiking trail" was mentioned as an example. Currently, an extension of the wind farm is being planned by the same operator. As of 09.05.2011, 2,470 people lived in the associated districts of Oberndorf, Helberhausen, Hadem and (Alt-)Hilchenbach.

For the selection of an area in *group 4 (low-frequency sound sources), the* proximity to energy generation plants/power stations, traffic facilities/transport, sorting and screening plants as well as industrial plants were defined as exclusion criteria. The search for such areas on the

basis of an internet search was not successful, therefore one feedback from the city of Bonn and two feedbacks from the city of Wuppertal were used. These feedbacks were available from the respective cities due to complaints from residents. In addition to the assessment via Google Maps, these potential study areas were also visited on site. One potential study area contained a combined heat and power plant as a low-frequency noise source, but had to be excluded because there was a high-voltage pylon in the immediate vicinity whose lines ran over the residential area. Another study area with complaints about air-source heat pumps had to be excluded due to numerous other noise sources (motorway and railway lines <400 m away and a stadium <700 m away). Another new development area with a high proportion of air-source heat pumps was located >800 m from a motorway, but the noise from the motorway could only be perceived as distant noise during the site inspection and thus led to the decision in favour of this area.

For the selection of an area without exposure to infrasound, it was determined that there should be no visible or audible installations for energy production and transport (combined heat and power plant, WTs, transformer stations, etc.) or air-source heat pumps. Furthermore, residents should not live in the direct vicinity of busy railway lines, busy roads and (major) construction sites. Proximity to airports and direct adjacency to industrial and production facilities were also excluded in advance. Taking these criteria into account, the district of Emst in Hagen was chosen as the *no exposure area.* During a site inspection of the district, addresses were identified and excluded in this area that were closer than the third row of houses to a busy road (Karl-Ernst-Osthaus-Straße and Cunostraße). The composition of the building types, with an increased occurrence of single-family houses and low-rise multi-family houses, shows a similar settlement structure to that found in the other study areas. The selected area in Hagen-Emst is located close to the A45 motorway and the B54 trunk road, but is protected from the acoustic effects of these roadways due to a continuous development in between.

The *citizens' initiatives (CI's; group 3)* were researched on the internet, whereby the focus here was on those CI's that deal with the topic of infrasound on a local and/or regional level.

3.2.2 Recruiting participants

The study areas were delineated taking into account the inclusion and exclusion criteria. Based on a map study, the building addresses located therein were identified. For the addresses identified in the study areas, household names and corresponding telephone numbers were researched in publicly accessible telephone directories. A random sample of n = 50 households was drawn from the total number of households available for each study area. For the area of *group 4 (low-frequency sound sources),* only 46 households could be researched, therefore all available households were included here.

Letters were sent by post to the random sample in the four study areas (n = 196 households). These letters informed them about the purpose of the study, invited them to participate in a qualitative telephone interview and provided information on data protection. The households contacted were also informed that they would be contacted by telephone in the next few days at the telephone number listed in the telephone directories. There was also the option to contact the researcher independently to provide a correct telephone number or to arrange an interview appointment. The letter was accompanied by a letter of support from the German Environment Agency informing about the study and inviting participation.

For the third group, citizens' initiatives were researched on the internet. Care was taken to ensure that the CI’s were active, came from different locations and were characterised by different local/regional participation. A total of 14 CI’s were invited to participate.

3.2.3 Mode of data collection for the qualitative study

Within the framework of the qualitative study, it was planned to conduct structured group interviews in relevant geographical regions with 8 - 10 participants each (a total of 40 - 50 people). Due to the pandemic situation in 2021 and the associated uncertain development of infection figures and legal restrictions, face-to-face group interviews were not conducted. Two further options were then compared:

- The *online implementation of structured group interviews* in workshop style is associated with several advantages. Especially the possibility of location-independent participation and the significantly lower effort for the participants are to be positively emphasised (Breitenfelder et al. 2004). The possibility to participate from home can also be advantageous, for example, with regard to possible spatial accessibility. The implementation as a pure group chat, as a conversation with audio and video recordings or a combination of both methods would be conceivable. However, there may be organisational difficulties both in creating enough alternative dates and in filling the groups with the appropriate number of people, especially in the case of mixed groups, i.e. participants from different study areas or groups. Furthermore, it cannot be assumed that all participants or persons contacted have the technical prerequisites in the form of a laptop/computer, microphone, headphones, if necessary, a stable internet connection and basic technical knowledge.
- *Individual telephone interviews* have the advantage that apart from a landline or a mobile phone, no other technical requirements or previous knowledge need to be available. The scheduling of appointments is also much more flexible, which significantly minimises the risk of people being excluded due to scheduling overlaps. Furthermore, in other UBA projects (FKZ 3719 55 101 0 - Evaluation Sportanlagenlärmschutzverordnung, FKZ 3718 55 100 0 - Reduction of Commercial Noise in Cities) and in the EU project ANIMA (Aviation Noise Impact Management through novel Apporaches; https://anima-project.eu), qualitative telephone interviews were successfully conducted.

Based on these considerations, it was decided to conduct individual telephone interviews as an alternative to face-to-face group interviews.

3.2.4 Development of guidelines

The guiding questions for the qualitative survey were:

- In order to capture cognition, it is of interest which ideas people have about infrasound or what they understand by it.
- For the recording of emotions, it is fundamental which feelings people have in relation to infrasound. The (health) effects mentioned are also to be classified here.
- Research is also guided by the question of the mechanisms underlying the development of emotions.

Based on these guiding questions, a guideline was drawn up (see Appendix A.1), which structured the open interview and is divided it into 5 sections. The first section was intended to introduce the topic of infrasound and covered positive, negative or neutral aspects of the residential environment as well as the question of noise sources that are perceived as positive, negative or neutral. This was followed by a transition to infrasound and the question of whether the term was known. If this question was answered in the negative and no spontaneous associations were made, a short definition of infrasound was given at this point. If the original question was answered in the affirmative or if the participants spontaneously thought of

something to do with the term infrasound after the definition was read out, the questions about the understanding of infrasound followed. The cognitions were recorded with a definition, spontaneous associations, assumed sources and the presumed effects on humans. Emotions were captured with questions about the feelings the term arouses and presumed risks. In order to uncover the mechanism by which these emotions and associated thoughts may have come about, questions were asked about personal experience and previous engagement with the topic. In the case of previous engagement, it is of interest whether there was a trigger for this, which sources are used for information, whether there is an exchange within the family, circle of friends or acquaintances and what opinion these circles hold.

In group interviews, an information input is often given to stimulate discussion, which can consist of a text, picture, web page, short lecture or a combination of these (Schulz 2012). Providing an impulse can also lead to spontaneous associations and feelings in individual interviews, which can contribute to answering the guiding questions. For this purpose, statements were researched on the internet that represent a total of 4 different positions:

- Position 1: Scientists who point out the lack of evidence for adverse health effects;
- Position 2: Scientists who point out the dangers of infrasound;
- Position 3: Practitioners, residents, stakeholder organisations, decision-makers who warn of infrasound and point to health risks;
- Position 4: Practitioners, residents, stakeholder organisations, decision-makers who consider infrasound harmless.

For position 1, a publication of the German Environment Agency was cited, position 2 was taken from an interview with Professor Christian-Friedrich Vahl on SWR aktuell. Position 1 and position 2 were compared with each other.

- Position 1: "Noise measurements and noise impact studies show that infrasound levels from WTs are below the human perception threshold". (Myck & Wothge 2021) [*translation by authors]*.
- Position 2: "There is much evidence to suggest that only about 30% of people actually perceive infrasound. But that doesn't change the fact that biophysical energy is at work - whether you hear it or not." (SWR aktuell 2021) [*translation by authors].*

Position 3 was illustrated with a quote from the website of the organisation Vernunftkraft and contrasted with position 4, a quote from a publication of the Hessian Ministry of Economics, Energy, Transport and Regional Development.

- Position 3: "Technically generated infrasound with periodic components differs substantially from naturally occurring infrasound." (Vernunftkraft, retrieved 2021) [*translation by authors].*
- Position 4: "Various measurements at distances of 600, 700 and 1,200 metres have shown that the infrasound of a technical installation can hardly be distinguished from background noise (e.g. infrasound caused by wind)." (HA Hessen Agentur GmbH 2015) [*translation by authors].*

The statements were read out to the participants without indicating the source. After the comparison, the participants were asked which statement they would tend to agree with (statement 1 or 2 or statement 3 or 4) and what thoughts and feelings these statements triggered in them.

The 4th section of the guide includes a role play in which the participants are asked to take on the role of a consultant for the German Environment Agency. They are asked to advise on how best to inform the public about infrasound, i.e. what content the participant would convey, what content would be important for the participant him/herself or his/her family and neighbours. This section is particularly important for later project work in which recommendations for an informational concept are drafted.

In the 5th section of the interview, a short technical definition of infrasound according to ISO standard and DIN is read out to the participants.

3.2.5 Conducting the qualitative interviews

The qualitative interviews were conducted with the support of the survey centre uzbonn GmbH, Bonn. The interviewers were provided with information about the project and answers to expected questions from the participants, as well as an introduction to the interview in which they were asked about their willingness to participate, an appointment was arranged if necessary, and attention was drawn to data protection in general and to the audio recording of the interview.

After the first three interviews, it became clear that the technical definition of "infrasound" was not sufficient to arouse spontaneous associations among the participants. Therefore, it was decided to give examples of the occurrence of infrasound in such cases. If the topic of infrasound was still not tangible for the participant, sections two and three of the interview were skipped and the role play was taken up. Skipping these sections was intended to prevent the participants from becoming unsettled by repeated questions about e.g. effects, risks, feelings, etc. and thus building up fears or suggesting answers.

The interviews were conducted between 24.08.2021 and 25.09.2021 on Mondays to Fridays (in exceptional cases also on Saturdays if desired) between 10:00 am and 7:30 pm. The target number of participants was based on the initially planned group interviews of 8 to 10 participants per study area.

A total of 45 interviews could be conducted; in two interviews, technical problems caused the audio recording to break off at the beginning or in the course of the interview. This left 43 interviews for evaluation. In groups 4 "low-frequency sound sources" and 5 "no exposure", 10 persons each could be won over for participation, for group 1 WT-North 9 persons and for group 2 WT-South 11 persons. For group 3 "Active against WTs" only 3 interviews with 4 persons could be conducted. Since the contact with the citizens' initiatives was made via an e-mail address, no statements can be made about how many people were forwarded the invitation within the CI.

On average, there were 5 - 10 call attempts. The following Table 3 gives an overview of the fieldwork:

Table 3: Fieldwork qualitative telephone interviews

Process	Quantity n	Quantity %
Full interview	45	22,50
Interview cancelled	0	0,00
Answering machine/no answer/ ringback tone	78	39,00
Connection busy	2	1,00

Appointment - Telephone number changed	0	0,00
Information refused	60	30,00
No household/no target person	1	0,50
Fax/no dial tone/no connection	4	2,00
Letter could not be delivered, no call attempt	10	5,00
Total operations during fieldwork	**200**	**100,00**

3.2.6 Processing of the telephone interviews

The participants were informed about the recording of the interview and actively agreed to the recording. The audio files of the interviews were password-protected and uploaded to an online storage which could also only be opened with a password. The audio files were downloaded at the contractor's and also stored in a folder with restricted access. From here, they were uploaded into the transcription programme AmberScript and mentions of personal data or data that could be used for tracing, e.g. name of the participant, street or place names, were removed and replaced by e.g. "[city]". Parts of sentences or words that were not understandable were marked accordingly with "[incomprehensible]".

The interviews were then coded using the qualitative content analysis method according to Mayring (2015). The transcribed text was read into the MAXQDA software and the participants' answers were divided into categories with the help of the guideline.

The item *conditions and quality of life in the living environment* can be divided into 2 categories. On the one hand, the answers regarding the living environment were divided into positive and negative. On the other hand, the existing noise sources mentioned by the participants were listed (category 3) and, if necessary, categorised according to their evaluation (negative/disturbing or positive/neutral/not disturbing). The results of this first point of the telephone interview also serve to describe the sample. Information on the age or gender of the participants was not collected. Rather, the description of the results is based on the division into the study areas:

- Group 1: WT-North
- Group 2: WT- South
- Group 3: Citizens' initiatives
- Group 4: low-frequency sound source
- Group 5: no exposure

The main component of the guideline includes the already described guiding questions on cognition, emotion and mechanisms (see section 3.2.4). The target variable cognition was captured with questions about understanding infrasound through spontaneous associations, naming suspected sources and effects on humans. In the context of the given stimuli, agreement and triggered thoughts refer to cognition. For the description of the target variable emotion, it was asked directly what feelings the term infrasound and the statements trigger. Since the assessment of risks in humans is also associated in particular with the emotions triggered by the corresponding topic, in order to answer the question about emotions, it was asked which risks

were suspected by the participants due to infrasound. In order to identify the mechanisms that contribute to the development of emotions, the participants' own experiences with infrasound, their preoccupation with the topic (since when and by what trigger), the exchange with other people (family, friends, neighbours) and the used sources of information were included.

The fourth point of the guideline (*role play)* on *infrasound education* provides important information on what content should be included in a communication on the topic of infrasound and through which media it should be disseminated.

3.2.7 Results

3.2.7.1 Conditions and quality of life in the residential environment

The question on the *living environment* gathered a classification into positive and negative aspects in general, without the evaluation of noise sources. In the 43 interviews that could be used, more positive aspects of the living environment were mentioned than negative ones (51 vs. 30 mentions). The positive aspects included in particular an idyllic and quiet location as well as access to nature (e.g. the sea or forest). Most positive mentions were made by participants from the WT-North area, followed by participants from the area with other infrasound sources (air-source heat pumps) and the 'no exposure'-group.

Among the negative aspects of the residential environment, the WTs were named first with 6 mentions (WT-South, WT-North, CI), followed by the "low local traffic" (WT-North, CI) and the new development area that has emerged, which restricts privacy and has obstructed the free view (low-frequency sound sources).

Table 4: Results of qualitative survey - conditions and quality of life in the living environment

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
positive aspects	**8**	**15**	**5**	**12**	**11**	**51**
idyllic and quiet	4	7	3	4	5	23
Nature (sea, forest, air)	3	5	2	5	5	20
Good neighbourhood/neighbours	1	2	0	1	0	4
other	0	1	0	2	1	4
negative aspects	**5**	**6**	**3**	**10**	**6**	**30**
WTs	3	2	1	0	0	6
Local transport offer low (car necessary)	0	2	2	0	0	4
New development area	0	0	0	4	0	4
higher traffic volume	1	1	0	0	1	3
other	0	0	0	5	0	5
none	1	1	0	1	5	8

With regard to the *noise sources*, a division was made into positive (two mentions), neutral (14 mentions) and negative (34 mentions) noise sources. The positive noise sources include the nearby kindergarten (here: the calling of the children) and the sounds of the church, such as church bells and the rehearsal of the church choir. These mentions came exclusively from the study area *air-source heat pumps*.

The neutral noise sources were mainly mentioned in the wind energy areas (south and north, nine mentions) and most mentions were given to WTs, which do not disturb or which should not be "overrated". Furthermore, "sometimes noise from gardening equipment, but everything is fine" was mentioned (two mentions, *no exposure*) and agriculture, especially tractors, which did not represent any negative noise (two mentions, WT North and CI).

Across all areas, road traffic (nine mentions), WTs (nine mentions) and neighbours (five mentions) were cited as negative noise sources. The most frequent mentions of road traffic noise came from the study area *no exposure* and the area with air-source heat pumps. The fact that WTs are generally disturbing when sitting outside or at night was mentioned in the WT study areas and by CIs.

Overall, the study area with air-source heat pumps had the most negative noise sources listed (13 mentions), with neighbourhood noise as the most common disturbing factor, followed by road traffic noise and construction noise.

Table 5: Results qualitative survey - noise sources

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
positive noise sources	**0**	**0**	**0**	**2**	**0**	**2**
Kindergarten, Calling children	0	0	0	1	0	1
Church bells, church choir	0	0	0	1	0	1
neutral noise sources	**4**	**5**	**1**	**1**	**3**	**14**
WT, but do not overvalue/ does not disturb	2	4	0	0	0	6
sometimes noise from garden tools, but all good	0	0	0	0	2	2
Agriculture, tractors - but no negative noise	0	1	1	0	0	2
Church bells in the morning and evening, don't know it any other way	0	0	0	0	1	1
Ventilation system (can calmly hide this)	1	0	0	0	0	1
Wind, Birds, Lawnmower	1	0	0	0	0	1
Traffic noise, part of life, not disturbing	0	0	0	1	0	1
negative noise sources	**6**	**5**	**5**	**13**	**5**	**34**

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Road traffic noise	1	1	1	3	3	9
WT disturb/ sitting outside/ at night	4	3	2	0	0	9
Neighbourhood noise	0	0	0	4	1	5
Aircraft noise	1	0	0	1	1	3
Construction noise	0	0	0	3	0	3
Noise from agricultural operation	0	1	1	0	0	2
Event, recreational noise	0	0	0	1	0	1
Other	0	0	1	0	0	1
None	0	0	0	1	0	1
other noise sources perceived - without evaluation	**0**	**0**	**0**	**3**	**1**	**4**
Construction noise	0	0	0	1	0	1
Motorway	0	0	0	2	1	3

3.2.7.2 Cognition, emotion and underlying mechanisms

The tabular presentation of results for the target variables cognition, emotion and the underlying mechanisms can be found in the Appendix A.2 to A.4.

The target variable cognition was collected via questions about the familiarity with the term infrasound, the suspected sources and effects on humans. A total of 18 respondents were familiar with the term infrasound or stated that they had heard of it. Most of the mentions (10) came from study areas with WTs. On the other hand, 23 participants were not familiar with infrasound; accordingly, most of the mentions came from the *no exposure* study area (7) and the study area with other infrasound sources (8). In the WT-South study area, slightly more people stated that they were not aware of infrasound than were aware of it (five to four mentions). Most people stated that they had heard of infrasound in connection with WTs, followed by the statement that it is "sound [that] you don't hear" and that it is "something dull". However, various individual spontaneous associations were also mentioned, e.g. vibrating, unpleasant, infrastructure, continuous noise like water on the beach, low frequencies, etc. The sources mentioned were mainly WTs, especially in the WT study areas. In the other areas, various types of traffic noise (road, rail and air traffic) and domestic appliances (e.g. refrigerator, washing machine, heat/heating pumps) were suspected sources. The most frequent description of the presumed effects on humans was that infrasound gets on the nerves or triggers stress or a bad mood (seven mentions). Sleep disturbances (six mentions) and heart damage (three mentions) were also mentioned. Specific symptoms such as headaches and nausea were named individually, but also rather vague statements such as "internal damage" or "not beneficial to health". A total of 27 mentions were made of the presumed effects of infrasound on humans. This contrasts with 21 mentions that are rather vague ("may be"), do not suspect any effects or do not know/ cannot judge.

For 14 of the respondents, the term infrasound does not trigger any feelings. On the other hand, uneasiness, trepidation, restlessness, etc. were mentioned in isolated cases. When asked about the suspected risks, most of the responses (20) were in the rather vague range, i.e. seven of the participants suspected risks but could not name them. A further seven people stated "don't know", three people do not suspect any risks in humans and another three people feel that this has not yet been properly documented.

The largest proportion of mechanisms that trigger such emotions are the participants' own experiences with infrasound. The most frequently mentioned were associations with WTs, especially the proximity to WTs and the disturbances at night / when it is quieter. Other individual mentions related to pumps, the “infrequent perception on the road” or that there are people who perceive it but oneself does not. In the cases where there was prior engagement with the topic, the main sources of information mentioned were the internet (10 mentions) and scientific publications (8 mentions), with three participants each obtaining information from citizens' initiatives / associations or newspapers / press.

The aforementioned results were used for the questionnaire of the main survey as statements whose agreement was recorded on a 5-point scale (with 1=not at all to 5=very much). The statements were:

- Emotion: Because of infrasound, proximity to a WT causes me anxiety; Concern about health risks from infrasound from WTs is justified; If you express concerns about infrasound from WTs, you are not taken seriously by friends and family / operators and authorities.
- Cognition: Effects of infrasound from WTs on humans have not yet been sufficiently researched; Infrasound from WTs has a negative effect on sleep; People can get used to infrasound from WTs; Infrasound from WTs is no different from naturally occurring infrasound.
- Mechanisms: Information about infrasound from WTs must be understandable and usable for residents; I form my opinion about infrasound from WTs based on the experiences of friends and family; Helpful information about infrasound from WTs can only be found at public authorities.

3.2.7.3 Impulses for the infrasound discussion

The interviewees were presented with four statements about infrasound in order to provide impulses for the subjects' own preferences, cognitions and emotions.

The first two statements are contrasting statements from people in the scientific community, with the first statement pointing to the lack of evidence for adverse health effects of infrasound (position 1), while the second statement emphasises the health hazards of infrasound with reference to the effect of the biophysical energy of infrasound even in the absence of perception (position 2).

The other two statements come from institutions from the field. Position 3 refers to the difference between technical and natural infrasound from the point of view of citizens' initiatives,

On the other hand, position 4, from the point of view of the economic development agency (Wirtschaftsförderungsgesellschaft) of a federal state, emphasises the harmlessness of infrasound with reference to the fact that infrasound measured at distances of between 600 and 1200 metres from a technical installation can hardly be distinguished from background noise.

The table in the Appendix A.5 shows the collected statements of agreement, cognitions and emotions on the impulses, which are presented below.

Evaluation of the scientific statements Position 1 and 2

In the scientific statements (positions 1 and 2), more people agree with position 2 (n = 10), which refers to a biophysical effect of infrasound on humans even in the absence of perception. In contrast, seven people agree with position 1 that the infrasound levels of WTs are below the human perception threshold. 6 persons cannot decide between the two positions with regard to their agreement. It should be noted, however, that the two positions are not fundamentally mutually exclusive and that position 2 can also be understood as an intellectual supplement and thus possibly as more complete or more differentiated than position 1.

Position 1 triggers just as many confirming as critical or rejecting thoughts (three mentions each). Critical thoughts include that the statement is seen as contradictory, that the measurements referred to in the statement are seen as wrong and that the term "perception threshold" is to be understood as broader and that the perception of infrasound does not - as the statement assumes - only refer to hearing. More supportive thoughts include the confirmation that position 1 can be read everywhere, that it is considered more scientific than position 2 and that studies state that infrasound does not affect the human body.

Position 2 triggers thoughts of one's own experiences in 5 cases, for example that one has become accustomed (to infrasound), at least psychologically, the body possibly not. On the one hand, habituation is mentioned in a resigned way ("it's no use, you can't do anything about it"), on the other hand also in a confident sense ("[one] becomes resistant", "at some point you won't hear it anymore"). Other thoughts suggest a critical attitude towards position 2, it is regarded as "esoteric" or as "pure conjecture". In one mention, a Norwegian study is assumed to be the source of the position, in which "serious diseases" were found.

Further associations to both positions 1 and 2 refer to WTs, starting with the sober statement that it may well be that WTs produce infrasound, to the point that WTs are necessary, generally do not disturb, a distance of 1000 m is not necessary, but conversely WTs are perceived as visually disturbing and as blighting the landscape. One person does not believe that infrasound can be heard.

With regard to the feelings triggered by the two positions 1 and 2, four people report having no particular feelings about it. In the remaining six mentions, uncertainty is formulated about whether infrasound is good for health, and reference is made to the fact that “the dose makes the poison” and that infrasound should be avoided if possible, but that it is also acceptable and can be overheard if distracted, and that the situation of infrasound immission is not nice but also cannot be changed. Similar to the thoughts, the feelings also show a mixture of insecurity in knowledge, on the one hand - partly resigned - acquiescence, but also the desire to avoid.

Evaluation of the positions 3 and 4 originating from practice

Among the positions originating from practice, position 4, with its reference to the fact that at discrete distances between 600 and 1,200 metres infrasound from a technical source can hardly be distinguished from background noise, receives more frequent agreement (n = 10) than position 3, which refers to periodic components with which technical infrasound differs substantially from natural infrasound (n = 5). Eight people cannot decide which of the two positions they agree with.

Regarding position 3 with the reference to technical infrasound with its periodic components, there are few mentions of cognitions (n = 4). It is added that natural infrasound has no "sinus-

shaped frequencies of rotating machines", it can be heard as "tremendous, bad when wind dies down" and there is uncertainty about whether the described characteristic of technical infrasound is related to cancer in the area. One person suspects a polling institute as the source of the position and adds that technical infrasound is perceived with periodicity as an interaction of senses.

Position 4 (n = 9) triggers more cognitions than position 3. Five of them are rather positive or confirming. They confirm in their own words that there is a lot of noise in this low frequency range, that nothing has come out of many measurements taken, that more wind than turbine noise can be heard, especially in bad weather, that one can get used to it and that infrasound from WTs is part of the general risk of life. Position 4 also triggers critical thought in two cases that it only says something about perception and that turbine manufacturers hold this position. The measurement of structure-borne sound instead of airborne sound is formulated as a requirement. This can be understood as a further criticism of position 4. One person expresses uncertainty about the truth of the statement.

Both positions together trigger resignation ("You can't fight it") and the aspect of the omnipresence of infrasound ("Infrasound is practically always there") as further cognitions.

Six mentions of the emotions triggered by positions 3 and 4 refer to expressions of resignation ("no use anyway"), evaluation of the infrasound situation ("unpleasant thing"), actor-related feelings ("that they are being cheated", "one is not taken seriously") and to the statement that technical and natural infrasound are perceived differently.

The evaluation of positions 3 and 4 also reveals uncertainties in knowledge, acceptance or toleration of the infrasound situation, but also critical comments on the presumed authors or representatives of the positions. The relationship between stakeholders and those affected is addressed more clearly than in the scientific statements; the comments can be understood as a perceived lack of procedural fairness ("being cheated", "not taken seriously").

3.2.7.4 Role play

The role play was introduced in order to determine the content and media to be used to communicate information about infrasound and its effects on people. 13 people did not give any information on this, almost half of them from the *WT-South* study area alone. The citizens' initiatives described the type of communication desired as authentic, comprehensible, justifiable and scientific, but at the same time expressed scepticism that such information would be used to demand that people "adapt". Three further general individual responses were recorded from the *WT-North* study area. One was that there was no need or interest, while another indicated that there was already enough information on the subject. The last mention expressed resignation because the WTs cannot be turned off by the residents.

A total of 44 mentions of the desired contents could be collected. The (medical) effects of infrasound on humans were mentioned most frequently (14 mentions), followed by information about a definition (nine mentions) and factual information about the audibility and distance of WTs. These described contents were requested together more often in the *no exposure* study area and the area with other infrasound sources (*air-source heat pumps*). Further individual mentions concerned, for example, the wish for a clear, central theme that can be followed in a few sentences. Also, not only a definition should be mentioned, but at the same time it should be

pointed out what this means for the people in detail. Furthermore, a contact point and the naming of communication possibilities and coping strategies were desired.

The most important sources were, in order, newspaper articles (six mentions), television (five mentions) and the internet (three mentions). The results can be found in the table in the Appendix A.6.

3.2.7.5 Summary

The qualitative survey on the understanding of infrasound showed that overall less than half of the respondents were familiar with the term "infrasound". If the term was known, then mostly in connection with WTs and road traffic (vehicles, roadway, etc.). Almost equal numbers of respondents mentioned WTs as both negative noise sources (eight mentions) and neutral noise sources (six mentions). Own experiences with infrasound are mainly linked to the installation of (more) WTs.

Associations with the term infrasound vary, e.g. it is described as "sound you hear or perceive" or "not heard but perceived" or as dull and subliminal. People from the *WT-North* study area and from *CI's* see health effects on humans, especially sleep disturbances, whereby *CI's* also note that the topic has not yet been sufficiently researched.

4 Cognitions and emotions about infrasound in connection with WTs

4.1 Literature analysis on the scientific state of research

The topic of the influence of cognitions and emotions about infrasound on the acceptance of WTs was initially dealt with by means of a literature analysis and also carried out in the form of a scoping review (see also Chapter 3.1).

The aim of the literature analysis was to obtain information on relevant factors for the acceptance of WTs, taking into account the state of scientific research, which can be used for the development of the survey instrument and to derive indications for the development of the informational concept. The research question and the inclusion and exclusion criteria for the selection of literature were formulated according to the PEOS system (Population, Exposure, Outcomes, Study Design) (Freiberg et al. 2019; Morgan et al. 2018).

Table 6: Leading research questions of WP2 broken down according to the PEOS system

Topic	PEOS	Question
Transmission	Population	In the general population, what effect does...
	Exposure	...the understanding of (subjective theories, mental models, beliefs) and the emotions about infrasound (e.g. fear) and its effects have...
	Outcomes	...on the acceptance of WTs?
	Study design	What study design was used to investigate this?
Interactions	Population	In the general population, ...
	Exposure	...are there interactions of cognitions and emotions to infrasound...
	Outcomes	...with other acceptance factors of WTs?
	Study design	What study design was used to investigate this?
Expectations regarding the precautionary principle	Population	In the general population, ...
	Exposure	...what are the precautionary expectations regarding health effects associated with infrasound emissions from WTs...
	Outcomes	...and what influence do these have on the acceptance of WTs?
	Study design	What study design was used to investigate this?

For the selection of literature, the following inclusion and exclusion criteria were fulfilled (Table 7).

Table 7: Inclusion and exclusion criteria for the literature selection in WP2

	Inclusion criteria	Exclusion criteria
Population	General population, stakeholder groups (e.g. operators of WTs, members of citizens' initiatives, environmental/ supervisory authorities)	Animals
Exposure	Infrasound from WTs, information on infrasound from WTs (media, internet contributions/social media), cognitions and emotions in relation to WTs, expectations of precautions against health effects from WTs	other environmental pollution, sound of higher frequencies ("auditory sound")
Outcomes	Acceptance factors of WTs	Biopsychosocial infrasound effects on health, symptoms, effects on cognitions, brain activities, technical/acoustic measurement, calculation results
Study design	Longitudinal study, cross-sectional study, theoretical article, discussion paper	Comment responses to published articles, introduction to a journal

The following *subject databases* were used for the literature search:

- EBSCO (covers the databases PsycINFO, Psycarticles and Psyndex plus)
- PubMed (contains Medline articles)
- SCOPUS (multidisciplinary subject database)

Based on the research question, the following *search terms* were linked:

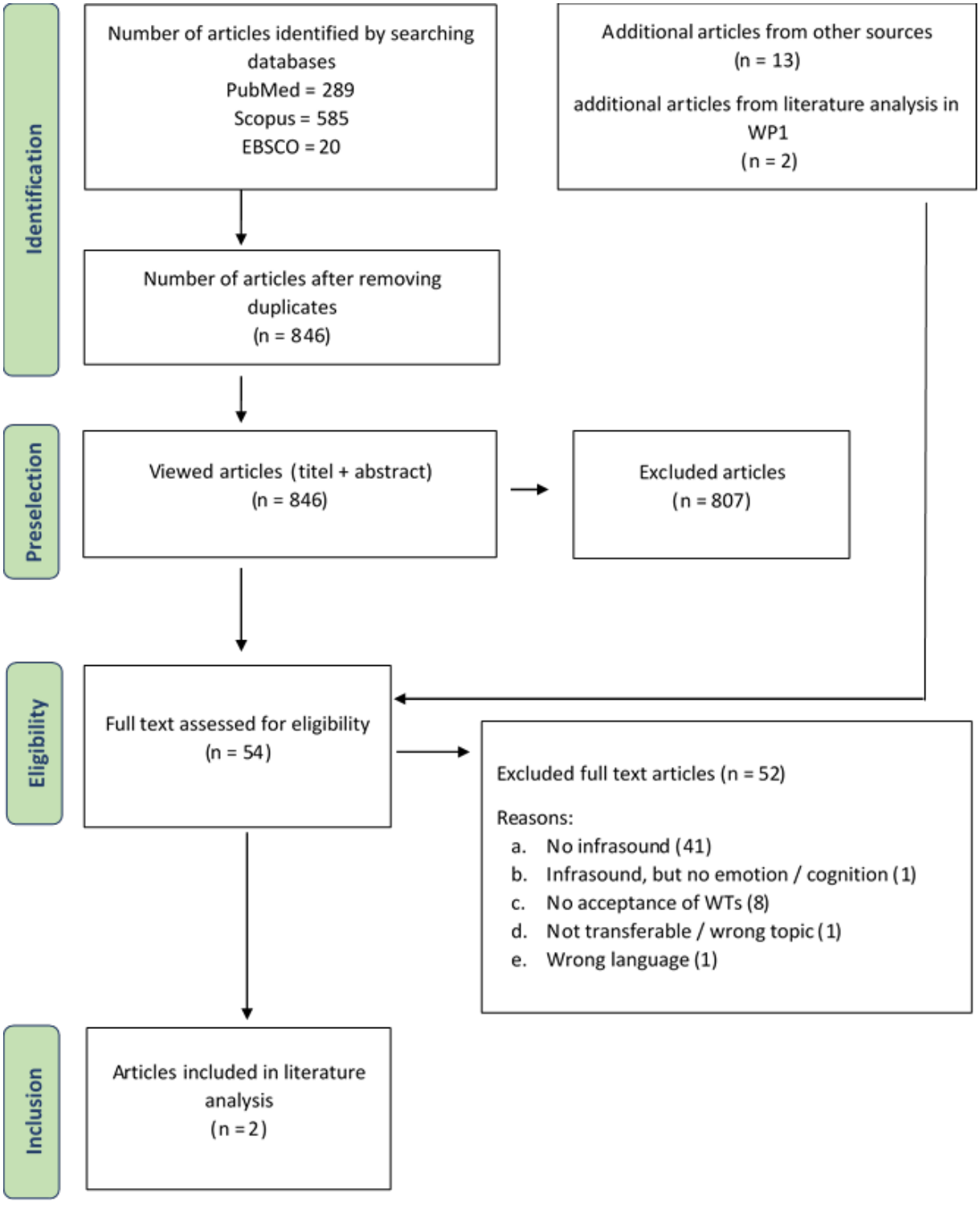
> *(wind turbine AND (cognition OR emotion OR affect OR subjective definition OR mental model OR mental concept OR cognitive concept OR comprehension OR framing OR (risk perception) OR (risk communication) OR acceptance OR understanding OR (acceptance of technology)))*

After an initial review of the found literature, a further search was carried out in PubMed with the search string *(wind turbine AND infrasound).*

4.1.1 Results of the literature search

The search results of the subject databases (title, abstract, authors, year of publication) were transferred to the programme Rayyan, with the help of which the abstract screening was carried out. Based on the inclusion criteria, 41 articles were identified, which were checked for their suitability on the basis of their full texts. The following flow chart, based on the PRISMA statement (Moher et al. 2009; Tricco et al. 2018), shows the literature selection process.

Figure 6: PRISMA flowchart showing the process and results of the literature search WP2



Source: own representation, ZEUS GmbH

Two articles could be found that follow the path of the leading questions (see Table 6) whether the cognitions and emotions about infrasound can be transferred to the acceptance of WTs or interact with other acceptance factors of WTs.

4.1.2 Extracted knowledge and findings to answer the guiding questions

The results of their laboratory study, first published by **Crichton et al. (2013),** show that the number and intensity of perceived symptoms (e.g. headaches, pressure in the ear, itchy skin, dizziness, etc.) increase before and during the exposure to infrasound sounds in the subjects who expect these symptoms. These high expectations were triggered by the audiovisual information on negative health effects that was provided to the test persons before the sounds were played. A second group of test persons was shown information that did not represent a connection between infrasound from WTs and health damage. In this group, there was no change in the perceived symptoms or their intensity. These results were shown for both real infrasound and sham infrasound, suggesting that the expectations that information raises may be the link between WT exposure and health complaints.

Another result of the literature review is an article by Crichton et al. (2014a), which has already been included in the analysis of WP1. In this review, Crichton et al. explicitly attribute research results from their own laboratory studies as well as other experimental and epidemiological work to the nocebo effect. This states that negative expectations cause unfavourable health effects in that people search for health symptoms or attribute existing symptoms to infrasound, regardless of the actual exposure. Although the acceptance of WTs is not explicitly investigated, the authors argue that the rejection of the expansion of WTs can be attributed to the nocebo effect and thus to concerns about or expectations of negative health effects.

In addition to these two literature sources, the work of **Borch et al. (2020)** showed the high influence of social media on the development of wind energy in Denmark. Although this paper does not address infrasound, it does address low-frequency sound from WTs. For this reason, this article is discussed here, even though it does not fulfil all the inclusion criteria of the literature analysis. The article describes a content-analytical study of Facebook pages of wind power opponents. The authors conclude that opponents can create a (one-sided) resonance space here to present their arguments in a public debate. At the same time, there is no classification of or reaction to the arguments of public authorities or operators. In the evaluation of a total of 11,278 entries on Facebook pages or in public Facebook groups, concerns about noise and low-frequency sound as well as health and landscape identity on the one hand, and concerns about procedural fairness, ethical concerns and empathy on the other hand were mentioned most frequently.

4.1.3 Conclusions from the literature review

Overall, the literature review shows that there are hardly any studies that explicitly consider the relationship between cognitions and emotions about infrasound and the acceptance of WTs. Two articles that fulfil the inclusion criteria as well as another article that does not deal with infrasound but transferable results on low-frequency sound from WTs were identified. According to this, cognitions and emotions or concerns regarding infrasound and low-frequency sound have an influence on the acceptance and evaluation of the construction and operation of WTs. Almost without exception, the cognitions and associated emotions concern adverse health effects of infrasound and low-frequency sound. They are used to justify the rejection of the construction and operation of WTs and thus the low acceptance of these installations. Publicly available information and media reports play an important role in this. The work of Crichton et al. (2013, 2014a) shows the effectiveness of the nocebo effect, according to which expectations of health impairments built up by information can trigger corresponding symptoms or cause them to be attributed to infrasound as a trigger. This is accompanied by a reduction in the acceptance of WTs, as shown by the work of Crichton et al. (2013, 2014a) and Borch et al. (2020). The study by Borch et al. (2020) points to the difficulty of assessing the quality and truth

of information in social media in particular. Facts and '*fake news*' are on an equal footing. The various groups (proponents and opponents of WT, operators and public authorities) form homogeneous information circles that hardly exchange information with each other, so that different points of view and arguments often stand side by side without comment.

The role that cognitions and emotions about infrasound play in addition to other factors for the acceptance of infrasound-emitting installations was investigated in this project by means of a quantitative survey described in the following sections, in addition to the development of the current state of research in this area on the basis of the described literature analysis.

4.2 Quantitative survey on the acceptance of WTs

The quantitative survey of this research project deals with the acceptance of WTs and the significance of infrasound in this context. For this project, the role of infrasound was of particular importance. The acceptance of WTs is to be understood as an example to show the importance of cognitions and emotions about infrasound for the perception and acceptance of infrasound-emitting turbines. From this, starting points for education and communication efforts are derived, which should help the population to classify the phenomenon of "infrasound" and its significance for living in the vicinity of infrasound sources.

The qualitative survey was conducted in study areas with WTs and one area without exposure and correspond to the already defined study areas (see chapter 3.2.1).

- Group 1 "WT-North" includes the area of Ochtersum (with the villages of Barkholt, Ost- and Westochtersum south of the WT and Fulkum and Epshausen north of the WTs) and the area of Dornum (with the villages of Roggenstede west of the WTs and Schwittersum, Westeraccum and the southern part of Dornum (north-east of the WTs));
- The study areas of Hilchenbach and Issum (with the villages of Hartefeld, Geldern, Oermten and Sevelen) were selected for *Group 2 "WT-South";*
- Group 5 "no exposure" included people from a region largely without infrasound (Hagen, NRW).

4.2.1 Development of the questionnaire

The questionnaire was developed on the basis of the literature analyses and the results of the qualitative interviews. Furthermore, own work on the topic of infrasound was used for the compilation of the contents and also relevant survey instruments of other research studies were used, as far as they were not already included on the basis of the literature research.

The questionnaire for the WT study areas can be found in Appendix B.1 and includes the following thematic blocks or concepts:

- Living situation (including length of residence, home ownership, if applicable type and position of windows, room orientation towards the WT), type of building, outdoor living space (balcony, garden, etc.);
- Housing satisfaction, perceived housing quality, perceived housing location (e.g. rurality); housing/living conditions: positive conditions, disruptive conditions);
- Place Attachment (Devine-Wright & Wiersma 2019; Lewicka 2011);

- General sensitivity to environmental pollution (including noise, odours, low-frequency fields [power lines], mobile phones);
- Annoyance caused by noise from WTs (total, when indoors and outdoors) gathered according to international recommendations of the International Commission on Biological Effects of Noise (*ICBEN*; Fields et al. 2001);
- For control/demarcation: annoyance from selected other noise sources (street, neighbourhood, air-source heat pumps, construction sites, biogas plants, other), oriented to Fields et al. (2001);
- Line of sight to WT, perceived distance, location of WT, opinion on WT before construction, timing and type of information about planning/construction (including Haac et al. 2019);
- Acceptance of WTs (satisfaction, advocacy, acceptance of WTs on site);
- Acceptance factors: Essential postulated acceptance factors according to Hübner et al. (2020):
  - Economic effects on site: Property value, energy costs, opportunity to participate in energy production, in leasing, and, if applicable, a rebate on energy purchases;
  - Attitudes towards the energy transition, wind energy in general, WT operation in the residential environment;
  - If residents lived in the vicinity of the local WT before it was erected: authenticity of stakeholders during process planning (operators, policy/administration at different levels);
  - Perceived fairness (distributive justice of burdens/benefits, procedural fairness of decision-making processes for the erection and operation of WTs), possibility of citizen participation;
  - Impacts on people and nature:
    - Disturbances caused by wind energy noise: activity disturbances, noise annoyance, collected according to international recommendations (Fields et al. 2001) and based on previous relevant noise impact studies (e.g. Schreckenberg et al. 2015);
    - Visual and other non-acoustic impacts of the WTs (shadows cast, landscape, obstacle marking, rotational movements, ice shedding);
    - Impact on the landscape (sealing), on animal/nature conservation; attitude towards environmental protection and nature conservation, landscape protection;
  - Social norm: opinions of others in the locality.
- Other factors of WTs: attractiveness of WTs (Petrova 2016), trust in technology (Linzenich 2018), risks of WTs (Fischhoff et al. 1978), audibility of WTs (Haac et al. 2019);
- Opinions and attitudes towards infrasound (questions based on the results of the qualitative interviews and, if necessary, adaptations or extensions based on the literature analysis of WP2):
  - Spontaneous association with the term "infrasound", type of perception of infrasound
  - Cognition:

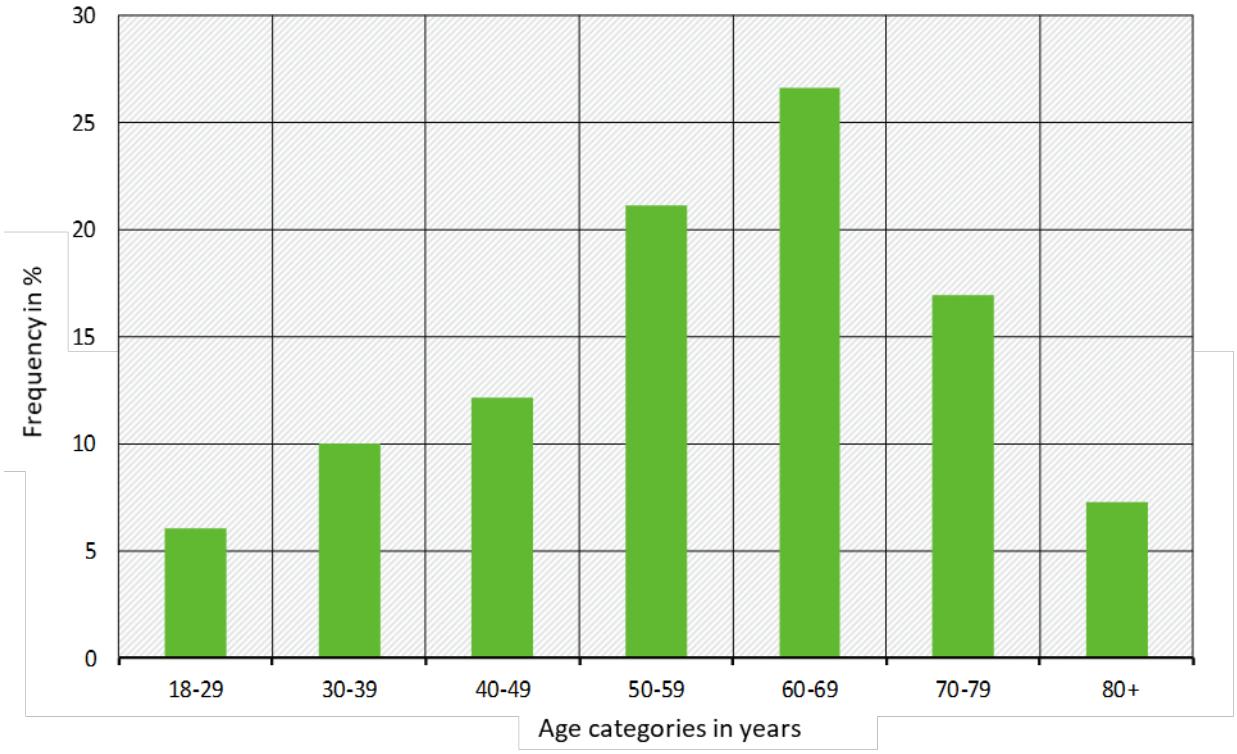
        - Knowledge, meaning of infrasound, conceptual understanding in general,
        - Significance of infrasound in the context of local WTs;
    - Emotions:
        - Concerns, emotions, affective reactions to infrasound in general and in the context of local WTs;
    - Perceived disturbance due to noise from the WTs;
- Personal stress experience (*Perceived Stress Scale, PSS*, after Cohen and Williamson 1988, german version by Büssing 2011);
- Sociodemographics: age, gender, school education, vocational training, occupation, net household income, number of persons in the household.

The complete questionnaires for the WT study areas and the control area can be found in the Appendices B.1 and B.2.

4.2.2 Basics and sample description

A total of 340 questionnaires were received, of which 55 were completed in online mode and in 285 cases the offer to return the completed questionnaire free of charge was taken up. Of these, 72 responses were received from the control area (without any apparent technical infrasound source in the residential area) and 264 from the 4 WT study areas. Four questionnaires were returned without an ID and could therefore not be assigned to any area. The target of 50 responses per area was exceeded throughout. Overall, 47.4% of respondents were female, 51.8% were male, 0% were diverse and 1.8% did not provide gender information. Figure 7 shows the number of participants by age.

Figure 7: Age of all participants (n = 331, no information: n = 9)



Source: own representation, ZEUS GmbH

After all responses have been received, the data were processed with regard to plausibility (e.g. plausible use of filter guidance), standardisation of any deviating characteristics in variables between the modes, missing analyses and - where necessary - recoding of variables for the following evaluations.

4.3 Data preparation - factor analyses, formation of summary scores

After data processing, various items were subjected to an Exploratory Factor Analysis (EFA) in order to "explain correlations between the items by a smaller number of underlying homogeneous factors" (Bühner 2011, p. 296) [*citation translated by authors]*. In most cases, a principal axis analysis with promax rotation was conducted. These factors provided indications of which items could be combined into mean scores and thus included in the further calculations either as a score or - where a summary did not appear to make sense statistically - as individual items.

4.3.1 Opinions and attitudes to infrasound

11 individual questions (items) concern opinions and attitudes towards infrasound (see questions 115 to 125 in the questionnaire of the WT study areas). According to the results of the EFA on the 11 items, nine items load on three factors, the remaining two items cannot be combined into one factor or do not load sufficiently (below a set loading level of 0.45) on one of the three identified factors. Due to the low reliability (Cronbach's alpha) of the third factor, only the respective items of factors 1 and 2 are used to form corresponding mean scales.

Table 8: Factor loadings of the statements on infrasound

Items	Factor 1: health concerns	Factor 2: social debate	Factor 3: Informedness by third parties
115. Concerns about health risks from infrasound from wind turbines are justified.	0,774		
120. Infrasound from wind turbines has a negative effect on sleep.	0,732		
116. Because of the infrasound, the proximity to the wind turbine causes me anxiety.	0,719		
121. You can get used to infrasound from wind turbines.	-0,666		
119. Effects of infrasound from wind turbines on humans have not yet been adequately researched.		0,786	
118. If you express concerns about infrasound from wind turbines, you are not taken seriously by operators and authorities.		0,616	
123. Information on infrasound from wind turbines must be comprehensible and usable for residents.		0,491	
125. Helpful information on infrasound from wind turbines can only be found at public authorities.			0,622
124. I form my opinion about infrasound from wind turbines based on the experience of friends and family.			0,486
Cronbach's Alpha	*0,884*	*0,658*	*0,412*
% of variance per factor	*30,123*	*11,520*	*4,352*
% of the cumulative variance	*30,123*	*41,642*	*45,994*
Items without factor assignment			
122. The infrasound from wind turbines does not differ from naturally occurring infrasound.	-0,193	0,149	0,412
117. If you express concerns about infrasound from wind turbines, you are not taken seriously by family and friends.	0,179	0,328	0,138

4.3.2 Factor analyses on the independent variables

According to the procedure under 4.3.1 factor analyses were carried out for all independent variables of interest and corresponding scales were formed.

- Three items were identified for the acceptance of WTs, which together load on one factor (see Table 9). Accordingly, a mean score was formed with which the further evaluations were carried out.

Table 9: Factor loadings of the statements on acceptance of WTs

	Factor 1: Acceptance of WTs
73. I am in favour of the wind turbines here.	0,979
74. I am satisfied with the wind turbines here.	0,944
75. I accept the wind turbines here.	0,914
Cronbach's Alpha	*0,962*

- From the 9 questions on sensitivities, two factors could be found (see Table 10). The excluded item "sensitivity to the weather" was not included in the further evaluations due to its low significance.

Table 10: Factor loadings of the statements on sensitivity to environmental stresses

Sensitivity to...	**Factor 1: Environmental sensitivity**	**Factor 2: Electrosensitivity**
34. ...sounds in general	0,824	
30. ... Noise	0,764	
33. ...monotonous humming	0,676	
27 ... Stress in general	0,655	
26. ... odours	0,568	
32. ...bass noises, low tones	0,561	
31. ...mobile communications		0,974
29. ...power lines		0,700
Cronbach's Alpha	*0,844*	*0,795*
% of variance per factor	*40,469*	*9,310*
% of the cumulative variance	*40,469*	*49,780*
Items without factor assignment		
28. weather	0,287	-0,020

- Following the concept of *place attachment* (Devine-Wright & Wiersma 2019, Lewicka 2011), a principal component analysis with varimax rotation was carried out on the items relating to place attachment for better comparability with the results of Devine-Wright and Wiersma (2019). Three factors were also identified, as by Devine-Wright and Wiersma (2019), although the third factor is excluded from further analyses due to its weaker reliability (Cronbach's alpha) (see Table 11). For the factor analysis, item numbers 18 and 19 were recoded so that the response values point in the same direction as the other items in terms of their orientation, i.e. higher values reflect a higher attachment to place.

Table 11: Factor loadings of the data on place attachment

	Factor 1: traditional place attachment	**Factor 2: active place attachment**	**Factor 3: Placelessness**
15. Even if there are better places, I will not move away from here.	0,822		
16. I can't imagine moving away from here.	0,829		
17. I never thought about whether it wouldn't be better to live somewhere else.	0,820		
20. I like to explore my area and discover new places.		0,794	
21. I often take photos of different places here.		0,809	
22. From time to time I rediscover my area.		0,875	
18. I wouldn't mind leaving my place of residence and moving somewhere else.			0.743 (recoded)
19. There are many places in Germany and in the world where I could live.			0.763 (recoded)
23. It is more important for me how I live than where I live.			-0,595
Cronbach's Alpha	*0,816*	*0,788*	*0,517*
% of variance per factor	*29,616*	*24,527*	*12,083*
% of the cumulative variance	*29,616*	*54,143*	*66,226*

- Questions on satisfaction with citizen participation and the provided information as well as the course of the planning process could be combined into a mean score "procedural fairness" based on the factor analysis. The corresponding items and their factor loadings can be found in the Table 12.

Table 12: Factor loadings of the data on the planning process and informedness

	Procedural fairness
60. How satisfied were you with the possibility of citizen participation?	0,739
59. How satisfied were you with the information provided?	0,779
63. My objections were heard during the planning process.	0,825
62. As part of the planning process, there was an opportunity to contact the initiators.	0,885
61. During the planning process, my concerns were taken seriously.	0,892
Cronbach's Alpha	*0,913*
% of variance per factor	*68,253*

- The assessments on the authenticity of different stakeholders resulted in two factors. Factor 1 "Authenticity of WT stakeholders" and Factor 2 "Authenticity of nature conservation stakeholders" together account for 68.83% of the variance in authenticity. The item on the assessment of the authenticity of opponents of WTs has a low factor loading just below the set loading level of 0.45 and is therefore not included in the formation of a mean score (see the following Table 13).

Table 13: Factor loadings on the assessments of the authenticity of various actors

	Factor 1: authenticity of WT stakeholders	Factor 2: authenticity of conservation stakeholders
66. Project planners (who plan and erect wind turbines)	0,930	
65. Investors (who use wind turbines as a financial investment)	0,862	
71. Proponents of wind turbines	0,821	
67. Licensing authorities	0,799	
69. Mayors	0,769	
70. Nature conservation associations		0,978
68. Nature conservation experts		0,810
Cronbach's Alpha	*0,813*	*0,926*
% of variance per factor	*49,514*	*19,315*
% of the cumulative variance	*49,514*	*68,830*
Items without factor assignment		

72. opponents of wind turbines	-0,446	0,349

- The assessment of the operation of WTs in the residential environment allowed the formation of two factors: on the one hand, items loaded onto a factor that tend to assume negative consequences of operation ("WT concerns"). On the other hand, there were assessments with rather positive connotations ("positive WT attitudes"). Two items were excluded due to their low factor loading (see Table 14).

Table 14: Factor loadings of the statements on WTs in the residential environment

	Factor 1: WT concerns	Factor 2: Pos. WT attitudes
79. The operation of wind turbines makes it unpleasant to spend time in the garden, on the terrace or on the balcony.	0,917	
87. The operation of wind turbines harms tourism in the region.	0,818	
83. The operation of the wind turbines makes local recreation more difficult.	0,771	
85. The wind turbines are hazardous to human health.	0,742	
80. The wind turbines are the basis for disputes within the neighbourhood.	0,687	
77. The operation of wind turbines results in a reduction in the value of surrounding houses and properties.	0,679	
81. Wind turbines disfigure the landscape.	0,579	
76. Wind turbines promote the further development of the region.		0,817
78. The operation of wind turbines creates new jobs in the region.		0,803
84. The operation of the wind turbines reduces electricity costs.		0,664
89. Wind turbines are an attractive feature of the landscape.		0,520
82. The operation of wind turbines is good for the environment.		0,517
Cronbach's Alpha	*0,910*	*0,769*
% of variance per factor	*43,676*	*6,851*
% of the cumulative variance	*43,676*	*50,527*
Items without factor assignment		
86. The operation of wind turbines endangers native animals.	0,433	-0,335

88. There is no defence against the erection of wind turbines.	0,402	0,105

- Two items on risks associated with WT infrastructure and 1 item on confidence in WT technology load onto one factor and were combined into one mean-based score (see Table 15).

Table 15: Factor loadings of the statements on WT infrastructure and technology

	Technology Trust
91. The risks associated with the infrastructure of wind turbines are known to scientists.	0,845
92. The risks associated with wind turbine infrastructure are well known to the general public.	0,637
90. I have confidence in the technology of wind turbines.	0,624
Cronbach's Alpha	*0,739*
% of variance per factor	*50,292*

- Specific disturbance aspects of WTs could be combined into one item "visual WT annoyance" due to their loadings and reliability statistics (see Table 16).

Table 16: Factor loadings of the statements on specific disturbance aspects of WTs

Disruptive aspects	visual annoyance
93. sight	0,877
97. effect on the landscape	0,837
96. rotary motion	0,829
95. obstacle marking	0,796
94. shadowing	0,783
Cronbach's Alpha	*0,913*
% of variance per factor	*68,060*

- Activity disturbances caused by noise from WTs were directly combined into mean scores due to their proven use in other noise impact studies: indoor activity disturbance, outdoor activity disturbance, sleep disturbance. Table 17 shows the items and reliability statistics for the respective scale.

Table 17: Reliability statistics of the activity disturbances caused by noise from the WTs

Disturbances during activities in the house	***Cronbach's Alpha***
during conversations or when using the telephone in the flat/house	
When listening to the radio/music or watching television	
When reading, thinking or concentrating in the flat/house	*0,944*
When relaxing and resting after work in the apartment/house	
For domestic socialising or when you have visitors in the apartment/house	
Interference with activities around the house	***Cronbach's Alpha***
When staying and relaxing outdoors (on the terrace, balcony, in the garden)	*0,940*
During outdoor conversations/conversations	
Sleep disorders	***Cronbach's Alpha***
when falling asleep	
at night, during sleep	*0,971*
when sleeping at the end of the sleep period	

- The statements on climate change and climate protection load on one factor and were summarised accordingly (Table 18).

Table 18: Factor loading of the general statements on climate change and climate protection

	Concerns about climate change
132. Renewable energies generally contribute to climate protection.	0,996
133. Local wind turbines contribute to climate protection.	0,765
131. How concerned are you about climate change?	0,529
Cronbach's Alpha	*0,796*
% of variance per factor	*61,860*

- All seven items on the assessment of the energy transition in Germany load on one factor. Table 19 shows the opposite poles of the semantic differential and the respective factor loadings.

Table 19: Factor loadings of the statements about the energy transition in Germany (semantic differential)

The energy turnaround in Germany is altogether...	Energy transition_advocates
138. unjust | just	0,792
136. uneconomical | economical	0,776
137. damaging to nature | compatible with nature	0,765
139. damaging to the landscape | compatible with the landscape	0,737
135. bad | good	0,661
134. superfluous | desirable	0,635
140. badly implemented | well implemented	0,580
Cronbach's Alpha	*0,874*
% of variance per factor	*50,486*

- The *Perceived Stress Scale (PSS)* has 2 subscales in its original form: *Helplessness* and *Self-efficacy*. In this study, only the helplessness subscale could be replicated and combined into a mean score. The self-efficacy subscale shows a factor loading that is too low for two of the original four items (see Table 20). For this reason, it was decided not to create a second mean scale.

Table 20: Factor loadings of the items of the *Perceived Stress Scale (PSS)*[1]

In the last month, how often have you...	Factor 1: PSS helplessness	Factor 2: PSS self-efficacy
142. ... you felt that you were unable to control the important things in life?	0,782	
143. ... you felt nervous and "stressed"?	0,767	
150. ... felt difficulties were piling up so high that you could not overcome them?	0,683	
146. ... found that you could not cope with all the things that you had to do?	0,604	
149. ... angered because of things that were outside of your control?	0,593	
141. ... have you been upset because of something that happened unexpectedly?	0,443	

[1] In this study the german version of the PSS was used (Büssing 2011), Table 20 shows the original english wording by Cohen and Williamson (1988).

144. ... felt confident about your ability to handle your personal problems?		0,682
147. ... been able to control irritations in your life?		0,510
145. ... felt that things were going your way?		0,399
148. ...felt that you were on top of things?		0,221
Cronbach's Alpha	*0,798*	*0,441*
% of variance per factor	*31,898*	*8,521*
% of the cumulative variance	*31,898*	*40,418*

5 Results of the quantitative survey

The results presented in Chapter 4 serve as a basis for information and decision-making for the orientation of the informational concept on infrasound. First, the sample is presented (section 5.1) and any differences between the study areas are examined (section 5.2). In the following, section 5.3 shows which potential demographic and attitudinal factors, including assessments of infrasound, have an effect on the acceptance of WTs. This already provides a classification of the significance of infrasound for the acceptance of WTs. Subsequently, in section 5.4 results are presented on which of the surveyed factors determine the assessments of infrasound. Finally, on the basis of a selection of these identified factors, in section 5.5 the results of a cluster analysis are described, which aims to identify groups of people as a basis for the personas for which an informational concept is developed in WP3.

5.1 Description of the total sample

A total sample of 340 people was obtained across five study areas. The average age in the sample is M= 57.62 years ± 15.7 (min.-max. 19-90 years), 9 persons did not give any information about their age. In the sample, 173 persons are male and 161 female, no person identified themselves as diverse, six persons did not give any information about their gender. The majority of the sample lives in a detached single-family house (almost 63%) and owns the apartment/house in which they live. The average level of satisfaction with their home is 4.3 (SD± 0.8). The quality of outdoor living is also rated as *rather good* (4) to *very good* (5). The average state of health in the sample is assessed as good (M=2.97, SD=±0.9).

Table 21: Descriptive representation of the total sample

Gender	**N**	**%**
male	173	50,88
female	161	47,35
Age	**N**	**%**
18-29	20	5,88
30-39	33	9,71
40-49	40	11,76
50-59	70	20,59
60-69	88	25,88
70-79	56	16,47
80+	24	7,06
Total	**331**	**97,35**

Note: N = Number.

Table 22: Descriptive representation in the study areas

Gender	No exposure (Hagen, NRW)	WT area N1 Ochtersum	WT area N2 Dornum	WT area S1 Issum	WT area S2 Hilchenbach
male	37	38	34	26	35
female	34	36	30	25	36
Total	**71**	**74**	**64**	**51**	**71**
Age					
18-29	4	5	2	3	6
30-39	7	5	2	13	6
40-49	10	10	7	4	9
50-59	12	20	10	14	14
60-69	15	19	24	7	23
70-79	16	11	15	6	5
80+	6	3	4	3	8
Total	**70**	**73**	**64**	**50**	**71**

Table 23: Ownership status and building type in the total sample

Ownership status	N	%
Owner	282	82,94
Tenant	56	16,47
Total	**338**	**99,41**
Building type	**N**	**%**
detached one-family house	214	62,94
Terraced end house	7	2,06
Mid-terrace house	8	2,35
Semi-detached house	37	10,88
Flat in a multi-storey apartment building	63	18,53
Total	**329**	**96,76**

Table 24: Housing satisfaction in the total sample

	M	*SD*	N	*Min*	*Max*
Housing satisfaction (living environment)	4,26	0,81	335	1	5
Living satisfaction (flat / house)	4,40	0,74	332	1	5
Quality of stay in outdoor living environment	4,20	0,80	335	1	5
Health status	2,97	0,90	333	1	5

Attachment to the place of residence was assessed using a Place Attachment scale (Table 25). On average, all items of the scale receive medium agreement. The statement "I like to explore my area and discover new places" receives slightly higher agreement (M=3.8, SD±1.1).

Table 25: Agreement with statements (in %) that survey attachment to the place of residence (Place Attachment)

Please indicate to what extent you agree with the following statements.	**not (1)**	**a little (2)**	**moderately (3)**	**rather (4)**	**very (5)**	**N**	***M***	***SD***
Even if there are better places, I will not move away from here.	20,1	11,5	17,1	26,5	24,8	339	3,2	1,5
I can't imagine moving away from here.	21,1	16,3	13,9	23,4	25,2	337	3,2	1,5
I never thought about whether it wouldn't be better to live somewhere else.	24,8	18,7	24,8	16,0	15,7	331	2,8	1,4
I wouldn't mind leaving my place of residence and moving somewhere else.	29,4	19,5	20,7	20,4	9,9	333	2,6	1,4
There are many places in Germany and in the world where I could live.	18,1	22,2	26,6	20,6	12,5	320	2,9	1,3
I like to explore my area and discover new places.	5,3	7,8	19,7	37,8	29,4	320	3,8	1,1
I often take photos of different places here.	29,0	23,1	20,9	16,8	10,3	321	2,6	1,3
From time to time I rediscover my area.	10,0	19,0	29,3	30,5	11,2	321	3,1	1,2

It is more important for me how I live than where I live.	12,0	10,2	30,9	27,5	19,4	324	3,3	1,2

Note: N = number. M= mean value. SD= standard deviation.

Furthermore, the participants' sensitivity to various environmental stresses such as noise, odours and low tones was surveyed (Table 26). For noise (M=3.6; SD±1.11) and monotonous buzzing (M=3.38; SD±1.21), the sensitivity was rated on average as moderate to fairly high. The total sample was less sensitive to mobile communications (M=2.4; SD±1.13), power lines (M=2.53; SD±1.18) and weather (M=2.56; SD±0.95).

Table 26: Sensitivity to environmental stresses (in %)

	not (1)	a little (2)	moderately (3)	rather (4)	very (5)	N	M	SD
Odours	5,0	21,9	33,4	26,9	12,7	339	3,20	1,08
Stress in general	7,1	21,4	36,2	27,6	7,7	337	3,07	1,04
Weather	11,5	37,9	37,0	10,1	3,6	338	2,56	0,95
Power lines	23,1	28,5	27,9	13,5	6,9	333	2,53	1,18
Noise	3,9	13,9	23,9	34,2	23,9	330	3,60	1,11
Mobile communications	24,5	32,9	26,6	10,6	5,4	331	2,40	1,13
Bass noises, low tones	10,5	22,5	27,8	23,4	15,9	334	3,12	1,23
monotone hum	8,4	15,8	25,1	30,7	20,0	335	3,38	1,21
Sounds in general	3,6	20,8	40,9	24,9	9,8	337	3,17	0,98

Remark. N = number. M= mean value. SD= standard deviation.

The annoyance caused by the WTs on site in the last 12 months was surveyed overall as well as specifically related to inside and outside (Table 27). Outside, the annoyance caused by WTs is estimated to be higher with M=2.03 (SD±1.36) than inside (M=1.72; SD±1.21), the average annoyance caused by WTs overall is M=2.13(1.35).

Table 27: Annoyance caused by WTs in the last 12 months (in %)

	not at all (1)	slightly (2)	moderately (3)	very (4)	Extremely (5)	N	*M*	*SD*
Total	49,81	15,97	13,69	12,93	7,60	263	2,13	1,35
WT inside	68,82	7,60	11,03	7,98	4,56	263	1,72	1,21
WT outside	54,58	15,27	11,07	10,69	8,40	262	2,03	1,36

Note: N = number. M= mean value. SD= standard deviation.

In order to gain a more detailed insight into the disturbing aspects of the WTs, the disturbance potential of individual aspects of the WTs was surveyed (Table 28). The effect of the WTs on the landscape was judged to be more disturbing (M=2.8, SD± 1.4) (Table 28). In contrast, the lowest average disturbance was caused by shadows cast by the WTs (M=1.8; SD±1.2).

Table 28: Disturbing aspects of WTs in the residential environment (in %)

	not at all (1)	slightly (2)	moderately (3)	very (4)	extremely (5)	N	*M*	*SD*
Sight	34,7	23,7	20,6	14,5	6,5	262	2,3	1,3
Shadow cast	58,1	15,5	13,6	8,9	3,9	258	1,8	1,2
Obstacle marking*	47,1	18,5	15,1	12,7	6,6	259	2,1	1,3
Rotation	51,7	13,9	20,5	9,3	4,6	259	2,0	1,2
Landscape effect	22,6	23,4	18,0	22,2	13,8	261	2,8	1,4

Note: N = number. M= mean value. SD= standard deviation. *Includes nocturnal light signals on the tower of the WT.

In addition to relevant characteristics of WTs, the annoyance caused by various other noise sources in the last 12 months was recorded (Table 29). The annoyance caused by the sources surveyed was on average less than 2= slightly. Road traffic was on average rated as the most annoying (M=1.96; SD±1.06) followed by construction sites (M=1.82; SD±1.01) and the neighbourhood (M=1.76; SD±0.95).

Table 29 : Annoyance from different sources in the last 12 months (in %)

	not at all (1)	slightly (2)	moderately (3)	very (4)	extremely (5)	N	*M*	*SD*
Road traffic	45,1	25,4	19,7	8,1	1,8	335	1,96	1,06
Neighbourhood	51,6	27,5	14,9	4,8	1,2	335	1,76	0,95
Air-source heat pumps	87,9	6,5	4,7	0,0	0,9	340	1,20	0,60
Construction sites	48,3	31,5	11,7	6,3	2,1	333	1,82	1,01
Biogas plants	84,0	8,0	4,9	1,2	1,8	325	1,29	0,78

Note: N = number. M= mean value. SD= standard deviation.

On average, respondents of WT study areas indicated a medium level of agreement to support (M=3.41; SD±1.33), be satisfied with (M=3.27; SD±1.34) and accept (M=3.56; SD±1.3) local WTs (Table 30).

Table 30: Assessment of local WT (in%)

	not (1)	a little (2)	moderately (3)	rather (4)	very (5)	N	*M*	*SD*
I support the wind turbines here.	14,12	9,92	19,85	32,82	23,28	262	3,41	1,33
I am satisfied with the wind turbines here.	16,03	12,98	17,94	34,35	18,70	262	3,27	1,34
I accept the wind turbines here.	11,46	8,30	21,74	29,64	28,85	253	3,56	1,30

Note: N = number. M= mean value. SD= standard deviation.

The participants were asked how infrasound can be perceived in the body (Table 31), a multiple choice of answers was possible here. 12.2% stated that it can be perceived with the ears, another 34.9% stated that it can be perceived with the ears, but not as a sound. 26% stated that they could not perceive it at all.

Table 31: Perception of infrasound

How do you think infrasound can be perceived? Infrasound can be...	yes	Not selected	N
...perceived with the ears.	12,2	87,8	279
...perceived with the ears, but not as a sound.	34,9	65,1	298
...felt as vibrations in the building and other objects.	26,5	73,5	291
...felt as vibrations in different parts of your own body.	28,0	72,0	300
...perceived with no senses, but affects me in a different way and triggers physical discomfort.	36,8	63,2	291
...not perceived at all.	26,0	74,0	288

Furthermore, the participants were presented with general statements on infrasound, to which they were asked to assess their agreement (Table 32). Higher average agreement values were obtained for the statements that information about WTs should be understandable and usable for residents (M=4.02; SD±1.21) and that the effects of infrasound from WTs on humans have not yet been sufficiently researched (M=3.19; SD±1.23). On the other hand, there was little agreement with the statement that the proximity to a WT causes anxiety due to infrasound (M=2.07; SD±1.2).

Table 32: Agreement with statements about infrasound (in %)

	not (1)	a little (2)	moderately (3)	rather (4)	very (5)	N	*M*	*SD*
Concerns about health risks due to infrasound from wind turbines are justified.	16,88	27,71	27,71	18,15	9,55	314	2,76	1,21
Because of the infrasound, the proximity to the wind turbine triggers anxiety in me.	44,98	22,65	17,48	10,36	4,53	309	2,07	1,20
When you express concerns about infrasound from wind turbines, you are not taken seriously by family and friends.	32,08	24,57	33,45	7,85	2,05	293	2,23	1,05
If you express concerns about infrasound from wind turbines, you are not taken seriously by operators and authorities.	24,56	17,19	25,61	18,25	14,39	285	2,81	1,37
Effects of infrasound from wind turbines on humans have not yet been adequately researched.	13,61	12,59	29,25	30,27	14,29	294	3,19	1,23
Infrasound from wind turbines has a negative effect on sleep.	21,84	21,16	27,65	19,45	9,90	293	2,74	1,27
You can get used to infrasound from wind turbines.	30,94	17,99	33,45	13,67	3,96	278	2,42	1,17
Infrasound from wind turbines is no different from naturally occurring infrasound.	25,65	16,73	37,17	13,75	6,69	269	2,59	1,20
Information on infrasound from wind turbines must be understandable and usable for residents.	8,84	2,72	11,22	32,31	44,90	294	4,02	1,21
I form my opinion about infrasound from wind turbines based on the	37,59	23,79	25,17	9,31	4,14	290	2,19	1,16

experience of friends and family.								
Helpful information on infrasound from wind turbines can only be found at public authorities.	37,41	24,46	26,26	8,63	3,24	278	2,16	1,12

Note: N = number. M= mean value. SD= standard deviation.

Respondents were asked about their attitudes towards climate change and the energy transition (Table 33). The average concern about climate change was relatively strong with M=3.76 (SD±0.98). Higher agreement was also given to the statements that renewable energies (M=4.04; SD±1.2) and local WTs contribute to climate protection (M=3.73; SD±1.13).

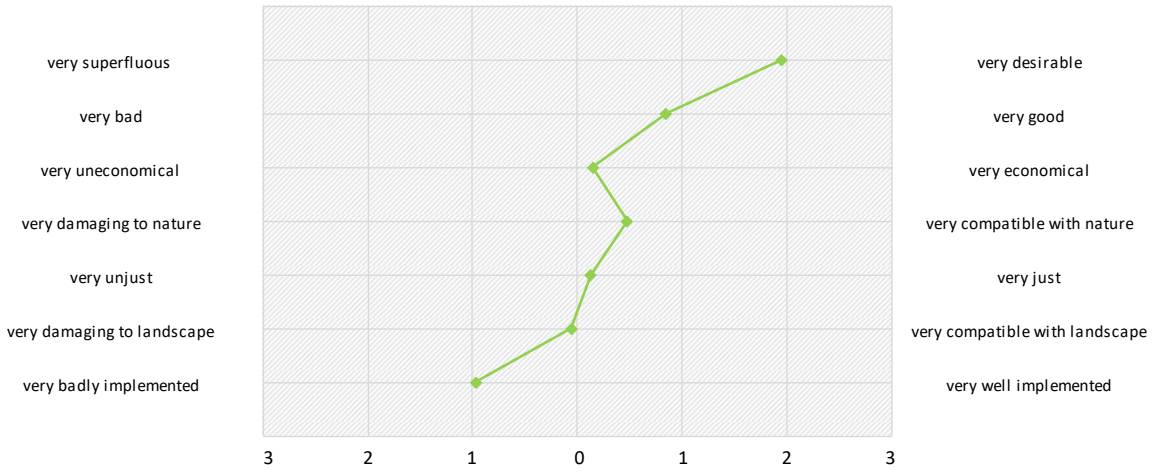
Table 33: Attitudes towards climate change and renewable energies (in %)

Concern about climate change	**not at all (1)**	**slightly (2)**	**moderately (3)**	**very (4)**	**Extremely (5)**	**N**	**M**	**SD**
How concerned are you about climate change?	2,09	9,85	20,60	45,37	22,09	335	3,76	0,98
Renewable energies and climate protection	**not (1)**	**a little (2)**	**moderately (3)**	**rather (4)**	**very (5)**	**N**	***M***	***SD***
Renewable energies generally contribute to climate protection.	2,69	4,78	17,01	37,01	38,51	335	4,04	0,99
The local wind turbines contribute to climate protection.	4,21	11,11	21,46	33,72	29,50	361	3,73	1,13

Note: N = number. M= mean value. SD= standard deviation.

Attitudes towards the energy transition were additionally queried on the basis of several individual aspects on a semantic differential (Figure 8). The results show that although the energy transition is considered desirable on average, it is considered to be poorly implemented. For some questions, the majority tends towards the assessment “neither nor”, for example, the energy transition is not clearly assessed as damaging to the landscape nor as compatible with it.

Figure 8: Attitudes towards the energy transition in Germany



Source: own representation, ZEUS GmbH

Furthermore, individual stress items were assessed, the individual results of which are shown in Appendix C.1.

5.2 Group comparison between the areas

In order to check whether the mean values of the relevant variables differ significantly within the study areas and not merely a random variation of the data, an analysis of variance can be applied (Backhaus et al. 2016, p. 174). With an analysis of variance, the effect of a factor, here the study area, on one or more dependent variables can be examined. If there are several dependent variables, it is generally advisable to conduct a MANOVA (Multivariate Analysis of Variance) instead of an ANOVA (Analysis of Variance), as this only examines the effect of an independent variable on a single dependent variable (Johnson and Wichern 2007, p. 296 ff.). A MANOVA, on the other hand, can evaluate the effect of a factor on several dependent variables simultaneously and also examine the relationship between the dependent variables (Warne 2014, p. 2-3). By additionally considering the covariances and correlations of the dependent variables, the probability of an alpha error is significantly reduced (Warne 2014, p. 2-3). The descriptive statistics of the dependent variables in the one-factor MANOVA can be found in the Appendix C.2.1.

Only those variables that were statistically significant in the previous regression analyses and whose regression coefficients indicated a measurable influence on WT acceptance are to be taken into account. Moreover, the acceptance of WTs is also included as a dependent variable, as here, too, the consideration of the mean values in the individual study areas is of interest.

In order to be able to conduct a MANOVA, however, certain requirements must be met (Tabachnick and Fidell 2013, p. 252 ff.). Some of these, such as the independence of the measurements, the required scaling of the variables or also the sample size are already fulfilled by the study design (Tabachnick and Fidell 2013, p. 252 ff.). The avoidance of univariate outliers is also easier to realise with the used 5-level interval scales and could be implemented accordingly. Other prerequisites such as linearity, no multicollinearity or homoscedasticity could not initially be fulfilled when all the intended variables were included. In order to ensure the validity of the results, the variables that did not lead to non-compliance with the prerequisites

were therefore included in the MANOVA. Linearity, no multicollinearity, homoscedasticity and the avoidance of multivariate outliers could be met with the following variables:

- WT concerns;
- positive WT attitudes;
- Concerns about climate change;
- Technology Trust;
- WT acceptance;
- authenticity of the WT stakeholders.

Only the multivariate normal distribution and the homogeneity of the covariance matrices were not consistently given. However, the one-factor MANOVA is considered robust even with heterogeneous covariance matrices and non-existent normal distribution from a sufficient sample size per factor, which is present in this study (for this, see Seo et al. 1995; or Tabachnick and Fidell 2013, p. 253). Ateş et al. (2019) also point out that the Wilks-Lambda statistic provides the most robust results in this case.

The prerequisites for a MANOVA are therefore sufficiently fulfilled. The results of the MANOVA carried out are therefore presented and classified below.

The single factor MANOVA showed a statistically significant difference between the study areas for the combined dependent variables ($F(24, 354.44) = 3.78$, $p<0.001$, partial $\eta^2 = 0.2$, Wilk's $\Lambda = 0.52$).

Post-hoc, a one-factor ANOVA was conducted for each dependent variable. There was a statistically significant difference between the areas for all dependent variables except for technology confidence and concern about climate change (see Appendix C.2.2). To determine where exactly the differences occurred, between-group post-hoc tests were calculated with all significant ANOVAs (see Appendix C.2.3 statistically significant differences were marked with an asterisk). Since there is no homogeneity of the covariance matrices, the Games-Howell test is always interpreted. The Games-Howell test showed a significant difference between areas N1 and S2 for the acceptance of WT ($p < .001$ (MDiff = -1.091, 95%-CI[-1.76, -0.42])) and areas N1 and S2 ($p < .001$ (MDiff = -1.2532, 95%-CI[-2.04,-0.47])).

The average acceptance for WT on a 5-point scale is 1.091 points lower in study area N1 than in area S2. For concerns about WTs, the LSD post-hoc test shows significant differences between areas N1 and S2, $p < .001$ (MDiff = 1.05, 95%-CI[0.53, 1.57]), areas N2 and S2, $p < .01$ (MDiff = 0.8423, 95%-CI[0.26, 1.43]), and S1 and S2, $p < .01$ (MDiff = 0. 7267, 95%-CI[0.1, 1.37]). Significant differences in positive WT attitudes exist between areas S1 and S2, $p < .01$ (MDiff = -0.6415, 95%-CI[-0.14, -0.15]. There were significant differences in authenticity of WT stakeholders between areas N1 and S2, $p < .001$ (MDiff = 1.1588, 95%-CI[-1.67, -0.65], areas N2 and S2 $p < .001$ (MDiff = -1.0854, 95%-CI[-1.66, -0.51] and areas S1 and S2, $p < .05$ (MDiff = -0.6831, 95%-CI[-1.27, -0.09].

5.3 Results of regression analyses on the acceptance of WTs

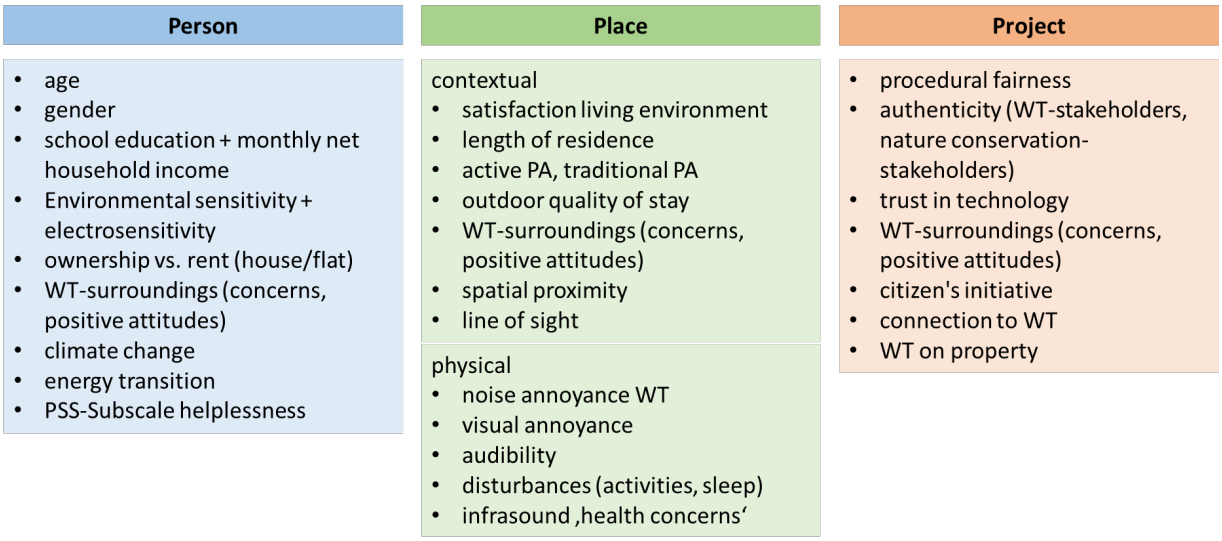
In a first block of regression analyses, the effect of various independent variables across the four spheres of influence on the acceptance of WTs was investigated.

To account for the different areas of acceptance of WTs, Devine-Wright and Wiersma (2019) divided the evaluations of their study into three areas of influence: Person, Place and WT

project. In their work on categorising determinants of WT acceptance, Emig and Kastner (2020) have subdivided the results of their review even more finely, e.g. the area of location. This categorisation and subdivision is transferred to the core variable infrasound in the following evaluations. The Figure 9 shows the distribution of potential influence variables and scales among the mentioned study areas. This breakdown was used for regression analyses on the acceptance of WTs as well as on opinions and attitudes towards infrasound.

Among the models related to the acceptance of WTs, the ones shown in Figure 9 were supplemented by the infrasound factors 1 (health concerns) and 2 (social debate).

Figure 9: Spheres of influence and variables on the acceptance of WTs and opinions and attitudes towards infrasound



Source: own representation, ZEUS GmbH, PA = place attachment (Devine-Wright 2009)

5.3.1 Personal characteristics and acceptance of WTs

The person-related variables clear up 72.6% of the variance for acceptance of WTs (WT acceptance) (corr. $R^2 = .726$, $F\,(12,191) = 45.862$, $p < .000$). The largest significant contributors to enlightenment are concerns about WTs, followed by positive attitudes towards WTs and concerns about climate change. The socio-demographic characteristics do not contribute statistically significantly to the variance elucidation of WT acceptance (see Table 34). In particular, the lower the WT concerns, the stronger the positive WT attitudes and the concern about climate change, the higher the WT acceptance turns out to be.

Table 34: Influence of the people variables on the acceptance of WTs

	Acceptance of the WT		
Person variables	**B**	**Beta**	**p**
Age	-0,005	-0,059	0,171
Gender	-0,051	-0,020	0,599
School education	0,037	0,048	0,272
Monthly net household income	0,006	0,008	0,858

Environmental sensitivity	-0,093	-0,061	0,208
Electrosensitivity	-0,053	-0,045	0,331
Ownership vs. rent	0,021	0,006	0,880
WT concerns	**-0,570**	**-0,466**	**0,000**
positive WT attitudes	**0,360**	**0,238**	**0,000**
Concern about climate change	**0,335**	**0,230**	**0,000**
Advocacy of the energy transition	0,031	0,034	0,505
PSS helplessness	-0,047	-0,027	0,509

* significant results are marked **in bold** ($p < 0.05$)

5.3.2 Context and acceptance of WTs

The context variables also explain 71.8% of the variance (corr. $R^2 = .718$, $F(10,183) = 50.043$, $p < .000$). Concerns about WTs and positive attitudes towards WTs make a highly significant contribution to the explanation of variance. A small statistically significant explanatory share is provided by the quality of time spent outdoors and the duration of residence (see Table 35). Again, lower levels of WT concerns and higher levels of positive WT attitudes are associated with higher WT acceptance. If the quality of time spent outdoors is assessed as higher, this is associated with a higher acceptance of WTs.

Table 35: Influence of context variables on the acceptance of WTs

	Acceptance of the WT		
Context variables	**B**	**Beta**	**p**
Satisfaction living environment	-0,052	-0,035	0,478
Satisfaction apartment/house	-0,002	-0,001	0,973
length of residence	-0,005	-0,061	0,134
active place attachment	-0,003	-0,002	0,955
traditional place attachment	0,017	0,017	0,675
Outdoor quality of stay	**0,184**	**0,115**	**0,019**
spatial proximity	0,048	0,041	0,322
Line of sight	0,007	0,001	0,972
WT concerns	**-0,669**	**-0,547**	**0,000**
positive WT attitudes	**0,550**	**0,358**	**0,000**

* significant results are marked **in bold** ($p \leq .05$)

5.3.3 Physical variables and acceptance of WTs

The variance of the acceptance of WTs is explained to 69.1% by the physical variables (corr. R^2 = .691, F (11,196) = 43.180, p < .000). The highest proportion (significant) is explained by the visual annoyance caused by WTs, followed by infrasound factor 1 (health concerns), as well as noise annoyance caused by WTs overall (see Table 36). The lower the visual and noise-related annoyance caused by WTs and the lower the health concerns about infrasound, the higher the acceptance of WTs.

Table 36: Influence of physical variables on the acceptance of WTs

	Acceptance of the WT		
physical variables	**B**	**Beta**	**p**
Total noise annoyance from wind turbines	**-0,200**	**-0,212**	**0,004**
Visual annoyance caused by wind turbines	**-0,496**	**-0,418**	**0,000**
Audibility of noise from wind turbines...			
...general	0,114	0,044	0,514
...when staying outside the house	0,070	0,027	0,697
...indoors with the window open	-0,284	-0,105	0,107
...indoors with the window closed	-0,076	-0,018	0,764
Activity disturbance - indoors due to wind turbine noise	-0,023	-0,013	0,887
Activity disturbance - outside due to wind turbine noise	-0,056	-0,048	0,590
Sleep disturbance due to wind turbine noise	0,083	0,068	0,507
Infrasound factor 1 - health concerns	**-0,363**	**-0,299**	**0,000**
Infrasound Factor 2 - social debate	0,057	0,048	0,274

* significant results are marked **in bold** (p ≤ .05)

5.3.4 Project-related variables and acceptance of WTs

The project- or process-related variables explain 72.3% of the variance (corr. R^2 = .691, F (11,196) = 43.180, p < .000). The largest share is also provided by concerns about WT (negatively pronounced) and positive attitudes towards WT. Other significant proportions are provided by the assessed authenticity of WT stakeholders and trust in the technology (see Table 37). The higher the authenticity of the WT stakeholders, the technology trust and the positive WT attitudes and the lower the WT concerns, the higher the WT acceptance.

Table 37: Influence of project- or process-related variables on the acceptance of WTs

Project- or process-related variables	Acceptance of the WT		
	B	Beta	p
Procedural fairness	0,024	0,018	0,823
authenticity of the WT stakeholders	**0,314**	**0,245**	**0,004**
authenticity of nature conservation stakeholders	0,072	0,060	0,284
Technology Trust	**0,257**	**0,150**	**0,024**
WT concerns	**-0,421**	**-0,321**	**0,000**
positive WT attitudes	**0,421**	**0,262**	**0,001**
Active in a citizens' initiative or other association concerned with wind turbines.	-0,016	-0,004	0,942
Connection to WT...			
...employment relationship	0,370	0,059	0,256
...financial participation (other than employment relationship)	0,125	0,026	0,635
...electricity cost savings in the household	-0,250	-0,024	0,630
...economic/financial advantage of the municipality	0,100	0,035	0,488

* significant results are marked **in bold** ($p \leq .05$)

Overall, the results of the regression analyses on WT acceptance show that infrasound, especially health-related concerns about the effects of infrasound, plays an important role in WT acceptance. However, the results also show that other attitudinal factors related to the turbine and the process of erection and operation, as well as the perception of the physical characteristics of the WTs (visual, noise-related annoyance) and the local context (quality of stay outdoors), co-determine the acceptance of WTs - sometimes to a greater extent.

5.4 Results of regression analyses on opinions and attitudes towards infrasound

Seven regression analyses were carried out with opinions and attitudes towards infrasound as the dependent variable and various potential influencing variables. Firstly, it was analysed which variables were selected from the variables shown in Figure 9 have an influence on factor 1 infrasound - health concerns and on factor 2 infrasound - social debate. Subsequently, analyses were carried out for each of the individual 5 infrasound items that were not combined in a mean value scale.

The above divisions resulted in 6 x 4 multiple regression analyses. At this point, those results are presented in which the respective variable sets significantly explain a variance > 10%.

Influencing factors identified as relevant in the regression analyses were subsequently subjected to a cluster analysis in a further step to identify groups of people for a possible target group-specific approach within the framework of an information/awareness campaign (see section 5.5). Influencing factors with an explanatory share (regression weight) of at least one beta > 0.100 and a significance level of p < 0.20 were considered relevant. In these analyses, a higher significance level than the conventional level of 5% (p = 0.05) was applied in order not to prematurely exclude descriptive characteristics of clusters of persons relevant for the cluster analysis, whose influence weight in the multiple regression analyses might not become significant in the context of partly correlating co-predictors, although they would be useful for the description of groups of persons and a communication based on them.

5.4.1 Personal characteristics and infrasound

The personal characteristics with all 12 variables explain 50.9% of the variance of the first factor infrasound - health concerns (corr. R^2 = .509, F (12,186) = 18.083, p < .000). In particular, the WT concerns explain a higher proportion of the variance of the factor "health concerns about infrasound" compared to the other variables included in the model. A smaller but statistically significant share is explained by positive attitudes towards WT (negative expression), environmental sensitivity, attitudes towards climate change, helplessness and gender. The personal variables can only explain up to 10% of the variance of the second factor infrasound - social debate and the other items on opinions on infrasound.

The following Table 38 shows the statistical parameters for the influence of the personal variables on the first factor of infrasound (health concerns):

Table 38: Influence of personal variables on health concerns about infrasound

	Factor 1: health concerns		
Person variables	**B**	**Beta**	**p**
Age	-0,002	-0,028	0,629
Gender	**-0,220**	**-0,102**	**0,055**
School education	0,023	0,034	0,564
Monthly net household income	-0,003	-0,004	0,948
Environmental sensitivity	**0,198**	**0,150**	**0,023**
Electrosensitivity	-0,019	-0,019	0,761
Ownership vs. rent	0,013	0,004	0,938
WT concerns	**0,507**	**0,482**	**0,000**
Positive WT attitudes	**-0,272**	**-0,209**	**0,003**
Concern about climate change	**-0,192**	**-0,154**	**0,039**
Advocacy of the energy transition	0,073	0,092	0,210
PSS helplessness	**0,158**	**0,106**	**0,056**

* Results with a significance level of p < .20 are marked **bold**

Concerns about infrasound health effects are higher the higher the WT fears and the lower the positive WT attitudes and climate change concerns are. Men are more likely to fear infrasound-related health effects than women.

5.4.2 Context and infrasound

The variance explanation of the context variables clearly exceeds the threshold of 10% only for infrasound factor 1 - health concerns (corr. R^2 = .524, F (10,180) = 21.897, p < .000). With a variance resolution of 52.4%, the concerns about the WTs as well as the positive attitudes towards the WTs (negatively pronounced) result in a high significant proportion. The *active place attachment* has a further lower proportion (see Table 39).

The variance explanation for the second infrasound factor – social debate – is quite low at 16.6% (corr. R^2 = .166, F (10,173) = 4.642, p < .000). Here, too, the highest significant share of the variance is accounted for by the concerns of WTs and the positive attitudes towards WTs (negative). This is followed by quality of stay outdoors as well as active and traditional place attachment (see Table 39).

The health concerns about infrasound are therefore associated with a higher *active place attachment*, a higher level of concerns about WTs and lower positive attitudes towards WTs. The social confrontation with infrasound, which is assessed as low/absent, is determined by a lower satisfaction with the apartment/house, a higher active and traditional place attachment and a higher perceived quality of stay outdoors.

Table 39: Influence of context variables on attitudes towards infrasound

	Factor 1: health concerns			Factor 2: social debate		
Context variables	**B**	**Beta**	**p**	**B**	**Beta**	**p**
Satisfaction living environment	-0,058	-0,045	0,493	0,015	0,012	0,894
Satisfaction apartment/house	0,020	0,014	0,808	**-0,178**	**-0,124**	**0,105**
Duration of residence	0,001	0,010	0,850	0,001	0,008	0,914
active place attachment	**0,131**	**0,120**	**0,024**	**0,156**	**0,148**	**0,038**
traditional place attachment	-0,019	-0,021	0,692	**0,168**	**0,197**	**0,008**
Outdoor quality of stay	-0,056	-0,040	0,526	**0,209**	**0,156**	**0,073**
Spatial proximity of WTs	-0,060	-0,059	0,277	-0,111	-0,113	0,125
Visual contact with wind turbines	0,082	0,020	0,708	0,049	0,012	0,866
WT concerns	**0,583**	**0,542**	**0,000**	**0,243**	**0,233**	**0,010**
Positive WT attitudes	**-0,313**	**-0,231**	**0,000**	**-0,245**	**-0,188**	**0,030**

* Results with a significance level of p < .20 are marked **bold**

5.4.3 Physical variables and infrasound

The physical variables clarify for the 1st factor (infrasound - health concerns) 49.8% of the variance (corr. R^2 = .498, F (9,205) = 24.603, p < .000), with general noise annoyance from WTs contributing the significantly largest proportion of the clarification, followed by visual annoyance, sleep disturbance and audibility when in the garden, on the balcony or terrace.

The variance of the second factor (infrasound - social debate), on the other hand, is only explained to 11.8% by the physical variables (corr. $R^2 = .118$, F (9,199) = 4.084, p < .000). A significant proportion of this is explained by the audibility of the noise of a WTs when staying in the flat or house with the window open, followed by the total noise immission caused by WTs.

A similarly low variance explanation is found for item 117 ("If one expresses concerns about infrasound from WTs, one is not taken seriously by family and friends") (corr. $R^2 = .114$, F (9,188) = 3.804, p < .000). A significant contribution to the variance is made by the disturbance of activities outside the house/apartment, followed with a smaller share by the audibility of the noise in general and indoors with an open window, as well as the total noise disturbance caused by WTs.

Health concerns about infrasound are higher with higher noise and visual annoyance from WTs and lower audibility of WT noise outside the house. The latter seems counterintuitive at first. On the other hand, lower audibility of WT noise may mean that there is greater concern that infrasound (usually described as inaudible) may pose an (unrecognised) health threat.

Table 40: Influence of physical variables on attitudes towards infrasound

	Factor 1: health concerns			Factor 2: social debate			Item 117		
Physical variables	**B**	**Beta**	**p**	**B**	**Beta**	**p**	**B**	**Beta**	**p**
Total noise pollution from wind turbines	**0,289**	**0,365**	**0,000**	**0,197**	**0,250**	**0,031**	**0,134**	**0,172**	**0,148**
Visual annoyance caused by wind turbines	**0,286**	**0,288**	**0,000**	**0,169**	**0,171**	**0,091**	0,090	0,092	0,373
Audibility of the noise from wind turbines									
...general	0,178	0,083	0,331	-0,324	-0,150	0,185	**-0,384**	**-0,180**	**0,131**
...when staying outside the house	**-0,380**	**-0,177**	**0,043**	-0,184	-0,085	0,463	0,212	0,099	0,411
...indoors with the window open	-0,147	-0,065	0,410	**0,681**	**0,299**	**0,005**	**0,400**	**0,178**	**0,101**
...indoors with the window closed	-0,193	-0,055	0,470	0,108	0,031	0,761	-0,113	-0,033	0,750
Activity disturbance - indoors due to wind turbine noise	0,196	0,130	0,258	0,035	0,024	0,879	-0,133	-0,092	0,575
Activity disturbance - outside due to wind turbine noise	-0,016	-0,016	0,887	-0,170	-0,172	0,245	**0,251**	**0,261**	**0,092**
Sleep disturbance due to wind turbine noise	**0,184**	**0,180**	**0,165**	-0,035	-0,034	0,844	-0,133	-0,134	0,461

* Results with a significance level of p < .20 are marked **bold**

5.4.4 Project or process-related variables and infrasound

The project- or process-related variables clarify 59.1% of the variance for factor 1 (infrasound - health concerns) (corr. R^2 = .591, F (11,107) = 16.487, p < .000), whereby the concern about WTs contribute the largest significant share to the clarification, followed by the authenticity of the stakeholders. The positive attitudes towards WTs only explain a small proportion of the variance of factor 1, but are taken into account in the following cluster analysis.

The results on the process variables illustrate that the lower the authenticity of WT stakeholders and, to a lesser extent, the positive WT attitudes, the higher the overall WT concern and the higher the health concerns about infrasound.

Table 41: Influence of project- or process-related variables on attitudes towards infrasound

	Factor 1: health concerns		
Project- or process-related variables	**B**	**Beta**	**p**
Procedural fairness	0,040	0,035	0,719
Authenticity of the WT stakeholders	**-0,328**	**-0,299**	**0,003**
Authenticity of nature conservation stakeholders	-0,086	-0,084	0,221
Technology Trust	0,142	0,099	0,234
WT concerns	**0,585**	**0,524**	**0,000**
positive WT attitudes	**-0,174**	**-0,127**	**0,181**
Active in a citizens' initiative or other association concerned with wind turbines.	-0,158	-0,046	0,477
Connection to WT...			
...employment relationship	0,042	0,008	0,899
...financial participation (other than employment relationship)	-0,128	-0,031	0,641
...electricity cost savings in the household	-0,168	-0,019	0,753
...economic/financial advantage of the municipality	0,125	0,051	0,406

* Results with a significance level of p < .20 are marked **bold**

Overall, it can be seen that factor 1 - health concerns about infrasound - is best explained across all other factors and individual items. The project- or process-related variables are most likely to have an effect (59.1% variance explanation), followed by the personal variables (51.3% variance explanation) and the physical variables (49.8% variance explanation).

5.5 Cluster analysis for the identification of infrasound and WT relevant groups of people

Based on the results of the study presented in the previous section 5.3, the next step is to use the opinions on infrasound, the most important influencing factors and basic socio-demographic factors to form subgroups of people who have characteristics, attitudes and perceptions that are as homogeneous as possible within the group and who differ between the groups. The statistical method used for this was hierarchical cluster analysis, which classifies people on the basis of variables (Backhaus et al. 2016). The square of the Euclidean distance was used as the distance measure and the Ward method as the cluster method. The following criteria were used for the inclusion of variables in the cluster analysis:

1. Basic inclusion of socio-demographic factors gender, age, highest formal school-leaving qualification, home ownership (renting vs. owning).
2. Basic inclusion of the summary factors on the opinion on infrasound, i.e. factor 1 - health concerns and factor 2 - societal engagement with the phenomenon of infrasound.
3. Further variables as far as they have a significant influence weight in at least one of the area-specific regression analyses on the opinions on infrasound, whereby the weight was set as significant at a beta > 0.10 and a significance level of $p < 0.20$.
4. The variables selected according to criterion 3 should not be highly correlated with each other, as this reduces the robustness of the results of the cluster analysis (Backhaus et al. 2016). A high positive or negative correlation was defined as a value of the product-moment correlation of $|r| > 0.70$. This is based on the consideration that, as a rule of thumb, the variables selected according to criterion 3 should not be highly correlated with each other. This setting follows the consideration that as a rule of thumb for reliability measures such as a Cronbach's alpha (in terms of content, the average correlation between responses to all individual questions [items] of a scale) in the amount of $\alpha \geq 0.70$ is to be considered acceptable (Nunnally & Bernstein 1994). This means that below an $\alpha = 0.70$, the answers to individual items would no longer be considered to belong consistently to each other. Accordingly, if the amount of intercorrelation of the variables selected for the cluster analysis is $|r| \geq 0.70$, one of the variables involved is excluded.
5. Inclusion of variables with a number of missings < 50%.

The application of the criteria led to the following selection of variables for cluster analysis:

- Gender[2] (with 1 = woman and 0 = man)
- Age in years
- School education, hierarchically coded in 4 levels from "no qualification" to "university entrance qualification"
- Net household income, hierarchically coded in 7 levels
- Home ownership (with 1 = ownership and 0 = rent)
- Number of persons in the household
- Infrasound factor 1 - Health concerns
- Infrasound factor 2 - Social debate

[2] As no participant identified themselves as diverse, a corresponding coding was not made at this point.

- Environmental sensitivity
- PSS helplessness
- Satisfaction with the apartment/house
- active place attachment
- traditional place attachment
- Quality of stay in the outdoor area
- WT concerns
- Positive WT attitudes
- Concerns about climate change
- Advocacy of energy transition
- Audibility of WTs - outdoors
- Audibility of WTs - indoors
- Sleep disturbance due to WT noise

The following variables that met criterion 3 were excluded according to criterion 4 (correlation amount with other variable equal to $|r| > 0.70$):

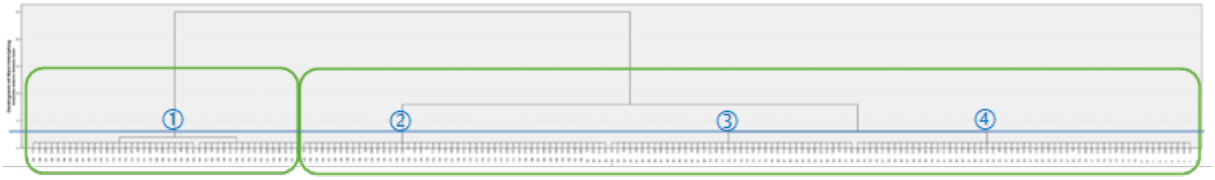
- Noise annoyance WT overall, activity disturbance due to WT noise outside and visual WT annoyance, as these correlate with each other and with the variable "WT concerns" remaining in the cluster analysis with $|r| > 0.70$.
- Audibility of WTs as a whole, as this correlates highly with audibility outdoors and indoors, but the latter correlate with each other with $|r| < 0.70$.
- Acceptance of WTs, as this correlates with the annoyance variables (noise, visual) and the WT attitude variables with $|r| > 0.70$.
- The authenticity of WT stakeholders, as due to the filtering by living in the residential area prior to the construction of the local WT, more than half of the respondents did not answer the questions on credibility.

With the help of the hierarchical cluster analysis with the included variables, 178 persons could be classified, the remaining persons were excluded from the analysis due to missing information. With regard to the "optimal" number of clusters, it is necessary to weigh up the "homogeneity requirement for the cluster solution" (homogeneity of the persons within a cluster) and the "manageability of the cluster solution" (manageable, small number of clusters) (Backhaus et al. 2016).

Decision-making tools include a consideration of increasing heterogeneity as the number of clusters decreases. The dendrogram in Figure 10 shows in overview the gradual summary classification of individuals - starting with individuals at the lower level and increasing aggregation into clusters towards the top. At first glance, two larger clusters seem to emerge (in Figure 10 framed in green). A non-hierarchical two-step cluster analysis carried out as a control, in which mixed scaled variables, i.e. variables in their original categorical gradation (e.g. home ownership, schooling) can be included together with metric variables (e.g. attitude scores), also

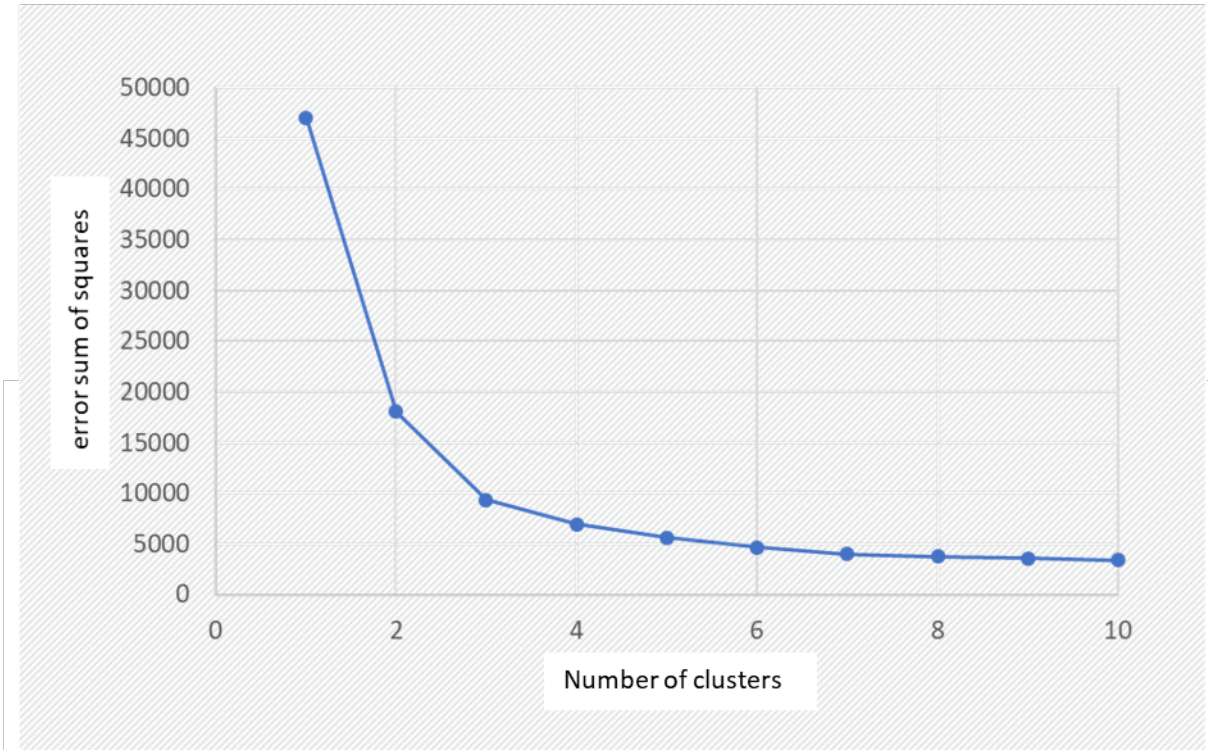
yields a two-cluster solution (not shown here). These clusters can be identified from the expressions of the included variables as groups of people who have a lower acceptance of WTs and stronger, especially health-related concerns regarding infrasound and, on the other hand, a more positive acceptance of WTs with fewer concerns regarding the effects of infrasound. The "Elbogen criterion" (Backhaus et al. 2016), which is derived from the scree plot in Figure 11 refers to a "kink" in the course of the decreasing error sum of squares with increasing number of clusters. A first, clear (elbow) kink can be seen with a two-cluster solution, although further kinks can be seen with three and four clusters, but hardly any with five or more clusters.

Figure 10: Dendrogram of the cluster analysis across the survey cases (n = 207)



Source: own representation, ZEUS GmbH

Figure 11: Scree plot for error sum of squares of cluster solutions, plotted against number of clusters



Source: own representation, ZEUS GmbH

For an informational concept on the phenomenon of "infrasound", a very strong grouping of people into two groups, supporters and opponents of a technical infrasound emitting plant, would not be very effective, as both groups would be too heterogeneous for a target group-specific communication based on personas. Therefore, the choice of the number of clusters also takes into account the objective of finding a number of groups of people that enable a more target group-specific approach. Figure 11 still shows an "elbow bend" with four clusters; the dendrogram shows that when four clusters are combined into three (above the blue line), there

is still a higher jump in heterogeneity, so that a four-cluster solution is overall the one proposed for the further course of the project and especially as one of the bases for decision-making for the development of an informational concept.

The individuals divided into four clusters show the characteristics listed in Annex C.3 The table also includes characteristics that were not included in the cluster analysis, but which serve here as a supplementary, rounded-off description of the clusters of persons.

Overall, the cluster analysis shows that apart from the division into groups of people with lower and higher acceptance of WT, further statistically differentiable clusters can be identified, but these hardly have any "handy" distinguishable personal characteristics that can serve as a basis for the personas originally planned for the informational concept. The personas approach was therefore not pursued further within the framework of the informational concept and a target group definition was formulated for content-related considerations (see section 6.1).

5.6 Conclusions

In the quantitative survey, 340 people from five study areas were asked about their acceptance of WTs. The areas are four wind farm areas, two of which are in Lower Saxony and two in North Rhine-Westphalia, as well as a control area in North Rhine-Westphalia that is not visibly affected by infrasound.

The survey showed that infrasound from WTs, and in particular concerns about negative health effects from infrasound, has an influence on the acceptance of WTs. However, the results also show that infrasound does not have by far the greatest influence on WT acceptance in terms of effect strength. Other, attitude-related factors, such as attitudes towards WTs and WT stakeholders and technology trust, play a much greater role.

- This means that the approaches of Devine-Wright and Wiersma (2019) and Emig and Kastner (2020) were used to examine person-related, local and project-related variables influencing the acceptance of wind farms. If we look at the influence of person-related characteristics on acceptance, we see on the one hand that above all attitude-related and emotion-based characteristics have an influence on acceptance. On the other hand, socio-demographic characteristics do not contribute significantly to the acceptance of WTs.
- In terms of location, both the quality of stay outdoors in the residential environment and the visual impairment in the residential environment by the WTs play a role in the acceptance of WTs.
- As process or project-related factors influencing the acceptance of WTs, the results of the group differences confirm that the authenticity of WT stakeholders, positive attitudes and concerns regarding WTs were identified as important determinants.
- If the subsamples of the study areas with different infrasound sources in the neighbourhood are compared, it becomes apparent that they do not differ with regard to trust in technology and the degree of concern about climate change. Differences can be seen in the concern about WTs, the positive attitude towards WTs, the acceptance of WTs and in the assessment of the authenticity of WT stakeholders. Especially in areas with a higher acceptance of WTs, there is a lower level of concerns regarding WTs, a more positive attitude towards WTs and a more positive assessment of the authenticity of WT stakeholders.
- One of the goals of the quantitative survey was to identify subgroups that differ in their attitudes and personal characteristics by means of a cluster analysis of the respondents with

regard to their acceptance of WT and the influencing factors related to it, and thus form a basis for the personas to be developed in the informational concept as a basis for target group-specific communication. It turned out that only two stable clusters were formed, one group with high and one group with low WT acceptance. These two groups appear to be too rough for the development of personas for the informational concept, so that the persona concept was given up.

6 Development of an informational concept

The informational concept translates the scientific knowledge gained in work packages 1 and 2 into a practically implementable communication plan. For this purpose, a detailed communication strategy and a detailed plan for three measures were developed. The measures are an information brochure, infographics and teaching suggestions on the topic of infrasound.

6.1 Communication strategy

The results from work packages 1 and 2 were discussed at a kick-off workshop. The main finding was that the clusters formed in these work packages did not differ significantly, so that the originally planned persona approach was not pursued further. Instead, three target groups were defined for the approach.

6.1.1 Target groups

- People who know little or nothing about infrasound;
- Residents of WTs who feel annoyed by infrasound;
- Pupils.

The three target groups are not sharply delineated, overlaps are possible. What they have in common is that early education about infrasound in all three groups can help them to make informed assessments of statements about infrasound and to develop resilience to activities aimed at fuelling unfounded concerns about the effects of infrasound on humans.

6.1.2 Aims of communication

In order to inform the target groups about infrasound, three specific communication objectives were defined:

- The target groups are less concerned about damage to health from infrasound.
- The target groups have basic knowledge about infrasound - in general and in relation to WTs.
- The target groups trust the communication.

All objectives are interlinked: if the target groups trust the communication, the education succeeds. This reduces concerns about damage to health caused by infrasound.

6.1.3 Core elements of the communication strategy

Two campaigns with similar challenges were analysed: The federal government's 5G awareness campaign (https://www.deutschland-spricht-ueber-5g.de) and a website on vaccinations - especially measles - by the Federal Centre for Health Education (https://www.impfen-info.de/impfpass/). The campaign around 5G is meeting with considerable, often politically motivated resistance. The vaccination campaign is interesting because it specifically addresses young people and there is a very polarised public debate on the topic of vaccination. From the analysis of these examples and with regard to the goals and target groups of education on infrasound, three core elements of the communication strategy were derived:

- Credible: refer to reputable sources, transparency;

- Sound: Information is science-oriented and verifiable, using scientific authorities as spokespersons;
- Approachable: easy to understand, picks up target groups at their level of knowledge, takes their concerns seriously.

It is equally important to uncover manipulations. Various stakeholders use the topic of infrasound specifically to mobilise against wind energy. Part of the strategy is to expose this instrumentalization and to invalidate the suggestive images of the critics. For this purpose, own images were set and a central idea was developed to guide the communication.

The strategy includes dealing with four specific challenges and proposes solutions to them. The central idea, which runs through all three communication measures, sets the general direction of communication. It can emotionalise information and thus bring it closer to people. It runs like a red thread through various information and communication products and thus frames them. It combines the individual approaches into one big whole. At the same time, the central idea remains flexible and scalable so as not to restrict the different contents.

The guiding idea is: we communicate a calm, manageable movement that provides long-term calm and stability. Movement and tranquillity address several levels.

- Movement: Infrasound waves moving, people moving (also in spirit), moving something together, WTs moving for renewable energy.
- Calmness stands for stability and security, infrasound is a long big wave, elephants and whales communicate with infrasound, they are calm and unhurried.

6.1.4 Messages

Four core messages shape the communication. They are not necessarily adopted verbatim, but set the direction of the communication products. The messages also guide the conception of the brochure and infographics.

On the one hand, the messages should be easy to understand, on the other hand, they should describe the complex phenomenon of infrasound in a scientifically sound and correct way:

1. Infrasound is very low-frequency sound that cannot usually be heard.
2. Infrasound is not harmful to health in the form it occurs in our everyday lives.
3. Infrasound is a physical phenomenon that has always existed in nature and that has not only entered our world through industry.
4. There are stakeholders who stir up concerns regarding infrasound in order to mobilise against wind power.

Further subordinate messages were developed to the four core messages.

6.1.5 Design and tonality

All communication materials were designed in the German Environment Agency's corporate design. They are target group oriented, but at the same time suitable for addressing the general public - young and old alike. The content was designed and prepared to be easy to understand for people without prior knowledge. The design of the communication materials is simple, slightly playful, approachable and inviting in order to counter the supposedly complicated idea of infrasound with something tangible.

Calm and objective language addresses the target groups in an appreciative but not overemotional way. A direct address with "you" instead of "the residents" picks people up well. The light and comprehensible language clearly identifies open questions and thus inspires trust.

Linguistic images that appear threatening and hectic were avoided. The critics' framing was invalidated by their own guiding idea of calm movement.

6.1.6 Measures for basic concepts

Three communication measures are planned as part of the strategy development: a brochure, a set of infographics and teaching suggestions for pupils.

The brochure has 16 inner pages plus a cover in DIN A4 format. It contains comprehensive basic information on infrasound and also deals with WTs.

Eight infographics were designed that can stand alone and were used as part of the brochure.

The brochure and infographics are aimed at the first two target groups and the general public. They have been designed in a modular way and are subject to the CC licence, so that they can also be used in parts, for example for press conferences or presentations. The infographics are also suitable for use in social media. The brochure and the graphics were designed in the German Environment Agency's corporate design.

The teaching unit was designed together with the freelance author and consultant Philipp Wichtrup. He conducts research in the field of teaching materials at the Institute for Didactics of Physics at the Westfälische Wilhelms-Universität Münster.

The unit is aimed at secondary school students. It has several small experiments with accompanying worksheets for the learners and accompanying material for teachers. Since infrasound can neither be generated nor measured in class, the experiments approach the phenomenon in different ways.

All three measures were planned in detail in the action plan.

6.1.7 Distribution

In order for the campaign to reach its target group, different strategies were proposed. With the pull principle, the campaign reaches the general public: material is made available and retrieved by interested people on their own.

Those affected are reached through targeted distribution by suitable multipliers using the push principle - this task is performed by the German Environment Agency itself.

All materials should be made public on the German Environment Agency's website. A specially marked area indicates special content for the press.

The brochure and infographics can be offered to the press, used in other communication media and for social media. Suitable multipliers include associations with cities and municipalities, associations for renewable energies and municipalities where WTs are planned or have already been built. Employees of the German Environment Agency can also display the brochure at thematically appropriate conferences.

The teaching experiment was designed to be integrated into the curriculum. Distribution can be done via the federal education servers. Numerous online portals for teachers publish teaching materials on request.

6.2 Action plan

An action plan for the communication products brochure, infographics and a school teaching trial for secondary level 1 was derived from the communication strategy. These communication products are made available as a result of the research project in the form of independent publications on the website of the German Environment Agency.

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Appendix A - Guidelines and results of the qualitative survey

A.1 Guideline for qualitative telephone interviews

Italics = information for interviewer, do not read aloud

1. *Conditions and quality of life in the residential environment*

   - First of all, we would like to know something about your living environment: What positive and negative aspects come to mind when you think of your living environment?
     - *If positive aspects were not mentioned*: What do you appreciate about your living environment?
     - *If negative aspects were not mentioned*: What do you not like so much about your living environment?
   - What sources of noise are there in your living environment that you perceive and would describe as positive or neutral? Are there also sources of noise that you perceive and would describe as negative?

2. *Understanding infrasound*

   In the following, we would like to talk to you about a specific type of noise: infrasound.

   - Have you ever heard of it?

     If "yes": continue with this block of questions. (from "What do you understand by infrasound?")

   If the person has never heard of infrasound, then please ask again carefully at this point: what do you think of when you hear the term now for the first time? Is there anything that spontaneously comes to mind*?*

   -> If "no": read out the technical definition. Then the same questions: Now that you have heard this definition, is there anything that spontaneously comes to mind about infrasound? Maybe a noise source that emits such low tones?

   -> If "yes", continue with this block of questions.

   -> If still "no": I will gladly give you some examples: You can find infrasound in wind, ocean noise, technical equipment, e.g. for power generation or in pumps.

   Now that you have heard these examples, is there anything that spontaneously comes to mind about infrasound?

   ➔ If yes, continue with the block of questions.

   ➔ ***If the above questions still cannot be answered after giving the examples, please skip to block 4.***

   - What do you understand by infrasound? What comes to your mind spontaneously?
     - *If not mentioned*: Would you distinguish infrasound from other terms such as low-frequency noise, audible sound or ultrasound?
   - What do you think: What are the sources of infrasound? Where does infrasound occur?
   - In your opinion, what effects does infrasound have on people?
   - When you think of infrasound, what feelings does the term evoke?
   - What do you think are the risks of infrasound?

- Have you already had experience with infrasound yourself?
  - *If only "yes":* can you describe your experience in more detail?

- Have you ever dealt with the topic of infrasound before this interview or before you asked to participate in the survey? *(Only ask this question if the person has already heard of infrasound or associates a phenomenon (e.g. a humming sound) with the term (first question in this block).*

  If so,
  - How long have you been dealing with this topic? Was there a particular trigger for this? If so, what was it?
  - When you read up on infrasound: What sources do they draw on?
  - Do you exchange views on this topic with family and/or friends?
  - What do your family/friends think about infrasound?

3. *Impulses*

In the following we would like to read out different statements to you. Then we will ask you some questions about these statements:

Statements 1 and 2 are:	
1. Noise measurements and noise impact studies show that infrasound levels from wind turbines are below the human perception threshold.	2. There is much evidence to suggest that only about 30% of people actually perceive infrasound. But that does not change the fact that biophysical energy is at work - whether you hear it or not.

- Which statement would you rather agree with: 1 or 2?
- What do you think when you hear these statements?
- How do you feel when you hear that?

Statements 3 and 4 read:	
3. Technically generated infrasound with periodic components differs significantly from naturally occurring infrasound.	4. Various measurements at distances of 600, 700 and 1,200 metres have shown that the infrasound of a technical installation can hardly be distinguished from background noise (e.g. infrasound caused by wind).

- Which statement would you rather agree with: 3 or 4?
- What do you think when you hear these statements?
- How do you feel when you hear that?

4. *Role play to inform about infrasound*

Imagine you are advising the German Environment Agency on how it should inform the public about infrasound: What content would you convey? What content would be important for you/your family/your neighbours?

5. *End: Short clarification*

Thank you very much, we are now at the end of the survey. Is there anything else you would like to add?

We are at the end of our interview. If you like, I can give you the definition of infrasound:

Technical definition of infrasound

According to the international standard ISO 7196, infrasound refers to airborne sound waves that lie in a frequency range of 1 to 20 Hertz; these are very low tones. According to DIN 1320, infrasound is below the threshold of hearing.

Once again, thank you very much for your participation and I wish you a nice day/evening.

A.2 Results qualitative survey - cognition

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
II.1 Infrasound known / heard before	**4**	**6**	**3**	**2**	**3**	**18**
spontaneous associations						
in connection with wind turbines	1	3	1	0	2	7
Sound(s) that cannot be heard	2	0	1	1	0	4
Something dull	0	0	0	0	2	2
Sound that you do not perceive	1	0	1	0	0	2
Infrasound and audible sound occur together, cannot be separated	0	0	1	0	0	1
Low frequencies that you don't actually hear but perceive	1	0	0	0	0	1
is below the hearing threshold	0	0	0	1	0	1
Constant sound, always there, not loud, muffled	0	1	0	0	0	1
Sound that you perceive	0	0	1	0	0	1
low frequencies	0	0	1	0	0	1
vibrating	0	0	0	0	1	1
Infrastructure	0	0	0	0	1	1
Road noise	0	0	0	0	1	1
uncomfortable	0	0	0	0	1	1
is created by the blades of the wind turbines when the wind passes through them.	0	1	0	0	0	1
never heard of it, don't know how it is created	1	0	0	0	0	1
Continuous noise like water on the beach	0	1	0	0	0	1
II.2 Infrasound not known	**5**	**3**	**0**	**8**	**7**	**23**
spontaneous association						
Waves	0	1	0	0	0	1
if someone in the house is particularly loud?	0	0	0	1	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Occurring covertly / subthreshold noises	1	0	0	0	0	1
Infrared	1	0	0	0	1	2
inside	0	0	0	1	0	1
II.3 Associations Infrasound after hearing definition						
the only noise is planes/helicopters	0	1	0	0	0	1
Creates a basic tone that is only perceived indirectly	0	0	0	1	0	1
Air traffic	0	0	0	0	1	1
Radio or similar?	0	0	0	1	0	1
Noise that one does not actively perceive	0	0	0	1	0	1
Infrasound triggers anxiety	0	0	1	0	0	1
Latin translation	0	0	0	1	0	1
says something, but don't have a big problem with	1	0	0	0	0	1
seems to cause unrest	0	0	0	1	0	1
disturbs	0	0	0	1	0	1
deep waves that create pressure - imaginable	0	0	0	1	0	1
underlying hum	1	0	0	0	0	1
never perceived	0	0	0	0	3	3
Term never heard before	1	0	0	2	0	3
II.4 spontaneous association after naming of examples						
Wind turbines	2	0	0	0	0	2
not disturbing	1	0	0	0	0	1
II.5 Sources						
Wind turbines	6	4	1	0	0	11
Engines/ car noise/ roadway/ humming motorway	0	0	1	4	1	6
Traffic	0	1	0	1	2	4
Aircraft noise/air traffic	0	0	0	0	2	2
Fridge/ Washing machine	0	0	1	1	0	2

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Heat source/ heating pumps	0	1	0	0	1	2
Biogas plants	0	1	0	0	0	1
Installations (that constantly emit noise)	0	1	0	0	0	1
Loudspeaker	0	0	0	1	0	1
by any technology, e.g. sound waves from mobile phones	0	0	0	1	0	1
don't know	2	2	0	3	1	8
II.6 Effects on humans	**8**	**12**	**13**	**10**	**7**	**50**
Nerves/ stress/ bad mood	2	0	0	3	2	7
Sleep disorders	0	4	1	0	1	6
Heart damage	0	1	2	0	0	3
Blood pressure	0	1	0	0	1	2
Stroke	0	0	1	0	0	1
Nausea	0	0	1	0	0	1
Dizziness	0	0	1	0	0	1
Headache	0	0	1	0	0	1
everyone perceives infrasound, but not everyone can handle it	0	1	0	0	0	1
TU Berlin investigation Position + effect of frequency ranges	0	0	1	0	0	1
some people feel it, I didn't notice any of it	0	1	0	0	0	1
internal damage	0	1	0	0	0	1
unhealthy	0	1	0	0	0	1
maybe	0	0	1	2	3	6
no	3	1	0	0	0	4
not sufficiently researched (1x radioactivity or X-ray)	0	0	2	0	0	2
cannot say anything about it / cannot judge	1	1	0	0	0	2
don't know	2	0	0	5	0	7
Note possible damage to biodiversity	0	0	1	0	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Unknown how infrasound affects animals	0	0	1	0	0	1

A.3 Results of the qualitative survey - Emotions

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
III.1 Feelings triggered by the term						
Curiosity	0	0	0	1	1	2
Concern about lack of study of the phenomenon	0	0	1	0	0	1
you have to adapt well when change happens	0	0	1	0	0	1
Feeling of trepidation when driving through wind farm	0	0	1	0	0	1
sounds like unpleasant noise	0	1	0	0	0	1
Feels sleep disturbances	0	1	0	0	0	1
somehow restless	0	0	0	1	0	1
finds it very unpleasant	0	0	0	0	1	1
this is not good	0	0	0	0	1	1
personally no problems	0	1	0	0	0	1
funny feeling because you can't make out what it is	1	0	0	0	0	1
Malaise	1	0	0	0	0	1
none	5	2	0	3	4	14
III.2 Suspected risks						
yes, but unspecific	1	2	2	0	2	7
don't know	1	3	0	2	1	7
no	3	0	0	0	0	3
finds that is not yet properly documented	1	1	0	0	1	3
Nausea	0	0	0	1	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Influence on nervous system	0	0	0	0	1	1
Influence on physical functions	0	0	0	0	1	1
not yet heard of	0	0	0	0	1	1
science must clarify	1	0	0	0	0	1
notice no	1	0	0	0	0	1

A.4 Results of the qualitative survey - Mechanisms

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
IV.1 Own experience						
In the area of the intention to erect WTs	0	0	1	0	0	1
WTs cost a lot of quality of life	0	0	1	0	0	1
Landscape destroyed by wind turbines	0	0	2	0	0	2
Less droning in the head when wind turbines are turning fast	0	0	1	0	0	1
all adults in the house perceive infrasound from wind turbines	0	0	1	0	0	1
250 wind turbines within a radius of 10 km	0	0	1	0	0	1
have wind turbines in the vicinity (approx. 800 m)	0	1	0	0	0	1
It used to be quieter without wind turbines	0	1	0	0	0	1
perceives infrasound from wind turbines, can deal with it	0	1	0	0	0	1
Optical disturbance due to red flashing of the wind turbines	0	1	0	0	0	1
at night: perception as if sound is transmitted via the ground	0	1	0	0	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Perception especially when resting (e.g. sitting down)	0	1	0	0	0	1
During the day, depending on the wind, extreme perception of wing beat	0	1	0	0	0	1
More wind turbines over the years	0	1	0	0	0	1
Wind turbines are not far from settlement	0	1	0	0	0	1
Wind turbines disturb at night with open windows	1	0	0	0	0	1
Depending on the wind direction/strength, it makes boom boom in the house, uncomfortable	1	0	0	0	0	1
at night it is really disturbing	1	0	0	0	0	1
you don't sleep as deeply as you used to	0	1	0	0	0	1
Different rooms are affected differently, often changes bedroom	0	0	1	0	0	1
Village is surrounded by wind turbines	0	1	0	0	0	1
Diabetics when sleeping at home, not elsewhere	0	0	1	0	0	1
thought one night he would die	0	0	1	0	0	1
Sees need for electricity production	0	1	0	0	0	1
No advantages such as lower electricity prices	0	1	0	0	0	1
Woman has blood pressure problems and sleep disorders	0	1	0	0	0	1
Some feel infrasound, some do not	0	1	0	0	0	1
yes, own children have big problems with it	0	1	0	0	0	1
Very rarely noticed on the road	0	0	0	0	1	1
live in heated building (pumps)	0	0	0	0	1	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Strong roar in the head when wind turbine turns slowly	0	0	1	0	0	1
Wife has burst vessels	0	0	1	0	0	1
low hum	0	1	0	0	0	1
hears it at night	0	1	0	0	0	1
Headache	0	1	0	0	0	1
Concert attendance - bass, deep rumble	0	0	1	0	0	1
Soil erosion sounds	0	0	1	0	0	1
you cannot locate the sound	0	0	1	0	0	1
You have to live with it, a fait accompli	0	1	0	0	0	1
Crunching in the night	0	0	1	0	0	1
none	4	3	0	6	7	20
IV.2 Prior engagement with topic						
no	5	1	0	4	3	13
if yes, since when						
since the WTs have been here and TN can no longer sleep: 20 years	0	0	1	0	0	1
about 5 years	0	1	0	0	0	1
final years	0	1	0	0	0	1
Trigger						
Erecting (more) wind turbines	0	2	1	0	0	3
Sources of information						
Not commercial but state-based	0	0	1	0	0	1
Scientific publications (journals, reports, technical papers)	0	0	5	1	2	8
Books	0	0	1	0	0	1
Environmental Research Newsletter	0	0	1	0	0	1
Operator event	0	1	0	0	0	1
Mayor	0	1	0	0	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Citizens' initiative/associations	0	2	1	0	0	3
Newspapers/Press	0	1	1	0	1	3
Events on site	0	1	0	0	0	1
Environmental Agency	0	1	0	0	0	1
further sufferers	0	1	0	0	0	1
Doctors in the circle of acquaintances	0	1	0	0	0	1
Internet (general)	2	4	0	3	1	10
Google (specific)	2	1	0	1	1	5
Wikipedia (specific)	0	0	0	0	1	1
Library	0	0	0	1	0	1
Owner is personally known	1	0	1	0	0	2
Exchange with others						
yes	2	3	3	0	0	8
no	5	1	0	4	4	14
Opinion Family/Friends						
the village puts up posters against infrasound	0	0	1	0	0	1
Children perceive infrasound	0	1	0	0	0	1
Neighbour cannot sleep without earplugs	0	0	1	0	0	1
Many neighbours do not notice this	0	0	1	0	0	1
Wife perceives more vibrations	0	0	0	1	0	1

A.5 Results of the qualitative survey - Evaluation of the impulses

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Impulses: Agreement with statement	**11**	**9**	**2**	**10**	**10**	**42**
1) Science: Lack of evidence	2	1	0	2	2	7

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
2) Science: Effect even in the absence of perception	3	3	2	2	1	11
3) Technical infrasound differs from natural infrasound	2	0	1	1	1	5
4) Infrasound hardly distinguishable from background noise	3	2	0	2	3	10
No decision on 1+2	1	0	1	1	3	6
No decision on 3+4	1	3	1	2	2	9
Impulses: triggered thoughts						
to statement 1:						
none	1	0	0	0	0	1
one reads everywhere	0	0	1	0	0	1
Contradictory, since statement says that one has no perception of it [has].	0	0	1	0	0	1
they have measured incorrectly	0	0	1	0	0	1
Perception threshold not only in hearing	0	1	0	0	0	1
rather scientific	0	0	0	1	0	1
Studies say it does not affect human body	0	0	0	0	1	1
to statement 2:						
Extension of statement 1	0	0	1	0	0	1
confirms that there is a need for further research	0	0	1	0	0	1
from Norweg. Study in which 25% of the people had serious illnesses	0	0	1	0	0	1
cannot confirm this with myself	1	0	0	0	0	1
has become accustomed, you can't do anything about it, it's no use	0	1	0	0	0	1
esoteric	0	0	0	1	0	1
one gets used to it, whether body gets used to it is questionable	0	1	0	0	0	1
there's a lot that you don't really realise...	1	0	0	0	0	1
pure speculation	1	0	0	0	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
you get used to it, become resistant	0	1	0	0	0	1
at some point you no longer hear it	0	1	0	0	0	1
Associations after statement 1+2						
none	0	0	0	1	0	1
Wind turbine distance of 1000m not necessary	0	0	0	1	0	1
does not believe that infrasound can be heard	0	0	0	1	0	1
Wind turbines may produce infrasound.	0	0	0	1	0	1
WTs are necessary	0	0	0	1	0	1
Wind turbines are a visual annoyance, disfigure the landscape	0	0	0	1	0	1
WTs generally do not interfere	0	0	0	1	0	1
to statement 3:						
Source of infrasound is perceived as an interaction of senses	0	0	1	0	0	1
This is because technically generated infrasound is sinusoidal, due to the rotating machines	0	0	1	0	0	1
Hearing the wind is tremendous, bad when the wind dies down.	0	1	0	0	0	1
don't know if this is related to cancer in the area	0	1	0	0	0	1
to statement 4:						
says nothing, only about perception	0	0	1	0	0	1
A lot of noise in this low frequency range	0	0	1	0	0	1
Measurement of structure-borne sound instead of airborne sound necessary	0	0	1	0	0	1
in stormy weather you hear more wind than wind turbines	0	1	0	0	0	1
what plant manufacturers say	0	1	0	0	0	1
unsure whether true	0	1	0	0	0	1
one can get used to it	0	0	0	0	1	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
General risk of life	1	0	0	0	0	1
Made many measurements, never came up with anything	0	1	0	0	0	1
none	2	0	0	1	0	3
triggered thoughts on 3+4						
You can't beat that	0	1	0	0	0	1
Infrasound is practically always there	0	1	0	0	0	1
Impulses 1+2: triggered feelings						
I don't know if that's good for your health.	0	1	0	0	0	1
The dose makes the poison.	0	0	1	0	0	1
one simply accepts it	0	1	0	0	0	1
when distracted, person does not listen or pay attention	0	1	0	0	0	1
Doesn't like it, but can't change anything	0	1	0	0	0	1
one should try to avoid it	0	0	0	0	1	1
none	0	2	0	2	0	4
Impulses 3+4: triggered feelings						
is of no use anyway	0	1	0	0	0	1
Never perceived infrasound	0	0	0	1	0	1
perceives technical + natural infrasound differently	0	0	1	0	0	1
unpleasant thing	0	1	0	0	0	1
that they are deceived	0	1	0	0	0	1
You are not taken seriously	0	1	0	0	0	1
none	0	1	0	3	2	6

A.6 Results of the qualitative survey - role play

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
general						
Authentic, comprehensible, justifiable, scientific	0	0	1	0	0	1
Scepticism that people are expected to adapt	0	0	1	0	0	1
No need, no interest	0	1	0	0	0	1
they can't do anything, wind turbines can't be shut down	0	1	0	0	0	1
there is enough information about it	0	1	0	0	0	1
no mentions	6	2	0	2	3	13
Proposed contents						
(Medical) effects	1	3	3	4	3	14
Definition	3	0	0	2	4	9
Factual information (audibility, distance, audible vs. infrasound)	1	0	1	1	2	5
First create a basis for understanding, e.g. statistics	0	0	1	0	0	1
few sentences, to the point	1	0	0	0	0	1
clear, red thread	1	0	0	0	0	1
not only def., also info what that means for me	1	0	0	0	0	1
Necessity for the future for energy production	1	0	0	0	0	1
No one-sided education	0	0	1	0	0	1
What does it do to people when the landscape is destroyed?	0	0	1	0	0	1
Statistical comparisons	0	0	1	0	0	1
Order of magnitude subjective attribution of diseases to InS	0	0	0	1	0	1
Cause	0	1	0	0	0	1
Audio sample	0	0	0	1	0	1
Name a contact point	0	0	0	1	0	1
Coping strategies	0	0	0	1	0	1

	WT-South (n=11)	WT-North (n=9)	Citizens' initiatives (n=3)	Air-source heat pumps (n=10)	No exposure (n=10)	Total (n=43)
Communication possibilities/exchange	0	0	0	1	0	1
Frequency of occurrence (of infrasound)	0	0	0	1	0	1
you can only communicate what you perceive yourself	0	0	0	0	1	1
Proposed media						
Newspaper article	0	2	0	3	1	6
Television	1	0	0	2	2	5
Internet	2	1	0	0	0	3
Radio	0	1	0	1	0	2
Direct mail	1	0	0	0	1	2
on all media	0	0	0	1	0	1
Posters	0	0	0	1	0	1
Media	0	0	0	0	1	1
social media	0	0	0	0	1	1
Brochure	1	0	0	0	0	1

Appendix B - Questionnaires for the quantitative survey

B.1 Questionnaire quantitative survey – WT study areas

Survey on the perception of environmental factors and technical installations in the living environment

Dear participant,

Thank you for choosing to participate in this survey.

In this questionnaire, you will be asked questions about your living environment, your perception of and attitude towards environmental factors and technical installations, as well as general questions about your household and yourself.

Please read the questions and statements carefully. Tick the box that corresponds to your chosen answer. If you are not sure of the answer to a question, choose the answer option that you think is most applicable. The questionnaire will take about 20-25 minutes to complete.

After you have filled out the questionnaire completely, send it back to us in the enclosed return envelope. We will of course pay the postage for you!

All information you provide will be treated confidentially. Of course, your participation is voluntary and you will not suffer any disadvantages in the event of non-participation or premature termination. Please also note our information on data protection in our cover letter.

Thank you very much for your support!

If you have any questions, please do not hesitate to contact us (Phone:, E-Mail:).

Zunächst möchten wir gern etwas über Ihre Wohnumgebung und Wohnsituation im Allgemeinen erfahren.

	Bitte geben Sie an, wie zufrieden Sie insgesamt mit den folgenden zwei Aspekten sind. Wie **zufrieden** sind Sie insgesamt mit Ihrer…	nicht	wenig	mittel-mäßig	ziemlich	sehr
1.	… Wohnumgebung?	❒	❒	❒	❒	❒
2.	…Wohnung bzw. mit Ihrem Haus?	❒	❒	❒	❒	❒

3.	Wann sind Sie in Ihre **jetzige Wohnung/Ihr jetziges Haus** eingezogen? Nennen Sie bitte das Jahr.	Jahr: _____
4.	Wo haben Sie gelebt, bevor Sie in Ihren jetzigen Wohnort gezogen sind?	❒ ländlich ❒ in einer Kleinstadt ❒ in einer Großstadt ❒ ich habe schon immer hier im Ort gewohnt
5.	Sind Sie bzw. jemand aus Ihrem **Haushalt Eigentümer*in** Ihrer Wohnung bzw. Ihres Hauses oder wohnen Sie **zur Miete**?	❒ Eigentümer*in ❒ Mieter*in
6.	In welcher **Art von Gebäude** wohnen Sie?	❒ freistehenden Einfamilienhaus ❒ Reihenendhaus ❒ Reihenmittelhaus ❒ Doppelhaushälfte ❒ Wohnung in einem mehrstöckigen Mehrfamilienhaus
	Wenn Frage 6 = „Wohnung in einem mehrstöckigen Mehrfamilienhaus“: In welchem Stockwerk liegt Ihre Wohnung?	❒ Souterrain/Erdgeschoss ❒ Obergeschoss/Etage:_____*(Bitte geben Sie die Nummer an)* ❒ keine Angabe

7.	Steht Ihnen zuhause ein **Balkon,** eine **Terrasse oder Garten** am Haus zur Verfügung?	Ja	Nein
	Balkon	❒	❒
	Terrasse	❒	❒
	Garten	❒	❒

	Wie ist das bei Ihnen üblicherweise in den **warmen Jahreszeiten**?	geschlossen	gekippt	geöffnet
8.	Haben Sie **nachts** die Fenster in Ihrem **Schlafzimmer** überwiegend geschlossen, gekippt oder geöffnet?	❒	❒	❒
9.	Wie haben Sie **tagsüber** die Fenster in Ihren **Wohnräumen** überwiegend?	❒	❒	❒
	Und wie ist es bei Ihnen üblicherweise in den **kalten Jahreszeiten**?	geschlossen	gekippt	geöffnet
10.	Haben Sie **nachts** die Fenster in Ihrem **Schlafzimmer** überwiegend geschlossen, gekippt oder geöffnet?	❒	❒	❒
11.	Wie haben Sie **tagsüber** die Fenster in Ihren **Wohnräumen** überwiegend?	❒	❒	❒

12.	Wie viele **Stunden** pro Tag sind Sie in etwa **außer Haus**, z. B. beim Arbeiten, Einkaufen oder für sonstige Erledigungen oder Aktivitäten?	Anzahl Stunden pro Tag
	...montags bis freitags	_____
	...samstags	_____
	...sonntags	_____
13.	Gibt es etwas, das Sie in Ihrer Wohnumgebung schätzen?	❒ Ja ❒ Nein
	Wenn ja, was genau:	_____ *(Freitext)*
14.	Gibt es etwas, das Sie in Ihrer Wohnumgebung stört?	❒ Ja ❒ Nein
	Wenn ja, was genau?	_____ *(Freitext)*

	Bitte geben Sie an, inwiefern Sie den folgenden Aussagen **zustimmen**	nicht	wenig	mittel-mäßig	ziemlich	sehr
15.	Selbst wenn es bessere Orte gibt, werde ich nicht von hier wegziehen.	❒	❒	❒	❒	❒
16.	Ich kann mir nicht vorstellen, von hier wegzuziehen.	❒	❒	❒	❒	❒
17.	Ich habe nie darüber nachgedacht, ob es nicht besser wäre, woanders zu leben.	❒	❒	❒	❒	❒
18.	Es würde mir nichts ausmachen, meinen Wohnort zu verlassen und woanders hinzuziehen.	❒	❒	❒	❒	❒

19.	Es gibt viele Orte in Deutschland und auf der Welt, an denen ich leben könnte.	❒	❒	❒	❒	❒
20.	Ich mag es, meine Gegend zu erkunden und neue Orte zu entdecken.	❒	❒	❒	❒	❒
21.	Ich mache oft Fotos von verschiedenen Orten hier.	❒	❒	❒	❒	❒
22.	Von Zeit zu Zeit entdecke ich meine Gegend neu.	❒	❒	❒	❒	❒
23.	Es ist für mich wichtiger, wie ich lebe, als wo ich lebe.	❒	❒	❒	❒	❒

		sehr schlecht	eher schlecht	teils gut/ teils schlecht	eher gut	sehr gut
24.	Wie schätzen Sie die Aufenthaltsqualität im Freien in Ihrer Wohnumgebung ein?	❒	❒	❒	❒	❒
25.	Wie würden Sie Ihre Wohnlage in 3 Worten beschreiben? Was fällt Ihnen spontan ein? *(z.B. ländlich, lebendig, ruhig)*	_____ *(Freitext)*				

Als nächstes geht es um die Empfindlichkeit gegenüber den Belastungen aus der Umwelt.

	Für wie **empfindlich** halten Sie sich gegenüber …	nicht	wenig	mittel-mäßig	ziemlich	sehr
26.	… Gerüchen?	❒	❒	❒	❒	❒
27.	… Stress allgemein?	❒	❒	❒	❒	❒
28.	… Wetter?	❒	❒	❒	❒	❒
29.	…Stromleitungen?	❒	❒	❒	❒	❒
30.	… Lärm?	❒	❒	❒	❒	❒
31.	…Mobilfunk?	❒	❒	❒	❒	❒
32.	…Bassgeräuschen, tiefen Tönen?	❒	❒	❒	❒	❒
33.	…monotonem Summen?	❒	❒	❒	❒	❒
34.	…Geräuschen im Allgemeinen?	❒	❒	❒	❒	❒

Im Folgenden geht es um Geräusche von verschiedenen Quellen.

Wenn Sie einmal an die **letzten 12 Monate** hier bei Ihnen denken, wie stark haben Sie sich durch den **Lärm von folgenden Quellen** insgesamt gestört oder belästigt gefühlt?

Ich habe mich durch … gestört oder belästigt gefühlt.		überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
35.	… Straßenverkehr	❒	❒	❒	❒	❒
36.	… Nachbarschaft	❒	❒	❒	❒	❒
37.	… Luftwärmepumpen	❒	❒	❒	❒	❒
38.	… Baustellen	❒	❒	❒	❒	❒
39.	… Biogasanlagen	❒	❒	❒	❒	❒
40.	…Windenergieanlagen **insgesamt**	❒	❒	❒	❒	❒
41.	…Windenergieanlagen, bei Aufenthalt **in Ihrer Wohnung / Ihrem Haus**	❒	❒	❒	❒	❒
42.	…Windenergieanlagen, bei Aufenthalt **außerhalb** Ihrer Wohnung / Ihres Hauses, z.B. im Garten oder auf der Terrasse / dem Balkon	❒	❒	❒	❒	❒
43.	Gibt es weitere Lärmquellen?	❒ Ja ❒ Nein *(weiter mit Frage 46)*				
	Falls ja, nennen Sie bitte **die zwei weiteren Quellen**, die Sie am stärksten belästigt haben. Bitte geben Sie an, wie stark Sie sich durch diese weiteren Quellen gestört oder belästigt fühlen.	überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
44.	**sonstige Lärmquelle 1**: _____	❒	❒	❒	❒	❒
45.	**sonstige Lärmquelle 2**: _____	❒	❒	❒	❒	❒

Nun möchten wir gern etwas über die Windenergieanlagen bei Ihnen in Ihrer Wohnumgebung wissen.		
46.	Wie viele Windenergieanlagen gibt es in Ihrer Nähe?	_____ (Anzahl, geschätzt)
47.	Wie weit entfernt ist die Windenergieanlage, die von Ihrer Wohnung / Ihrem Haus am **entferntesten** ist?	_____ (Meter, geschätzt)
48.	Wie weit entfernt ist die Windenergieanlage, die Ihrer Wohnung / Ihrem Haus am **nächsten** ist?	_____ (Meter, geschätzt)
49.	Die Windenergieanlage, die Ihrer Wohnung/Ihrem Haus am nächsten ist, empfinden Sie die als…	❒ nicht ❒ wenig ❒ mittel-mäßig ❒ ziemlich ❒ sehr …weit entfernt?
50.	Haben Sie von Ihrer Wohnung / Ihrem Haus Sichtkontakt zu den Windenergieanlagen?	❒ Ja (*weiter mit Frage 51*) ❒ Nein (*weiter mit Frage 53*)
51.	Wenn wir von 4 Himmelsrichtungen ausgehen, in wie viele Richtungen haben Sie Sichtkontakt zu den Windenergieanlagen?	❒ 1 Himmelsrichtung ❒ 2 Himmelsrichtungen ❒ 3 Himmelsrichtungen ❒ 4 Himmelsrichtungen ❒ kann ich nicht sagen, weiß nicht
52.	Gibt es einen Raum in Ihrer Wohnung oder Ihrem Haus, von dem aus kein Sichtkontakt zu den Windenergieanlagen besteht?	❒ Ja ❒ Nein
53.	Stehen Windenergieanlagen auf Ihrem Grundstück?	❒ Ja ❒ Nein
54.	Wann wurden die Windenergieanlage(n) in Ihrer Wohnumgebung errichtet? *(Bei mehreren Konstruktionswellen: Geben Sie nach Möglichkeit jedes Jahr an)*	_____ (Jahr) ❒ weiß nicht
55.	Haben Sie bereits in Ihrer Wohnumgebung gelebt **bevor** die erste Windenergieanlage errichtet wurde?	❒ Ja *(weiter mit Frage 56)* ❒ nein, nach der Errichtung zugezogen *(weiter mit Frage 59)*

	Wenn ja:	Sehr negativ	Negativ	Neutral	Positiv	Sehr positiv
56.	Welche Meinung hatten Sie zu der ersten geplanten Windenergieanlage **bevor** diese bei Ihnen vor Ort errichtet wurde? War Ihre Meinung dazu…	❒	❒	❒	❒	❒
57.	Wann wurden Sie über die Planung der Anlage/n informiert?	❒ von Anfang an ❒ die Planung hatte bereits begonnen ❒ bei Bau der Anlage/n ❒ nach Bau/Errichtung der Anlage/n				
58.	Wie wurden Sie über die Planungen zum Bau und/bzw. Betrieb der Anlage/n informiert?	❒ Medien (z.B. Zeitungsartikel, Lokalfernsehen) ❒ Nachbarn, Freunde, Familie ❒ Informationsschreiben vom Betreiber ❒ Informationsschreiben von der Stadt/ der Gemeinde ❒ sonstiges, und zwar_____				
	Bitte geben Sie im Folgenden Ihre **Zufriedenheit** an.	gar nicht	gering	mittel-mäßig	Ziemlich	sehr
59.	Wie zufrieden waren Sie mit den bereitgestellten Informationen?	❒	❒	❒	❒	❒
60.	Wie zufrieden waren Sie mit der Möglichkeit der Bürgerbeteiligung?	❒	❒	❒	❒	❒
	Bitte geben Sie an, inwiefern Sie den folgenden Aussagen **zustimmen**.	nicht	wenig	mittel-mäßig	ziemlich	sehr
61.	Im Rahmen des Planungsprozesses wurden meine Bedenken ernstgenommen.	❒	❒	❒	❒	❒
62.	Im Rahmen des Planungsprozesses gab es die Möglichkeit, mit den Initiatoren Kontakt aufzunehmen.	❒	❒	❒	❒	❒
63.	Meine Einwände wurden während des Planungsprozesses gehört.	❒	❒	❒	❒	❒
64.	Während des Planungsprozesses habe ich… *(Mehrfachnennungen möglich)*	❒ … mich bei dem Betreiber/ der Stadt/ den Initiatoren schriftlich/ telefonisch beschwert ❒ … an einem Informationstreffen des Betreibers / der Stadt teilgenommen ❒ … auf einem Informationstreffen des Betreibers/ der Stadt gesprochen/Fragen gestellt ❒ … zu einem Zeitungsartikel/ einer Webseite				

		beigetragen ❒ … ein Schild **gegen** die Anlage auf meinem Grundstück aufgestellt ❒ … ein Schild **für** die Anlage auf meinem Grundstück aufgestellt ❒ … andere Maßnahmen ergriffen, um mich zu äußern und zwar: _____ _____				
	Als wie **glaubwürdig** schätzen Sie die folgenden Akteure während der Prozessplanung ein?	nicht	wenig	mittel-mäßig	ziemlich	sehr
65.	Investor*innen (die Windenergieanlagen als finanzielle Anlage nutzen)	❒	❒	❒	❒	❒
66.	Projektierer*innen (die Windenergieanlagen planen und errichten)	❒	❒	❒	❒	❒
67.	Genehmigungsbehörden	❒	❒	❒	❒	❒
68.	Naturschutzgutachter*innen (die die Natur- und Umweltverträglichkeit von Windenergieanlagen begutachten	❒	❒	❒	❒	❒
69.	Bürgermeister*innen	❒	❒	❒	❒	❒
70.	Naturschutzverbände	❒	❒	❒	❒	❒
71.	Befürwortende von Windenergieanlagen	❒	❒	❒	❒	❒
72.	Gegner*innen von Windenergieanlagen	❒	❒	❒	❒	❒
	Bitte geben Sie an, inwiefern Sie den folgenden Aussagen **zustimmen**.	nicht	wenig	mittel-mäßig	ziemlich	sehr
73.	Ich befürworte die Windenergieanlagen hier.	❒	❒	❒	❒	❒
74.	Ich bin mit den Windenergieanlagen hier zufrieden.	❒	❒	❒	❒	❒

75.	Ich akzeptiere die Windenergieanlagen hier.	❒	❒	❒	❒	❒

Im Folgenden geht es um den Betrieb von Windenergieanlagen in Ihrer Wohnumgebung.						
Bitte geben Sie an, inwieweit Sie den folgenden Aussagen **zustimmen**:		nicht	wenig	mittel-mäßig	ziemlich	sehr
76.	Windenergieanlagen fördern die Weiterentwicklung der Region.	❒	❒	❒	❒	❒
77.	Durch den Betrieb von Windenergieanlagen kommt es zu einer Wertminderung der umgebenden Häuser und Grundstücke.	❒	❒	❒	❒	❒
78.	Durch den Betrieb von Windenergieanlagen entstehen neue Arbeitsplätze in der Region.	❒	❒	❒	❒	❒
79.	Durch den Betrieb von Windenergieanlagen wird einem der Aufenthalt im Garten, auf der Terrasse oder auf dem Balkon verleidet.	❒	❒	❒	❒	❒
80.	Die Windenergieanlagen sind Grundlage für Streitigkeiten innerhalb der Nachbarschaft.	❒	❒	❒	❒	❒
81.	Durch Windenergieanlagen wird das Landschaftsbild verschandelt.	❒	❒	❒	❒	❒
82.	Der Betrieb der Windenergieanlagen ist gut für den Umweltschutz.	❒	❒	❒	❒	❒
83.	Durch den Betrieb der Windenergieanlagen wird die Naherholung erschwert.	❒	❒	❒	❒	❒
84.	Durch den Betrieb der Windenergieanlagen sinken die Stromkosten.	❒	❒	❒	❒	❒
85.	Die Windenergieanlagen sind gesundheitsgefährdend für den Menschen.	❒	❒	❒	❒	❒
86.	Der Betrieb von Windenergieanlagen gefährdet die heimischen Tiere.	❒	❒	❒	❒	❒
87.	Der Betrieb von Windenergieanlagen schadet dem Tourismus in der Region.	❒	❒	❒	❒	❒

88.	Gegen das Aufstellen von Windenergieanlagen kann man sich nicht wehren.	❒	❒	❒	❒	❒
89.	Windenergieanlagen sind ein attraktives Merkmal der Landschaft.	❒	❒	❒	❒	❒

Die nachfolgenden Aussagen beziehen sich auf Windenergieanlagen ganz **allgemein**, nicht nur auf die bei Ihnen zuhause. Bitte geben Sie wieder an, inwieweit Sie den folgenden allgemeinen Aussagen **zustimmen**.

		nicht	wenig	mittel-mäßig	ziemlich	sehr
90.	Ich habe Vertrauen in die Technologie von Windenergieanlagen.	❒	❒	❒	❒	❒
91.	Die mit der Infrastruktur von Windenergieanlagen verbundenen Risiken sind bei Wissenschaftler*innen bekannt.	❒	❒	❒	❒	❒
92.	Die mit der Infrastruktur von Windenergieanlagen verbundenen Risiken sind der breiten Öffentlichkeit bekannt.	❒	❒	❒	❒	❒

Im Folgenden möchten wir gern etwas darüber wissen, welche Aspekte der Windenergieanlagen bei Ihnen Sie als störend oder belästigend empfinden.

Wie stark fühlen Sie sich von folgenden Aspekten der Windenergieanlagen in Ihrer Wohnumgebung gestört oder belästigt?		überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
93.	von dem **Anblick**	❒	❒	❒	❒	❒
94.	von dem **Schattenwurf**	❒	❒	❒	❒	❒
95.	von der **Hinderniskennzeichnung** *(Gemeint sind nächtliche Lichtsignale auf dem Turm der Windenergieanlage.)*	❒	❒	❒	❒	❒
96.	von der **Drehbewegung**	❒	❒	❒	❒	❒
97.	von der **Wirkung im Landschaftsbild**	❒	❒	❒	❒	❒

Hörbarkeit der Geräusche von Windenergieanlagen						
98.	Können Sie die Windenergieanlage(n) bei Ihnen generell hören?	❒ ja	❒ nein	❒ weiß nicht		
99.	Können Sie die Anlage(n) hören, wenn Sie sich bei Ihnen zuhause draußen auf dem Balkon/ der Terrasse oder im Garten aufhalten?	❒ ja	❒ nein	❒ weiß nicht		
100.	Können Sie die Anlage bei sich zuhause drinnen bei **offenem** Fenster hören?	❒ ja	❒ nein	❒ weiß nicht		
101.	Können Sie die Anlage bei sich zuhause drinnen bei **geschlossenem** Fenster hören?	❒ ja	❒ nein	❒ weiß nicht		
Wie stark haben Sie Geräusche von Windenergieanlagen **in den letzten 12 Monaten** in den folgenden Situationen **insgesamt gestört**?		überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
102.	Bei Unterhaltungen oder beim Telefonieren in der Wohnung/im Haus	❒	❒	❒	❒	❒
103.	Beim Radio-/Musikhören oder Fernsehen	❒	❒	❒	❒	❒
104.	Beim Lesen, Nachdenken oder Konzentrieren in der Wohnung/im Haus	❒	❒	❒	❒	❒
105.	Beim Entspannen und der Feierabendruhe in der Wohnung/im Haus	❒	❒	❒	❒	❒
106.	Bei häuslicher Geselligkeit oder, wenn Sie Besuch in der Wohnung/im Haus haben	❒	❒	❒	❒	❒
107.	Bei Aufenthalt und Erholung im Freien (auf der Terrasse, dem Balkon, im Garten)	❒	❒	❒	❒	❒
108.	Bei Unterhaltungen/Gespräche im Freien	❒	❒	❒	❒	❒
109.	Beim Einschlafen	❒	❒	❒	❒	❒
110.	Nachts, während des Schlafs (bzw. *bei Nachtschicht*: während der üblichen Schlafenszeit)	❒	❒	❒	❒	❒

111.	Beim Ausschlafen am Ende der Schlafzeit	❒	❒	❒	❒	❒

Der folgende Abschnitt befasst sich mit der Geräuschart Infraschall.

112. Was verstehen Sie unter dem Begriff „Infraschall"? Was fällt Ihnen spontan dazu ein?

_____
_____
_____
_____

113. Was glauben Sie, wie kann Infraschall wahrgenommen werden? Infraschall kann man…

(Mehrfachnennungen möglich)

❒ … mit den Ohren hören.

❒ … mit den Ohren wahrnehmen, aber nicht als Geräusch.

❒ …als Vibrationen im Gebäude und anderen Objekten spüren.

❒ …als Vibrationen an verschiedenen Stellen des eigenen Körpers spüren.

❒ … mit keinen Sinnen wahrnehmen, beeinflusst mich aber auf eine andere Art und löst körperliches Unwohlsein aus.

❒ … gar nicht wahrnehmen.

114. Woher erhalten Sie hauptsächlich Informationen über Infraschall?

(Bitte nur 1 Kreuz)

❒ überregionale Medien (Zeitung, TV)

❒ regionale/lokale Medien (Zeitung, TV)

❒ soziale Medien (Facebook, Instagram, Nachrichtendienste)

❒ Internet

❒ Freunde / Familie / Nachbarn

❒ Bürgerinitiativen

❒ weitere, und zwar

_____

❒ gar nicht

Im Folgenden würden wir gern wissen, inwiefern Sie den folgenden Aussagen zustimmen:	nicht	wenig	mittel-mäßig	ziemlich	sehr

115.	Die Sorge über gesundheitliche Risiken durch Infraschall von Windenergieanlagen ist berechtigt.	❒	❒	❒	❒	❒
116.	Wegen des Infraschalls löst die Nähe zur Windenergieanlage bei mir Beklommenheit aus.	❒	❒	❒	❒	❒
117.	Wenn man Sorgen über den Infraschall von Windenergieanlagen äußert, wird man von Familie und Freunden nicht ernstgenommen.	❒	❒	❒	❒	❒
118.	Wenn man Sorgen über den Infraschall von Windenergieanlagen äußert, wird man von Betreibern und Behörden nicht ernstgenommen.	❒	❒	❒	❒	❒
119.	Auswirkungen durch Infraschall von Windenergieanlagen auf den Menschen sind noch nicht hinreichend erforscht.	❒	❒	❒	❒	❒
120.	Infraschall von Windenergieanlagen wirkt sich negativ auf den Schlaf aus.	❒	❒	❒	❒	❒
121.	An Infraschall von Windenergieanlagen kann man sich gewöhnen.	❒	❒	❒	❒	❒
122.	Der Infraschall von Windenergieanlagen unterscheidet sich nicht von natürlich auftretendem Infraschall.	❒	❒	❒	❒	❒
123.	Informationen über Infraschall von Windenergieanlagen müssen für Anwohnende verständlich und nutzbar sein.	❒	❒	❒	❒	❒
124.	Meine Meinung über Infraschall von Windenergieanlagen bilde ich mir anhand der Erfahrung von Freunden und Familie.	❒	❒	❒	❒	❒
125.	Hilfreiche Informationen zu Infraschall von Windenergieanlagen findet man nur bei öffentlichen Behörden.	❒	❒	❒	❒	❒

Verbindung zu Windenergieanlagen		
126.	Steht Ihr **Beschäftigungsverhältnis** oder das einer anderen Person aus Ihrem Haushalt jetzt oder zukünftig in irgendeiner Weise **in Verbindung mit der/den Windenergieanlage/n**?	❒ Ja ❒ Nein
127.	Sind Sie oder eine andere Person aus Ihrem Haushalt **finanziell an der/ den Windenergieanlage/n beteiligt** (außerhalb eines Beschäftigungsverhältnisses, z.B. am Betrieb der Anlage oder der Verpachtung der Windenergieanlagenfläche)?	❒ Ja ❒ Nein
128.	Haben Sie in Ihrem Haushalt **eine Stromkostenersparnis bzw. einen vergünstigten Stromtarif** aufgrund der Windenergieanlage/n in Ihrer Wohnumgebung?	❒ Ja ❒ Nein
129.	Hat Ihre Kommune einen wirtschaftlichen/finanziellen Vorteil durch die Windenergieanlage/n in Ihrer Wohnumgebung?	❒ Ja ❒ Nein
130.	Sind Sie in **einer Bürgerinitiative oder sonstigen Vereinigung** aktiv, die sich mit Windenergieanlagen auseinandersetzt?	❒ Ja, für Windenergieanlagen ❒ Ja, gegen Windenergieanlagen ❒ Nein, weder noch

In diesem Abschnitt geht es um generelle Fragen zur Energiewende und zum Klimawandel					
	überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
131. Wie besorgt sind Sie wegen des Klimawandels?	❒	❒	❒	❒	❒
Bitte geben Sie an, wie sehr Sie den folgenden Aussagen zustimmen.	nicht	wenig	mittel-mäßig	ziemlich	sehr
132. Erneuerbare Energien tragen generell zum Klimaschutz bei.	❒	❒	❒	❒	❒
133. Die lokalen Windenergieanlagen tragen zum Klimaschutz bei.	❒	❒	❒	❒	❒

Ich finde die Energiewende in Deutschland insgesamt…

		sehr (3)	(2)	(1)	weder noch (0)	(1)	(2)	sehr (3)	
134.	überflüssig	❒	❒	❒	❒	❒	❒	❒	wünschenswert
135.	schlecht	❒	❒	❒	❒	❒	❒	❒	gut
136.	unwirtschaftlich	❒	❒	❒	❒	❒	❒	❒	wirtschaftlich
137.	naturschädigend	❒	❒	❒	❒	❒	❒	❒	naturverträglich
138.	ungerecht	❒	❒	❒	❒	❒	❒	❒	gerecht
139.	landschaftsschädigend	❒	❒	❒	❒	❒	❒	❒	landschaftsverträglich
140.	schlecht umgesetzt	❒	❒	❒	❒	❒	❒	❒	gut umgesetzt

Im Folgenden geht es um Ihre Gefühle und Gedanken während des letzten Monats.

	Im letzten Monat, wie oft…	nie	selten	manch-mal	häufig	sehr oft
141.	… wurden Sie von unerwarteten Ereignissen überrascht?	❒	❒	❒	❒	❒
142.	… hatten Sie das Gefühl, dass es Ihnen nicht möglich ist, wichtige Dinge in Ihrem Leben beeinflussen zu können?	❒	❒	❒	❒	❒
143.	… haben Sie sich nervös oder „gestresst“ gefühlt?	❒	❒	❒	❒	❒
144.	… hatten Sie sich im letzten Monat sicher im Umgang mit persönlichen Aufgaben und Problemen gefühlt?	❒	❒	❒	❒	❒
145.	… hatten Sie das Gefühl, dass sich die Dinge nach Ihren Vorstellungen entwickeln?	❒	❒	❒	❒	❒
146.	… hatten Sie das Gefühl, mit all den anstehenden Aufgaben und Problemen nicht richtig umgehen zu können?	❒	❒	❒	❒	❒
147.	… mit Ärger in Ihrem Leben klar zu kommen?	❒	❒	❒	❒	❒

148.	…hatten Sie das Gefühl alles im Griff zu haben?	❒	❒	❒	❒	❒
149.	… darüber geärgert, wichtige Dinge nicht beeinflussen zu können?	❒	❒	❒	❒	❒
150.	… hatten Sie das Gefühl, dass sich die Probleme so aufgestaut haben, dass Sie diese nicht mehr bewältigen können?	❒	❒	❒	❒	❒

		schlecht	weniger gut	gut	sehr gut	ausge-zeichnet
151.	Wenn Sie einmal an die **letzten 4 Wochen** denken: Wie würden Sie Ihren **Gesundheitszustand** im Allgemeinen beschreiben?	❒	❒	❒	❒	❒

Zum Schluss möchten wir Sie bitten, uns noch zu statistischen Zwecken Angaben zu Ihrer Person mitzuteilen. Diese Angaben helfen uns, die Befragungsdaten zwischen verschiedenen Gruppen zu vergleichen.

152. Welches **Geschlecht** haben Sie?

männlich	weiblich	divers
❒	❒	❒

153. In welchem Jahr sind Sie geboren? Jahr: _____

154. Wie viele **Personen** leben ständig **in Ihrem Haushalt**, Sie selbst mitgerechnet?
Zählen Sie dabei bitte auch Kinder mit.

_____ Personen insgesamt

davon:

_____ unter 14 Jahre (Kinder)

_____ von 14 bis unter 18 Jahre alt (Jugendliche)

_____ mindestens 18 Jahre alt (Erwachsene)

Als Privathaushalt gelten Personen, die zusammenwohnen und wirtschaften, die in der Regel ihren Lebensunterhalt gemeinsam finanzieren beziehungsweise die Ausgaben für den Haushalt teilen. Mitglieder einer Wohngemeinschaft ohne gemeinsame Haushaltsführung gelten als eigenständige Privathaushalte. Geben Sie in dem Fall nur die Anzahl der Personen in Ihrer Wohngemeinschaft an, die mit Ihnen zusammenwohnen und wirtschaften.

155. Welchen **Schulabschluss** haben Sie?
(Nennen Sie bitte nur den höchsten Abschluss.)

- ☐ Hauptschul-/Volksschulabschluss oder gleichwertiger Abschluss
- ☐ Realschulabschluss/Mittlere Reife oder gleichwertiger Abschluss
- ☐ Abschluss der Polytechnischen Oberschule
- ☐ Fachhochschulreife, Abschluss Fachoberschule
- ☐ Abitur
- ☐ anderer Schulabschluss
- ☐ Schule beendet ohne Abschluss
- ☐ noch keinen Schulabschluss

Questionnaire p. 1

156. Welche **Berufsausbildung** haben Sie?
(Nennen Sie bitte nur den höchsten Abschluss)

- ☐ beruflich-betriebl. Berufsausbildung (Lehre)
- ☐ beruflich-schulische Ausbildung (Berufsfachschule/Handelsschule)
- ☐ Ausbildung an einer Fachschule
- ☐ Fachhochschulabschluss, Ingenieurschule
- ☐ Universitäts- oder Hochschulabschluss
- ☐ anderer Berufsschulabschluss
- ☐ kein Berufsschulabschluss
- ☐ noch in beruflicher Ausbildung

157. Sind Sie …

- ☐ Vollzeiterwerbstätig
- ☐ Teilzeiterwerbstätig
- ☐ Geringfügig erwerbstätig, 450-Euro-Job, Minijob, Gelegentlich oder unregelmäßig beschäftigt
- ☐ „Ein-Euro-Job“ (bei Bezug von Arbeitslosengeld II)
- ☐ Altersteilzeit (in der Arbeitsphase befindlich)
- ☐ In einer beruflichen Ausbildung/Lehre oder Umschulung
- ☐ Schüler/in oder Studierende/r, die/der nicht gegen Geld arbeiten
- ☐ Mutterschafts-, Erziehungsurlaub, Elternzeit oder sonstige Beurlaubung
- ☐ In Pension/Rente, Altersteilzeit (in Freistellungsphase befindlich)
- ☐ zurzeit nicht erwerbstätig (arbeitslos, Vorruheständler/-innen)
- ☐ Noch nie erwerbstätig gewesen
- ☐ Wehrdienst/Bundesfreiwilligendienst (BFD), Freiwilliges Soziales Jahr (FSJ)
- ☐ Hausmann/-frau
- ☐ Sonstiges, und zwar _____

158. Welche **berufliche** Position nehmen Sie gegenwärtig ein?

Wenn Sie nicht mehr oder gegenwärtig nicht berufstätig sind, geben Sie bitte Ihre letzte Position an.

Arbeiter*in

- ☐ ungelernter Arbeiter*in;
- ☐ Angelernter oder gelernter Arbeiter*in
- ☐ Facharbeiter*in
- ☐ Vorarbeiter*in
- ☐ Meister*in

Angestellte*r

- ☐ mit ausführender Tätigkeit nach allgemeiner Anweisung (z. B. Verkäufer*in, Datentypist*in, Sekretariatsassistent*in, Pflegehelfer*in)
- ☐ mit einer qualifizierten Tätigkeit, die ich nach Anweisung erledige (z. B.

Selbständige*r

- ☐ selbständige/r Landwirt*in oder Genossenschaftsbauer*in
- ☐ Freiberuflich, selbständige/r Akademiker*in
- ☐ sonstiger Selbständige*r mit bis zu 9 Mitarbeitern*innen oder Partner*innen
- ☐ sonstiger Selbständige/r mit 10 und mehr Mitarbeitern*innen oder Partner*innen
- ☐ mithelfender Familienangehöriger

Beamte*r

- ☐ einfacher Dienst
- ☐ mittlerer Dienst
- ☐ gehobener Dienst

Sachbearbeiter*in, Buchhalter*in, technische(r) Zeichner*in), angestellte/r Industrie-/Werkmeister*in

☐ mit eigenständiger Leistung in verantwortlicher Tätigkeit bzw. mit Fachverantwortung für Personal (z. B. wissenschaftliche(r) Mitarbeiter*in, Prokurist*in, Abteilungsleiter*in bzw. Meister*in im Angestelltenverhältnis)

☐ mit umfassenden Führungsaufgaben und Entscheidungsbefugnissen (z. B. Direktor*in, Geschäftsführer*in, Mitglied des Vorstandes)

☐ höherer Dienst

☐ weiß nicht

☐ keine Angabe

159. Damit wir in unserer Studie die Angaben aus verschiedenen **Einkommensgruppen** vergleichen können, würde es uns sehr helfen, wenn Sie uns sagen, in welche Gruppe das monatliche Nettoeinkommen Ihres Haushaltes gehört? Ist es …

Zum Nettoeinkommen zählt in Summe das Einkommen aller Haushaltsmitglieder, die gemeinsam einen Privathaushalt bilden, d.h. zusammenwohnen und wirtschaften, nach Abzug von Steuern und Sozialabgaben (einschließlich Erziehungsgeld, Kindergeld, Beihilfen, sonstige Einkünfte).

☐ bis unter 1250 €
☐ 1250 bis unter 1750 €
☐ 1750 bis unter 2250 €
☐ 2250 bis unter 3000 €
☐ 3000 bis unter 4000 €
☐ 4000 bis 5000 €
☐ 5000 € und mehr

☐ weiß nicht
☐ keine Angabe

160. Sollten Sie noch Anmerkungen zur Befragung haben, können Sie uns diese hier gerne mitteilen.

_____
_____
_____
_____
_____
_____
_____

Thank you very much for your participation!

B.2 Questionnaire quantitative survey - control study area

Survey on the perception of environmental factors and technical installations in the living environment

Dear participant,

Thank you for choosing to participate in this survey.

In this questionnaire, you will be asked questions about your living environment, your perception of and attitude towards environmental factors and technical installations, as well as general questions about your household and yourself.

Please read the questions and statements carefully. Tick the box that corresponds to your chosen answer. If you are not sure of the answer to a question, choose the answer option that you think is most applicable. The questionnaire will take about 15-20 minutes to complete.

After you have filled out the questionnaire completely, send it back to us in the enclosed return envelope. We will of course pay the postage for you!

All information you provide will be treated confidentially. Of course, your participation is voluntary and you will not suffer any disadvantages if you do not participate or terminate your participation prematurely. Please also note our information on data protection in our cover letter.

Thank you very much for your support!

If you have any questions, please do not hesitate to contact us (Phone:, E-Mail:).

Zunächst möchten wir gern etwas über Ihre Wohnumgebung und Wohnsituation im Allgemeinen erfahren.

	Bitte geben Sie an, wie **zufrieden** Sie insgesamt mit den folgenden zwei Aspekten sind. Wie **zufrieden** sind Sie insgesamt mit Ihrer…	nicht	wenig	mittel-mäßig	ziemlich	sehr
1.	… Wohnumgebung?	❒	❒	❒	❒	❒
2.	…Wohnung bzw. mit Ihrem Haus?	❒	❒	❒	❒	❒

3.	Wann sind Sie in Ihre **jetzige Wohnung/Ihr jetziges Haus** eingezogen? Nennen Sie bitte das Jahr.	Jahr: _____
4.	Wo haben Sie gelebt, bevor Sie in Ihren jetzigen Wohnort gezogen sind?	❒ ländlich ❒ in einer Kleinstadt ❒ in einer Großstadt ❒ ich habe schon immer hier im Ort gewohnt
5.	Sind Sie bzw. jemand aus Ihrem **Haushalt Eigentümer*in** Ihrer Wohnung bzw. Ihres Hauses oder wohnen Sie **zur Miete**?	❒ Eigentümer*in ❒ Mieter*in
6.	In welcher **Art von Gebäude** wohnen Sie?	❒ freistehenden Einfamilienhaus ❒ Reihenendhaus ❒ Reihenmittelhaus ❒ Doppelhaushälfte ❒ Wohnung in einem mehrstöckigen Mehrfamilienhaus
	Wenn 6 „Wohnung in einem mehrstöckigen Mehrfamilienhaus“: In welchem Stockwerk liegt Ihre Wohnung?	❒ Souterrain/Erdgeschoss ❒ Obergeschoss/Etage:_____*(Bitte geben Sie die Nummer an)* ❒ keine Angabe

7.	Steht Ihnen zuhause ein **Balkon,** eine **Terrasse oder Garten** am Haus zur Verfügung?	Ja	Nein
	Balkon	❒	❒
	Terrasse	❒	❒
	Garten	❒	❒

	Wie ist das bei Ihnen üblicherweise in den **warmen Jahreszeiten**?	geschlossen	gekippt	geöffnet
8.	Haben Sie **nachts** die Fenster in Ihrem **Schlafzimmer** überwiegend geschlossen, gekippt oder geöffnet?	❒	❒	❒
9.	Wie haben Sie **tagsüber** die Fenster in Ihren **Wohnräumen** überwiegend?	❒	❒	❒
	Und wie ist es bei Ihnen üblicherweise in den **kalten Jahreszeiten**?	geschlossen	gekippt	geöffnet
10.	Haben Sie **nachts** die Fenster in Ihrem **Schlafzimmer** überwiegend geschlossen, gekippt oder geöffnet?	❒	❒	❒
11.	Wie haben Sie **tagsüber** die Fenster in Ihren **Wohnräumen** überwiegend?	❒	❒	❒

12.	Wie viele **Stunden** pro Tag sind Sie in etwa **außer Haus**, z. B. beim Arbeiten, Einkaufen oder für sonstige Erledigungen oder Aktivitäten?	Anzahl Stunden pro Tag
	…montags bis freitags	_____
	…samstags	_____
	…sonntags	_____
13.	Gibt es etwas, das Sie in Ihrer Wohnumgebung schätzen?	❒ Ja ❒ Nein
	Wenn ja, was genau:	_____ *(Freitext)*
14.	Gibt es etwas, das Sie in Ihrer Wohnumgebung stört?	❒ Ja ❒ Nein
	Wenn ja, was genau?	_____ *(Freitext)*

	Bitte geben Sie an, inwiefern Sie den folgenden Aussagen **zustimmen**	nicht	wenig	mittel-mäßig	ziemlich	sehr
15.	Selbst wenn es bessere Orte gibt, werde ich nicht von hier wegziehen.	❒	❒	❒	❒	❒
16.	Ich kann mir nicht vorstellen, von hier wegzuziehen.	❒	❒	❒	❒	❒
17.	Ich habe nie darüber nachgedacht, ob es nicht besser wäre, woanders zu leben.	❒	❒	❒	❒	❒
18.	Es würde mir nichts ausmachen, meinen Wohnort zu verlassen und woanders hinzuziehen.	❒	❒	❒	❒	❒

19.	Es gibt viele Orte in Deutschland und auf der Welt, an denen ich leben könnte.	❒	❒	❒	❒	❒
20.	Ich mag es, meine Gegend zu erkunden und neue Orte zu entdecken.	❒	❒	❒	❒	❒
21.	Ich mache oft Fotos von verschiedenen Orten hier.	❒	❒	❒	❒	❒
22.	Von Zeit zu Zeit entdecke ich meine Gegend neu.	❒	❒	❒	❒	❒
23.	Es ist für mich wichtiger, wie ich lebe, als wo ich lebe.	❒	❒	❒	❒	❒

		sehr schlecht	eher schlecht	teils gut/ teils schlecht	eher gut	sehr gut
24.	Wie schätzen Sie die Aufenthaltsqualität im Freien in Ihrer Wohnumgebung ein?	❒	❒	❒	❒	❒
25.	Wie würden Sie Ihre Wohnlage in 3 Worten beschreiben? Was fällt Ihnen spontan ein? *(z.B. ländlich, lebendig, ruhig)*	_____ *(Freitext)*				

Als nächstes geht es um die Empfindlichkeit gegenüber den Belastungen aus der Umwelt.

	Für wie **empfindlich** halten Sie sich gegenüber…	nicht	wenig	mittel-mäßig	ziemlich	sehr
26.	… Gerüchen?	❒	❒	❒	❒	❒
27.	… Stress allgemein?	❒	❒	❒	❒	❒
28.	… Wetter?	❒	❒	❒	❒	❒
29.	…Stromleitungen?	❒	❒	❒	❒	❒
30.	… Lärm?	❒	❒	❒	❒	❒
31.	…Mobilfunk?	❒	❒	❒	❒	❒
32.	…Bassgeräuschen, tiefen Tönen?	❒	❒	❒	❒	❒
33.	…monotonem Summen?	❒	❒	❒	❒	❒
34.	…Geräuschen im Allgemeinen?	❒	❒	❒	❒	❒

Im Folgenden geht es um Geräusche von verschiedenen Quellen.

Wenn Sie einmal an die **letzten 12 Monate** hier bei Ihnen denken, wie stark haben Sie sich durch den **Lärm von folgenden Quellen** insgesamt gestört oder belästigt gefühlt?

Ich habe mich durch … gestört oder belästigt gefühlt.		überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
35.	… Straßenverkehr	❒	❒	❒	❒	❒
36.	… Nachbarschaft	❒	❒	❒	❒	❒
37.	… Luftwärmepumpen	❒	❒	❒	❒	❒
38.	… Baustellen	❒	❒	❒	❒	❒
39.	… Biogasanlagen	❒	❒	❒	❒	❒
40.	Gibt es weitere Lärmquellen?	❒ Ja		❒ Nein *(weiter mit Frage 43)*		
	Falls ja, nennen Sie bitte **die zwei weiteren Quellen**, die Sie am stärksten belästigt haben. Bitte geben Sie an, wie stark Sie sich durch diese weiteren Quellen gestört oder belästigt fühlen.	überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
41.	**sonstige Lärmquelle 1**: _____	❒	❒	❒	❒	❒
42.	**sonstige Lärmquelle 2**: _____	❒	❒	❒	❒	❒

Im Folgenden geht es um den Betrieb von Windenergieanlagen allgemein.

Bitte geben Sie an, inwieweit Sie den folgenden Aussagen **zustimmen.** *Bitte wählen Sie jeweils die Antwortmöglichkeit, die Ihrer Ansicht nach am ehesten zutrifft.*		nicht	wenig	mittel-mäßig	ziemlich	sehr
43.	Windenergieanlagen fördern die Weiterentwicklung der Region.	❒	❒	❒	❒	❒
44.	Durch den Betrieb von Windenergieanlagen kommt es zu einer Wertminderung der umgebenden Häuser und Grundstücke.	❒	❒	❒	❒	❒
45.	Durch den Betrieb von Windenergieanlagen entstehen neue Arbeitsplätze in der Region.	❒	❒	❒	❒	❒

46.	Durch den Betrieb von Windenergieanlagen wird einem der Aufenthalt im Garten, auf der Terrasse oder auf dem Balkon verleidet.	❒	❒	❒	❒	❒
47.	Die Windenergieanlagen sind Grundlage für Streitigkeiten innerhalb der Nachbarschaft.	❒	❒	❒	❒	❒
48.	Durch Windenergieanlagen wird das Landschaftsbild verschandelt.	❒	❒	❒	❒	❒
49.	Der Betrieb der Windenergieanlagen ist gut für den Umweltschutz.	❒	❒	❒	❒	❒
50.	Durch den Betrieb der Windenergieanlagen wird die Naherholung erschwert.	❒	❒	❒	❒	❒
51.	Durch den Betrieb der Windenergieanlagen sinken die Stromkosten.	❒	❒	❒	❒	❒
52.	Die Windenergieanlagen sind gesundheitsgefährdend für den Menschen.	❒	❒	❒	❒	❒
53.	Der Betrieb von Windenergieanlagen gefährdet die heimischen Tiere.	❒	❒	❒	❒	❒
54.	Der Betrieb von Windenergieanlagen schadet dem Tourismus in der Region.	❒	❒	❒	❒	❒
55.	Gegen das Aufstellen von Windenergieanlagen kann man sich nicht wehren.	❒	❒	❒	❒	❒
56.	Windenergieanlagen sind ein attraktives Merkmal der Landschaft.	❒	❒	❒	❒	❒
57.	Ich habe Vertrauen in die Technologie von Windenergieanlagen.	❒	❒	❒	❒	❒
58.	Die mit der Infrastruktur von Windenergieanlagen verbundenen Risiken sind bei Wissenschaftler*innen bekannt.	❒	❒	❒	❒	❒
59.	Die mit der Infrastruktur von Windenergieanlagen verbundenen Risiken sind der breiten Öffentlichkeit bekannt.	❒	❒	❒	❒	❒

Der folgende Abschnitt befasst sich mit der Geräuschart Infraschall.

60. Was verstehen Sie unter dem Begriff „Infraschall“? Was fällt Ihnen spontan dazu ein?

_____
_____
_____
_____

61. Was glauben Sie, wie kann Infraschall wahrgenommen werden? Infraschall kann man…

(Mehrfachnennungen möglich)

❒ … mit den Ohren hören.

❒ … mit den Ohren wahrnehmen, aber nicht als Geräusch.

❒ …als Vibrationen im Gebäude und anderen Objekten spüren.

❒ …als Vibrationen an verschiedenen Stellen des eigenen Körpers spüren.

❒ … mit keinen Sinnen wahrnehmen, beeinflusst mich aber auf eine andere Art und löst körperliches Unwohlsein aus.

❒ … gar nicht wahrnehmen.

62. Woher erhalten Sie hauptsächlich Informationen über Infraschall?

(Bitte nur 1 Kreuz)

❒ überregionale Medien (Zeitung, TV)

❒ regionale/lokale Medien (Zeitung, TV)

❒ soziale Medien (Facebook, Instagram, Nachrichtendienste)

❒ Internet

❒ Freunde / Familie / Nachbarn

❒ Bürgerinitiativen

❒ weitere, und zwar

_____

❒ gar nicht

Im Folgenden würden wir gern wissen, inwiefern Sie den folgenden Aussagen zustimmen. *Bitte wählen Sie jeweils die*	nicht	wenig	mittel-mäßig	ziemlich	sehr

	Antwortmöglichkeit, die Ihrer Ansicht nach am ehesten zutrifft.					
63.	Die Sorge über gesundheitliche Risiken durch Infraschall von Windenergieanlagen ist berechtigt.	❒	❒	❒	❒	❒
64.	Wegen des Infraschalls löst die Nähe zur Windenergieanlage bei mir Beklommenheit aus.	❒	❒	❒	❒	❒
65.	Wenn man Sorgen über den Infraschall von Windenergieanlagen äußert, wird man von Familie und Freunden nicht ernstgenommen.	❒	❒	❒	❒	❒
66.	Wenn man Sorgen über den Infraschall von Windenergieanlagen äußert, wird man von Betreibern und Behörden nicht ernstgenommen.	❒	❒	❒	❒	❒
67.	Auswirkungen durch Infraschall von Windenergieanlagen auf den Menschen sind noch nicht hinreichend erforscht.	❒	❒	❒	❒	❒
68.	Infraschall von Windenergieanlagen wirkt sich negativ auf den Schlaf aus.	❒	❒	❒	❒	❒
69.	An Infraschall von Windenergieanlagen kann man sich gewöhnen.	❒	❒	❒	❒	❒
70.	Der Infraschall von Windenergieanlagen unterscheidet sich nicht von natürlich auftretendem Infraschall.	❒	❒	❒	❒	❒
71.	Informationen über Infraschall von Windenergieanlagen müssen für Anwohnende verständlich und nutzbar sein.	❒	❒	❒	❒	❒
72.	Meine Meinung über Infraschall von Windenergieanlagen bilde ich mir anhand der Erfahrung von Freunden und Familie.	❒	❒	❒	❒	❒
73.	Hilfreiche Informationen zu Infraschall von Windenergieanlagen findet man nur bei öffentlichen Behörden.	❒	❒	❒	❒	❒

In diesem Abschnitt geht es um generelle Fragen zur Energiewende und zum Klimawandel

		überhaupt nicht	etwas	mittel-mäßig	stark	äußerst
74.	Wie besorgt sind Sie wegen des Klimawandels?	❒	❒	❒	❒	❒

	Bitte geben Sie an, wie sehr Sie den folgenden Aussagen zustimmen.	nicht	wenig	mittel-mäßig	ziemlich	sehr
75.	Erneuerbare Energien tragen generell zum Klimaschutz bei.	❒	❒	❒	❒	❒

Ich finde die Energiewende in Deutschland insgesamt…

		sehr (3)	(2)	(1)	weder noch (0)	(1)	(2)	sehr (3)	
76.	überflüssig	❒	❒	❒	❒	❒	❒	❒	wünschenswert
77.	schlecht	❒	❒	❒	❒	❒	❒	❒	gut
78.	unwirtschaftlich	❒	❒	❒	❒	❒	❒	❒	wirtschaftlich
79.	naturschädigend	❒	❒	❒	❒	❒	❒	❒	naturverträglich
80.	ungerecht	❒	❒	❒	❒	❒	❒	❒	gerecht
81.	landschaftsschädigend	❒	❒	❒	❒	❒	❒	❒	landschaftsverträglich
82.	schlecht umgesetzt	❒	❒	❒	❒	❒	❒	❒	gut umgesetzt

Im Folgenden geht es um Ihre Gefühle und Gedanken während des <u>letzten Monats.</u>

	Im letzten Monat, wie oft…	nie	selten	manch-mal	häufig	sehr oft

83.	… wurden Sie von unerwarteten Ereignissen überrascht?	❒	❒	❒	❒	❒
84.	… hatten Sie das Gefühl, dass es Ihnen nicht möglich ist, wichtige Dinge in Ihrem Leben beeinflussen zu können?	❒	❒	❒	❒	❒
85.	… haben Sie sich nervös oder „gestresst“ gefühlt?	❒	❒	❒	❒	❒
86.	… hatten Sie sich im letzten Monat sicher im Umgang mit persönlichen Aufgaben und Problemen gefühlt?	❒	❒	❒	❒	❒
87.	… hatten Sie das Gefühl, dass sich die Dinge nach Ihren Vorstellungen entwickeln?	❒	❒	❒	❒	❒
88.	… hatten Sie das Gefühl, mit all den anstehenden Aufgaben und Problemen nicht richtig umgehen zu können?	❒	❒	❒	❒	❒
89.	… mit Ärger in Ihrem Leben klar zu kommen?	❒	❒	❒	❒	❒
90.	…hatten Sie das Gefühl alles im Griff zu haben?	❒	❒	❒	❒	❒
91.	… darüber geärgert, wichtige Dinge nicht beeinflussen zu können?	❒	❒	❒	❒	❒
92.	… hatten Sie das Gefühl, dass sich die Probleme so aufgestaut haben, dass Sie diese nicht mehr bewältigen können?	❒	❒	❒	❒	❒

		schlecht	weniger gut	gut	sehr gut	ausge-zeichnet
93.	Wenn Sie einmal an die **letzten 4 Wochen** denken: Wie würden Sie Ihren **Gesundheitszustand** im Allgemeinen beschreiben?	❒	❒	❒	❒	❒

Zum Schluss möchten wir Sie bitten, uns noch zu statistischen Zwecken Angaben zu Ihrer Person mitzuteilen. Diese Angaben helfen uns, die Befragungsdaten zwischen verschiedenen Gruppen zu vergleichen.

94.	Welches **Geschlecht** haben Sie?	männlich ❒	weiblich ❒	divers ❒
95.	In welchem Jahr sind Sie geboren?	Jahr: _____		

96.	Wie viele **Personen** leben ständig **in Ihrem Haushalt**, Sie selbst mitgerechnet? Zählen Sie dabei bitte auch Kinder mit.	_____ Personen insgesamt davon: _____ unter 14 Jahre (Kinder) _____ von 14 bis unter 18 Jahre alt (Jugendliche) _____ mindestens 18 Jahre alt (Erwachsene)

Als Privathaushalt gelten Personen, die zusammenwohnen und wirtschaften, die in der Regel ihren Lebensunterhalt gemeinsam finanzieren beziehungsweise die Ausgaben für den Haushalt teilen. Mitglieder einer Wohngemeinschaft ohne gemeinsame Haushaltsführung gelten als eigenständige Privathaushalte. Geben Sie in dem Fall nur die Anzahl der Personen in Ihrer Wohngemeinschaft an, die mit Ihnen zusammenwohnen und wirtschaften.

97.	Welchen **Schulabschluss** haben Sie? *(Nennen Sie bitte nur den höchsten Abschluss.)*	☐ Hauptschul-/Volksschulabschluss oder gleichwertiger Abschluss ☐ Realschulabschluss/Mittlere Reife oder gleichwertiger Abschluss ☐ Abschluss der Polytechnischen Oberschule ☐ Fachhochschulreife, Abschluss Fachoberschule ☐ Abitur ☐ anderer Schulabschluss ☐ Schule beendet ohne Abschluss ☐ noch keinen Schulabschluss
98.	Welche **Berufsausbildung** haben Sie? *(Nennen Sie bitte nur den höchsten Abschluss)*	☐ beruflich-betriebl. Berufsausbildung (Lehre) ☐ beruflich-schulische Ausbildung (Berufsfachschule/Handelsschule) ☐ Ausbildung an einer Fachschule ☐ Fachhochschulabschluss, Ingenieurschule ☐ Universitäts- oder Hochschulabschluss ☐ anderer Berufsschulabschluss ☐ kein Berufsschulabschluss ☐ noch in beruflicher Ausbildung
99.	Sind Sie …	☐ Vollzeiterwerbstätig ☐ Teilzeiterwerbstätig ☐ Geringfügig erwerbstätig, 450-Euro-Job, Minijob, Gelegentlich oder unregelmäßig beschäftigt ☐ „Ein-Euro-Job“ (bei Bezug von Arbeitslosengeld II) ☐ Altersteilzeit (in der Arbeitsphase befindlich) ☐ In einer beruflichen Ausbildung/Lehre oder Umschulung ☐ Schüler/in oder Studierende/r, die/der nicht gegen Geld arbeiten ☐ Mutterschafts-, Erziehungsurlaub, Elternzeit oder sonstige Beurlaubung ☐ In Pension/Rente, Altersteilzeit (in Freistellungsphase befindlich)

- ☐ zurzeit nicht erwerbstätig (arbeitslos, Vorruheständler/-innen)
- ☐ Noch nie erwerbstätig gewesen
- ☐ Wehrdienst/Bundesfreiwilligendienst (BFD), Freiwilliges Soziales Jahr (FSJ)
- ☐ Hausmann/-frau
- ☐ Sonstiges, und zwar _____

100. Welche **berufliche** Position nehmen Sie gegenwärtig ein?

Wenn Sie nicht mehr oder gegenwärtig nicht berufstätig sind, geben Sie bitte Ihre letzte Position an.

Arbeiter*in
- ☐ ungelernter Arbeiter*in;
- ☐ Angelernter oder gelernter Arbeiter*in
- ☐ Facharbeiter*in
- ☐ Vorarbeiter*in
- ☐ Meister*in

Angestellte*r
- ☐ mit ausführender Tätigkeit nach allgemeiner Anweisung (z. B. Verkäufer*in, Datentypist*in, Sekretariatsassistent*in, Pflegehelfer*in)
- ☐ mit einer qualifizierten Tätigkeit, die ich nach Anweisung erledige (z. B. Sachbearbeiter*in, Buchhalter*in, technische(r) Zeichner*in), angestellte/r Industrie-/Werkmeister*in
- ☐ mit eigenständiger Leistung in verantwortlicher Tätigkeit bzw. mit Fachverantwortung für Personal (z. B. wissenschaftliche(r) Mitarbeiter*in, Prokurist*in, Abteilungsleiter*in bzw. Meister*in im Angestelltenverhältnis)
- ☐ mit umfassenden Führungsaufgaben und Entscheidungsbefugnissen (z. B. Direktor*in, Geschäftsführer*in, Mitglied des Vorstandes)

Selbständige*r
- ☐ selbständige/r Landwirt*in oder Genossenschaftsbauer*in
- ☐ Freiberuflich, selbständige/r Akademiker*in
- ☐ sonstiger Selbständige*r mit bis zu 9 Mitarbeitern*innen oder Partner*innen
- ☐ sonstiger Selbständige/r mit 10 und mehr Mitarbeitern*innen oder Partner*innen
- ☐ mithelfender Familienangehöriger

Beamte*r
- ☐ einfacher Dienst
- ☐ mittlerer Dienst
- ☐ gehobener Dienst
- ☐ höherer Dienst

- ☐ weiß nicht
- ☐ keine Angabe

101. Damit wir in unserer Studie die Angaben aus verschiedenen **Einkommensgruppen** vergleichen können, würde es uns sehr helfen, wenn Sie uns sagen, in welche Gruppe das monatliche Nettoeinkommen Ihres Haushaltes gehört? Ist es …

Zum Nettoeinkommen zählt in Summe das Einkommen aller Haushaltsmitglieder, die gemeinsam einen Privathaushalt bilden, d.h. zusammenwohnen und wirtschaften, nach Abzug von Steuern und Sozialabgaben (einschließlich Erziehungsgeld, Kindergeld, Beihilfen, sonstige Einkünfte).

- ☐ bis unter 1250 €
- ☐ 1250 bis unter 1750 €
- ☐ 1750 bis unter 2250 €
- ☐ 2250 bis unter 3000 €
- ☐ 3000 bis unter 4000 €
- ☐ 4000 bis 5000 €
- ☐ 5000 € und mehr

- ☐ weiß nicht
- ☐ keine Angabe

102. Sollten Sie noch Anmerkungen zur Befragung haben, können Sie uns diese hier gerne mitteilen.

_____
_____
_____
_____
_____
_____
_____

Thank you very much for your participation!

Appendix C - Results of the quantitative survey

C.1 Descriptive representation of the results of the Perceived Stress Scale[3] (in %)

In the last month, how often have you...	never	almost never	sometimes	fairly often	very often	N	M	SD
... been upset because of something that happened unexpectedly?	8,79	38,48	36,36	11,82	4,55	330	2,6	1,0
... felt that you were unable to control important things in your life?	10,88	33,53	34,14	16,31	5,14	331	2,7	1,0
... you felt nervous and "stressed"?	9,97	30,21	35,05	18,73	6,04	331	2,8	1,0
... felt confident about your ability to handle your personal problems?	4,86	12,77	25,23	43,16	13,98	329	3,5	1,0
... felt that things were going your way?	3,65	21,28	33,43	35,56	6,08	329	3,2	1,0
... found that you could not cope with all the things that you had to do?	12,77	40,73	28,27	15,81	2,43	329	2,5	1,0
... been able to control irritations in your life?	13,50	27,30	28,83	22,70	7,67	326	2,8	1,2
...felt that you were on top of things?	3,06	8,56	23,55	49,24	15,60	327	3,7	0,9
... been angered because of things that were outside of your control?	7,10	21,91	40,12	21,60	9,26	324	3,0	1,0
... felt difficulties were piling up so high that you could not overcome them?	35,49	35,80	19,44	7,41	1,85	324	2,0	1,0

Remark. N = number. M= mean value. SD= standard deviation.

[3] This is the original wording of the PSS from Cohen and Williamson (1988). In this study we used the german translation by Büssing (2011).

C.2 Results of the one-factor MANOVA

C.2.1 Descriptive statistics of the dependent variables in the one-factor MANOVA

Variables	Area	M	SD	N
activePlaceAttachment	WT N1 OchtersumHoltgast	3,1	1,05	60
	WT N2 Dornum	3,1	1,15	55
	WT S1 HartefeldGeldern	3,2	0,91	52
	WT S2 Hilchenbach	3,2	0,93	65
	Total	**3,1**	**1,01**	**232**
traditionalPlaceAttachment	WT N1 OchtersumHoltgast	3,3	1,25	60
	WT N2 Dornum	3,0	1,21	55
	WT S1 HartefeldGeldern	3,3	1,19	52
	WT S2 Hilchenbach	3,0	1,26	65
	Total	**3,2**	**1,23**	**232**
Placelessness	WT N1 OchtersumHoltgast	2,7	0,88	60
	WT N2 Dornum	2,8	0,93	55
	WT S1 HartefeldGeldern	3,1	1,02	52
	WT S2 Hilchenbach	3,0	0,96	65
	Total	**2,9**	**0,95**	**232**
Acceptance_WT	WT N1 OchtersumHoltgast	3,0	1,21	60
	WT N2 Dornum	3,1	1,34	55
	WT S1 HartefeldGeldern	3,5	1,27	52
	WT S2 Hilchenbach	4,0	0,94	65
	Total	**3,4**	**1,25**	**232**
Technology_Trust	WT N1 OchtersumHoltgast	3,3	0,69	60
	WT N2 Dornum	3,3	0,91	55
	WT S1 HartefeldGeldern	3,3	0,81	52
	WT S2 Hilchenbach	3,6	0,71	65
	Total	**3,4**	**0,78**	**232**

Climate_change_concerns	WT N1 OchtersumHoltgast	3,7	0,93	60
	WT N2 Dornum	3,8	0,95	55
	WT S1 HartefeldGeldern	3,9	0,87	52
	WT S2 Hilchenbach	4,0	0,74	65
	Total	**3,8**	**0,88**	**232**
Energy transition_advocates	WT N1 OchtersumHoltgast	4,3	1,56	60
	WT N2 Dornum	4,4	1,35	55
	WT S1 HartefeldGeldern	4,5	1,17	52
	WT S2 Hilchenbach	4,5	1,31	65
	Total	**4,4**	**1,35**	**232**
PSS_Helplessness	WT N1 OchtersumHoltgast	2,8	0,68	60
	WT N2 Dornum	2,6	0,81	55
	WT S1 HartefeldGeldern	2,5	0,58	52
	WT S2 Hilchenbach	2,6	0,70	65
	Total	**2,6**	**0,71**	**232**
Environmental sensitivity	WT N1 OchtersumHoltgast	3,2	0,83	60
	WT N2 Dornum	3,3	0,93	55
	WT S1 HartefeldGeldern	3,3	0,74	52
	WT S2 Hilchenbach	3,3	0,79	65
	Total	**3,3**	**0,82**	**232**
Electrosensitivity	WT N1 OchtersumHoltgast	2,6	1,18	60
	WT N2 Dornum	2,5	0,96	55
	WT S1 HartefeldGeldern	2,4	0,92	52
	WT S2 Hilchenbach	2,6	1,10	65
	Total	**2,5**	**1,05**	**232**
WT_concerns	WT N1 OchtersumHoltgast	3,0	1,07	60
	WT N2 Dornum	2,9	0,99	55
	WT S1 HartefeldGeldern	2,6	0,99	52
	WT S2 Hilchenbach	2,1	0,80	65

	Total	**2,6**	**1,02**	**232**
WT_pos_attitudes_new	WT N1 OchtersumHoltgast	2,4	0,84	60
	WT N2 Dornum	2,5	0,83	55
	WT S1 HartefeldGeldern	2,4	0,83	52
	WT S2 Hilchenbach	2,8	0,79	65
	Total	**2,5**	**0,83**	**232**

Note. N = number. M= mean value. SD= standard deviation.

C.2.2 Tests of the between-subject effects in the MANOVA

Variable	df1	df2	F-value	p-value	partial Eta²
WT acceptance	**3**	**129**	**7,56**	**0,00**	**0,15**
WT concerns	**3**	**129**	**9,06**	**0,00**	**0,17**
positive WT attitudes	**3**	**129**	**3,53**	**0,02**	**0,08**
Technology Trust	3	129	1,65	0,18	0,04
Concern about climate change	3	129	2,66	0,05	0,06
Authenticity of the WT stakeholders	**3**	**129**	**12,95**	**0,00**	**0,23**

Note. df1= degrees of freedom of the numerator. df2 = degrees of freedom of the denominator. F-value. p= significance level. Partial Eta²= effect size.

C.2.3 Post-hoc results of the one-factor MANOVA to test for group differences between the areas.

Dependent variable	(I) Area	(J) Area	Mean difference (I-J)	Std. error	Sig.	95% confidence interval	
						Lower limit	Upper limit
WT acceptance	N1	N2	0,16	0,34	0,96	-0,74	1,07
		S1	-0,27	0,36	0,87	-1,23	0,68
		S2	-1,0906*	0,26	0,00	-1,77	-0,41
	N2	N1	-0,16	0,34	0,96	-1,07	0,74
		S1	-0,44	0,39	0,68	-1,46	0,59
		S2	-1,2532*	0,29	0,00	-2,03	-0,47
	S1	N1	0,27	0,36	0,87	-0,68	1,23
		N2	0,44	0,39	0,68	-0,59	1,46
		S2	-0,82	0,31	0,06	-1,66	0,02
	S2	N1	1,0906*	0,26	0,00	0,41	1,77
		N2	1,2532*	0,29	0,00	0,47	2,03
		S1	0,82	0,31	0,06	-0,02	1,66
WT concerns	N1	N2	0,21	0,26	0,85	-0,48	0,89
		S1	0,32	0,27	0,63	-0,40	1,04
		S2	1,05014*	0,20	0,00	0,53	1,57

	N2	N1	-0,21	0,26	0,85	-0,89	0,48
		S1	0,12	0,29	0,98	-0,65	0,88
		S2	,84230*	0,22	0,00	0,26	1,43
	S1	N1	-0,32	0,27	0,63	-1,04	0,40
		N2	-0,12	0,29	0,98	-0,88	0,65
		S2	,72672*	0,23	0,02	0,10	1,36
	S2	N1	-1,05014*	0,20	0,00	-1,57	-0,53
		N2	-,84230*	0,22	0,00	-1,43	-0,26
		S1	-,72672*	0,23	0,02	-1,36	-0,10
positive WT attitudes	N1	N2	-0,07	0,22	0,99	-0,65	0,51
		S1	0,21	0,21	0,75	-0,35	0,78
		S2	-0,43	0,19	0,11	-0,93	0,07
	N2	N1	0,07	0,22	0,99	-0,51	0,65
		S1	0,28	0,22	0,58	-0,30	0,86
		S2	-0,36	0,19	0,26	-0,87	0,15
	S1	N1	-0,21	0,21	0,75	-0,78	0,35
		N2	-0,28	0,22	0,58	-0,86	0,30
		S2	-,64146*	0,19	0,01	-1,14	-0,15

	S2	N1	0,43	0,19	0,11	-0,07	0,93
		N2	0,36	0,19	0,26	-0,15	0,87
		S1	,64146*	0,19	0,01	0,15	1,14
Authenticity of the WT stakeholders	N1	N2	-0,07	0,25	0,99	-0,74	0,59
		S1	-0,48	0,25	0,25	-1,15	0,20
		S2	-1,1588*	0,19	0,00	-1,67	-0,65
	N2	N1	0,07	0,25	0,99	-0,59	0,74
		S1	-0,40	0,27	0,46	-1,12	0,32
		S2	-1,0854*	0,22	0,00	-1,66	-0,51
	S1	N1	0,48	0,25	0,25	-0,20	1,15
		N2	0,40	0,27	0,46	-0,32	1,12
		S2	-,6831*	0,22	0,02	-1,27	-0,09
	S2	N1	1,1588*	0,19	0,00	0,65	1,67
		N2	1,0854*	0,22	0,00	0,51	1,66
		S1	,6831*	0,22	0,02	0,09	1,27

C.3 Characteristics of the respondents divided into four clusters

Cluster	1	2	3	4	total	Interpretation	Scale
Number	**70**	**38**	**25**	**45**	**178**		
Frequency per cluster in %							
Gender: Proportion of women	28,0%	47,3%	63,6%	57,5%	48,1%		
Home ownership: Proportion owned (vs. rented)	86,0%	85,5%	75,0%	87,5%	83,6%		
Total audibility WT	44,9%	46,3%	31,8%	60,5%	45,4%		
Audibility WT outside	52,0%	47,3%	29,5%	60,0%	47,1%		
Indoor audibility WT	38,0%	30,9%	25,0%	47,5%	34,9%		
Mean values							
Age in years	73,50	53,02	33,57	63,08	56,04	Higher values = older	Age in years
School education	2,34	3,45	3,73	3,00	3,13	Higher values = higher school education	1 = no school-leaving certificate/secondary school leaving certificate, 2 = school-leaving certificate Realschule/ Polytechn. S., 3 = entrance qualification for university of applied sciences, 4 = university entrance qualification
Net household income	4,11	5,33	4,83	4,23	4,66	Higher values = higher incomes	1 = ≤ 1250€, 2 = 1250-1750€, 3 = 1750-2250€, 4 = 2250-3000€, 5 = 3000-4000€, 6 = 4000-5000€, 7 = 5000€ and more.
Infrasound - health concerns	2,69	2,53	2,51	2,88	2,64	Higher values = higher concerns	Scale from 1 - 5

Cluster	1	2	3	4	total	Interpretation	Scale
Infrasound - social debate	3,36	3,26	3,25	3,40	3,31	Higher values = less social conflict. Conflict	Scale from 1 - 5
Sensitivity to environmental stress	3,09	3,34	3,35	3,43	3,29	Higher values = higher sensitivity	Scale from 1 - 5
PSS - Helplessness	2,55	2,51	2,64	2,78	2,61	Higher values = higher level of helplessness	Scale from 1 - 5
Satisfaction with apartment/house	4,42	4,56	4,30	4,50	4,45	Higher values = higher satisfaction	Scale from 1 - 5
active place attachment	2,90	3,34	3,20	3,18	3,16	Higher values = higher place attachment	Scale from 1 - 5
traditional place attachment	3,06	3,21	3,16	3,30	3,18	Higher values = higher place attachment	Scale from 1 - 5
Quality of stay in the outdoor area	4,14	4,45	4,30	4,17	4,28	Higher values = higher quality of stay	Scale from 1 - 5
Concerns about WTs	2,79	2,50	2,36	2,79	2,61	Higher values = higher levels of apprehension	Scale from 1 - 5
Pos. attitudes towards WT	2,53	2,49	2,75	2,51	2,56	Higher values = more positive attitude towards WTs	Scale from 1 - 5
Concerns about climate change	3,97	3,87	3,84	3,77	3,87	Higher values = higher concern	Scale from 1 - 5
Advocacy of energy transition	4,65	4,25	4,22	4,60	4,42	Higher values = higher level of endorsement	Scale from -3 to +3
Visual_WT_Annoyance	2,39	2,13	2,09	2,09	2,18	Higher values = higher annoyance	Scale from 1 - 5
Total noise annoyance from wind turbines	2,32	2,08	1,77	2,28	2,11	Higher values = higher annoyance	Scale from 1 - 5
Activity disturbances outside due to wind turbine noise	1,55	1,61	1,49	1,74	1,59	Higher values = higher level of disturbances	Scale from 1 - 5

Cluster	1	2	3	4	total	Interpretation	Scale
Sleep disturbance due to wind turbine noise	1,47	1,45	1,40	1,71	1,50	Higher values = higher level of disturbances	Scale from 1 - 5
Authenticity of the WT stakeholders	2,66	2,92	1,92	2,68	2,66	Higher values = higher level of authenticity	Scale from 1 - 5
Acceptance WT	3,34	3,50	3,83	3,29	3,49	Higher values = higher acceptance	Scale from 1 - 5