

(2015). "Judicial review proceedings of a neighbor against the designation of a priority area for wind energy in the Regional Spatial Planning Program (RRPP)." *Natur und Recht* **37**(10): 706-710.

(2016). "Erratum: Exposure to wind turbine noise: Perceptual responses and reported health effects (Journal of the Acoustical Society of America (2016) 139:3 (1443-1454))." *Journal of the Acoustical Society of America* **140**(4): 2457.

The authors made a reference error in the following statement: "As per ISO/TS (2003a), participants reporting to be either 'very' or 'extremely' annoyed were treated as 'highly annoyed' in the analysis." ISO/TS (2003a) does not specify how to define "highly annoyed." The correct reference for the statement is: Schultz, T. (1978). "Synthesis of social surveys on noise annoyance," *J. Acoust. Soc. Am.* **64**(2), 377-405. © Author(s) 2016.

(2016). "Erratum: Personal and situational variables associated with wind turbine noise annoyance (Journal of the Acoustical Society of America (2016) 139: 3 (1455-1466) DOI: 10.1121/1.4942390)." *Journal of the Acoustical Society of America* **140**(4): 2234.

This erratum is provided in acknowledgement of author errors that have been brought to our attention. The references in the caption of Fig. 1(d) should be to Pedersen et al. (2007) and Pedersen (2007), where the missing reference is: Pedersen, E. (2007). "Human response to wind turbine noise-Perception, annoyance and moderating factors," doctoral thesis, Goteborg University, Goteborg, [https:// gupea.ub.gu.se/handle/2077/4431](https://gupea.ub.gu.se/handle/2077/4431) (Last viewed 9/9/2016). Also, in Fig. 1(g) the CTL values should be reduced (shifted left) by approximately 0.8 dB and labeled as follows: CTL 57.7 (mean-1d); CTL=61.1 (mean); CTL=64.5 (mean+1d). Likewise, the WTN curve in Fig. 1(h) (leftmost line, black online) should be shifted left by approximately 0.8 dB. © Author(s) 2016.

Abbasi, M., et al. (2015). "Impact of wind turbine sound on general health, sleep disturbance and annoyance of workers: a pilot- study in Manjil wind farm, Iran." *J Environ Health Sci Eng* **13**: 71.

BACKGROUND: The wind turbine's sound seems to have a proportional effect on health of people living near to wind farms. This study aimed to investigate the effect of noise emitted from wind turbines on general health, sleep and annoyance among workers of manjil wind farm, Iran.

MATERIALS AND METHODS: A total number of 53 workers took part in this study. Based on the type of job, they were categorized into three groups of maintenance, security and office staff. The persons' exposure at each job-related group was measured by eight-hour equivalent sound level (LAeq, 8 h). A Noise annoyance scale, Epworth sleepiness scale and 28-item general health questionnaire was used for gathering data from workers. The data were analyzed through Multivariate Analysis of variance (MANOVA) test, Pillai's Trace test, Paired comparisons analysis and Multivariate regression test were used in the R software.

RESULTS AND DISCUSSION: The results showed that, response variables (annoyance, sleep disturbance and health) were significantly different between job groups. The results also indicated that sleep disturbance as well as noise exposure had a significant effect on general health. Noise annoyance and distance from wind turbines could significantly explain about 44.5 and 34.2 % of the variance in sleep disturbance and worker's general health, respectively. General health was significantly different in different age groups while age had no significant impact on sleep disturbance. The results were reverse for distance because it had no significant impact on health, but sleep disturbance was significantly affected.

CONCLUSIONS: We came to this conclusion that wind turbines noise can directly impact on annoyance, sleep and health. This type of energy generation can have potential health risks for wind farm workers. However, further research is needed to confirm the results of this study.

Abbasi, M., et al. (2016). "Assessment of noise effects of wind turbine on the general health of staff at wind farm of Manjil, Iran." *Journal of Low Frequency Noise Vibration and Active Control* **35**(1): 91-98.

The low-frequency noise generated by wind turbines is known as one of the risk factors for health. The aim of this study was to study the noise effect of wind turbine on the general health of staff at Manjil wind farm. For this purpose, workers were divided into three groups: maintenance, security, and office staff. Equivalent sound levels were measured for each group. Individual's health data were assessed using the 28-item General Health Questionnaire. Pearson correlation, analysis of variance, and multiple regression tests were used for data analysis in the R software. Statistical analysis results showed that the noise exposure is significantly correlated to all sub-scales of general health, except for depression. The low-frequency noise from wind turbines can cause harmful effects on the health of workers that are too close to the wind turbine and receive very intense noise. ©The Author(s) 2016.

Abe, K., et al. (2016). A Study on Reaction of Residents to Wind Turbines to Promote Local Economy. Procedia CIRP.

Renewable energy is strongly focused on in Japan after the accident at nuclear plant. Especially, Northeast area of Japan has high potential of wind energy. It is expected that the related industries, such as manufacturing of equipment, maintenance, investment on wind farms, and retailing of electricity can boost local economy. However, the area has not many big industries which will be the potential users of such wind energy. Thus, a promising strategy is to use wind energy in local communities. Our previous study suggested wind turbines have not big avoidance, when the local community is having benefits from wind energy. By comparing the opinions of residents obtained through a questionnaire and those of workers in a facility using the wind energy, the paper discusses the key issues in installing so-called "civil wind turbines" to local communities. It concluded that the obtained knowledge can be helpful in promoting on-site generation and on-site consumption of wind energy. © 2016 The Authors. Published by Elsevier B.V.

Abeliotis, K. and D. Pactiti (2014). "Assessment of the environmental impacts of a wind farm in central Greece during its life cycle." International Journal of Renewable Energy Research 4(3): 580-585.

Wind energy installations in Greece are increasing rapidly as a means to achieve the national goal for increasing the renewables' share in the country's energy balance. However, wind farm installations are not impact free from the environmental standpoint. The present study examines the cradle-to-grave impacts of a wind farm in central Greece composed of four, 850 MW each, wind turbines. Life cycle inventory data were obtained from secondary sources and the CML 2 baseline 2000 ready-made method was utilized for the environmental assessment in nine impact categories. The results indicate an intensity index of 4.1 kg CO₂ eq. per MWh along with an energy payback time of 7 months. Towers, nacelles and the foundations of the turbines are the wind farm components that cause the most environmental impacts. However, key impact categories associated with energy, such as alteration of local climate, killing of birds and bats, noise and visual impact are not assessed. Despite the limitation of the study, the major conclusion is that electricity generation from wind power is environmentally preferable compared to the current electricity generation mix in Greece.

Abromas, J., et al. (2015). "Visual impact assessment of wind turbines and their farms on landscape of kretinga region (lithuania) and grobina townscape (Latvia)." Journal of Environmental Engineering and Landscape Management 23(1): 39-49.

Early in 2013 as many as 5 wind farms were in operation in Kretinga region and the sixth was under construction. The wind farms are concentrated within two territories, i.e. in the south-west part of the region (between Kretinga and Palanga towns) and in the north-west (between Darbenai and the Senoji piltis villages). The region also houses seven individual wind turbines, the total number being 58 units. In seeking to assess the impact of wind turbines based in Kretinga region on the landscape and the villages, the analysis of cartography material was carried out and the inventory of all wind turbines was made (GIS data base). On assessing the importance of the roads with regard to the intensity of traffic and tourist flows, the observation places were established and photo fixation was performed. The impact was assessed from eleven observation places (all the places were close to the roads). During the study, the nature, importance and degree of contrast of the visual impact of wind turbines were assessed. In assessing the visual impact of wind turbines on the landscape, it was found that woodlands and villages make a significant impact on the visibility of turbines. The wind turbines seen on the axis of the road perspective are not only observed for some length of time, but often serve as a landmark. The investigation results were compared with the situation in western Latvia region (Grobina case). Copyright © 2015 Vilnius Gediminas Technical University (VGTU) Press.

Agterbosch, S., et al. (2009). "The relative importance of social and institutional conditions in the planning of wind power projects." Renewable and Sustainable Energy Reviews 13(2): 393-405.

Governments around the world try to stimulate the development and use of renewable energy technologies, like wind energy. While wind turbines are increasingly being implemented, however, a lack of social acceptance at the local level remains an important challenge for developers of wind power plants. This article aims to explore the relative importance of social and institutional conditions and their interdependencies in the operational process of planning wind power schemes. The article not only focuses on how negative local social conditions can frustrate public policy (cf. NIMBY syndrome), but also on how positive local social conditions can compensate for a negative public policy framework. We

analyzed the cases of implementing wind power of two actors (the regional energy distributor and small private investors) in the municipality of Zeewolde, the Netherlands. Both cases illustrate that the formal institutional framework (formal rules, procedures and instruments) is neutral in a certain sense. Social conditions - management styles, interests and informal contacts - put meaning in this framework. The way stakeholders deal with the prevailing institutional structure clarifies social acceptance and therewith implementation. © 2007 Elsevier Ltd. All rights reserved.

Alayrac, M., et al. (2011). "Total annoyance from an industrial noise source with a main spectral component combined with a background noise." *Journal of the Acoustical Society of America* **130**(1): 189-199.

When living close to an industrial plant, people are exposed to a combination of industrial noise sources and a background noise composed of all the other noise sources in the environment. As a first step, noise annoyance indicators in laboratory conditions are proposed for a single exposure to an industrial noise source. The second step detailed in this paper involves determining total annoyance indicators in laboratory conditions for ambient noises composed of an industrial noise source and a background noise. Two types of steady and permanent industrial noise sources are studied: low frequency noises with a main spectral component at 100 Hz, and noises with a main spectral component in middle frequencies. Five background noises are assessed so as to take into account different sound environments which can usually be heard by people living around an industrial plant. One main conclusion of this study is that two different analyses are necessary to determine total annoyance indicators for this type of ambient noise, depending on the industrial noise source composing it. Therefore, two total annoyance indicators adapted to the ambient noises studied are proposed. © 2011 Acoustical Society of America.

Alayrac, M., et al. (2011). "Total annoyance from an industrial noise source with a main spectral component combined with a background noise." *J Acoust Soc Am* **130**(1): 189-199.

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Alayrac, M., et al. (2010). "Annoyance from industrial noise: indicators for a wide variety of industrial sources." *J Acoust Soc Am* **128**(3): 1128-1139.

In the study of noises generated by industrial sources, one issue is the variety of industrial noise sources and consequently the complexity of noises generated. Therefore, characterizing the environmental impact of an industrial plant requires better understanding of the noise annoyance caused by industrial noise sources. To deal with the variety of industrial sources, the proposed approach is set up by type of spectral features and based on a perceptive typology of steady and permanent industrial noises comprising six categories. For each perceptive category, listening tests based on acoustical factors are performed on noise annoyance. Various indicators are necessary to predict noise annoyance due to various industrial noise sources. Depending on the spectral features of the industrial noise sources, noise annoyance indicators are thus assessed. In case of industrial noise sources without main spectral features such as broadband noise, noise annoyance is predicted by the A-weighted sound pressure level $L(Aeq)$ or the loudness level $L(N)$. For industrial noises with spectral components such as low-frequency noises with a main component at 100 Hz or noises with spectral components in middle frequencies, indicators are proposed here that allow good prediction of noise annoyance by taking into account spectral features.

Alimohammadi, I., et al. (2013). "The effects of low frequency noise on mental performance and annoyance." *Environ Monit Assess* **185**(8): 7043-7051.

Low frequency noise (LFN) as background noise in urban and work environments is emitted from many artificial sources such as road vehicles, aircraft, and air movement machinery including wind turbines, compressors, and ventilation or air conditioning units. In addition to objective effects, LFN could also cause noise annoyance and influence mental performance; however, there are no homogenous findings regarding this issue. The purpose of this research was to study the effects of LFN on mental performance and annoyance, as well as to consider the role of extraversion and neuroticism on the issue. This study was conducted on 90 students of Iran University of Medical Sciences (54 males and 36 females). The mean age of the students was 23.46 years ($SD=1.97$). Personality traits and noise annoyance were measured by using Eysenck Personality Inventory and a 12-scale self-reported questionnaire, respectively. Stroop and Cognitrone computerized tests measured mental performance of participants each exposed to 50 and 70 dBA of LFN and silence. LFNs were produced by Cool Edit Pro 2.1 software. There was no significant difference between mental performance parameters under 50 and 70 dBA of LFN, whereas there were significant differences between most mental performance parameters in quiet and under LFN (50 and 70 dBA). This research showed that LFN, compared to silence, increased the accuracy and the test performance speed ($p<0.01$). There was no association between LFN and noise annoyance ($p>0.01$). Introverts conducted the tests faster than extraverts ($p<0.05$). This research showed that neuroticism does not influence mental performance. It seems that LFN has increased arousal level of participants, and extraversion has a considerable impact on mental performance.

Alrashed, F. and M. Asif (2015). An Exploratory of Residents' Views Towards Applying Renewable Energy Systems in Saudi Dwellings. Energy Procedia.

Saudi Arabia is experiencing a rapid growth in the demand for energy and residential buildings. The residential sector alone is responsible for over 50% of the total national electricity consumption. The energy supplies in Saudi Arabia are completely reliant on fossil fuels that are regarded to be the main source of greenhouse gas emissions. In order to promote sustainable development it is vital for Saudi Arabia to reduce the usage of fossil fuels. The country is yet to meaningfully explore the renewable energy recourses. Public perception is a key factor in the take-up of renewable energy in any society. Given the importance of the residential sector in the energy scenario of Saudi Arabia, the presented work aimed to investigate the acceptability of renewable energy systems (RESs) amongst the domestic users through a questionnaire based survey. It covered three RESs including solar photovoltaic (PV), micro-wind turbines and solar water heaters. The results revealed that, solar PV is the most preferred choice. © 2015 The Authors. Published by Elsevier Ltd.

Alves, J. A., et al. (2015). "The influence of low-frequency noise pollution on the quality of life and place in sustainable cities: A case study from Northern Portugal." Sustainability (Switzerland) 7(10): 13920-13946.

Discussing urban planning requires rethinking sustainability in cities and building healthy environments. Historically, some aspects of advancing the urban way of life have not been considered important in city planning. This is particularly the case where technological advances have led to conflicting land use, as with the installation of power poles and building electrical substations near residential areas. This research aims to discuss and rethink sustainability in cities, focusing on the environmental impact of low-frequency noise and electromagnetic radiation on human health. It presents data from a case study in an urban space in northern Portugal, and focuses on four guiding questions: Can power poles and power lines cause noise? Do power poles and power lines cause discomfort? Do power poles and power lines cause discomfort due to noise? Can power poles and power lines affect human health? To answer these questions, we undertook research between 2014 and 2015 that was comprised of two approaches. The first approach consisted of evaluating the noise of nine points divided into two groups "near the source" (e.g., up to 50 m from power poles) and "away from the source" (e.g., more than 250 m away from the source). In the second approach, noise levels were measured for 72 h in houses located up to 20 m from the source. The groups consist of residents living within the distance range specified for each group. The measurement values were compared with the proposed criteria for assessing low-frequency noise using the DEFRA Guidance (University of Salford). In the first approach, the noise caused discomfort, regardless of the group. In the second approach, the noise had fluctuating characteristics, which led us to conclude that the noise caused discomfort. © 2015 by the authors.

Alves-Pereira, M. and N. A. Branco (2014). "Letter to the editor re: 'how the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'." Aust N Z J Public Health 38(2): 191-192.

Alves-Pereira, M. and N. A. C. Branco (2007). "Vibroacoustic disease: biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling." Progress in Biophysics and Molecular Biology **93**(1): 256-279.

Alves-Pereira, M. and N. C. Branco (2007). In-home wind turbine noise is conducive to vibroacoustic disease. Proceedings of the Second International Meeting on Wind Turbine Noise.

Antoniadou, I., et al. (2015). "Aspects of structural health and condition monitoring of offshore wind turbines." Philos Transact Ser A Math Phys Eng Sci **373**(2035).

Wind power has expanded significantly over the past years, although reliability of wind turbine systems, especially of offshore wind turbines, has been many times unsatisfactory in the past. Wind turbine failures are equivalent to crucial financial losses. Therefore, creating and applying strategies that improve the reliability of their components is important for a successful implementation of such systems. Structural health monitoring (SHM) addresses these problems through the monitoring of parameters indicative of the state of the structure examined. Condition monitoring (CM), on the other hand, can be seen as a specialized area of the SHM community that aims at damage detection of, particularly, rotating machinery. The paper is divided into two parts: in the first part, advanced signal processing and machine learning methods are discussed for SHM and CM on wind turbine gearbox and blade damage detection examples. In the second part, an initial exploration of supervisor control and data acquisition systems data of an offshore wind farm is presented, and data-driven approaches are proposed for detecting abnormal behaviour of wind turbines. It is shown that the advanced signal processing methods discussed are effective and that it is important to adopt these SHM strategies in the wind energy sector.

Anund, A., et al. (2015). "The effect of low-frequency road noise on driver sleepiness and performance." PLoS ONE **10**(4): e0123835.

It is a well-known fact today that driver sleepiness is a contributory factor in crashes. Factors considered as sleepiness contributor are mostly related to time of the day, hours being awake and hours slept. Factors contributing to active and passive fatigue are mostly focusing on the level of cognitive load. Less is known what role external factors, e.g. type of road, sound/noise, vibrations etc., have on the ability to stay awake both under conditions of sleepiness and under active or passive fatigue. The aim of this moving base driving simulator study with 19 drivers participating in a random order day and night time, was to evaluate the effect of low-frequency road noise on driver sleepiness and performance, including both long-term and short-term effects. The results support to some extent the hypothesis that road-induced interior vehicle sound affects driving performance and driver sleepiness. Increased low-frequency noise helps to reduce speed during both day- and night time driving, but also contributes to increase the number of lane crossings during night time.

Ascari, E., et al. (2015). "Low frequency noise impact from road traffic according to different noise prediction methods." Sci Total Environ **505**: 658-669.

The European Noise Directive 2002/49/EC requires to draw up noise action plans. Most of the implemented solutions consist in using barriers, even if some studies evidenced that annoyance could increase after their installation. This action dumps the high frequencies, decreasing the masking effect on low ones. Therefore, people annoyance and complaints may increase despite the mitigation. This can happen even in pedestrian zones near main roads due to the screening effect of first buildings row. In this paper, the authors analyze the post-operam screening effects in terms of low frequency noise. The difference between C- and A-weighted levels is calculated as annoyance indicator (LC-A). Different methods able to map noise with octave bands detail are tested in order to establish differences in the estimates of annoyance exposure. In particular, a comparison is carried out between data from interim method NMPB 96, its updated version 2008, NORD 2000 and those provided by a customized procedure through ISO 9613 propagation and Statistical Pass By measurements. Test sites are simulated in order to validate each model results through measurements. Results are discussed for real locations in Pisa city center and virtual scenarios in a rising scale of complexity. Copyright © 2014 Elsevier B.V. All rights reserved.

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Asian, S., et al. (2016). "Wind turbine accidents: A data mining study." *IEEE Systems Journal*.

Babisch, W., et al. (2013). "Noise annoyance—A modifier of the association between noise level and cardiovascular health?" *Science of the Total Environment* **452**: 50-57.

Bakker, R. H., et al. (2012). "Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress." *Sci Total Environ* **425**: 42-51.

PURPOSE OF THE RESEARCH: The present government in the Netherlands intends to realize a substantial growth of wind energy before 2020, both onshore and offshore. Wind turbines, when positioned in the neighborhood of residents may cause visual annoyance and noise annoyance. Studies on other environmental sound sources, such as railway, road traffic, industry and aircraft noise show that (long-term) exposure to sound can have negative effects other than annoyance from noise. This study aims to elucidate the relation between exposure to the sound of wind turbines and annoyance, self-reported sleep disturbance and psychological distress of people that live in their vicinity. Data were gathered by questionnaire that was sent by mail to a representative sample of residents of the Netherlands living in the vicinity of wind turbines **PRINCIPAL RESULTS:** A dose-response relationship was found between immission levels of wind turbine sound and self-reported noise annoyance. Sound exposure was also related to sleep disturbance and psychological distress among those who reported that they could hear the sound, however not directly but with noise annoyance acting as a mediator. Respondents living in areas with other background sounds were less affected than respondents in quiet areas. **MAJOR CONCLUSIONS:** People living in the vicinity of wind turbines are at risk of being annoyed by the noise, an adverse effect in itself. Noise annoyance in turn could lead to sleep disturbance and psychological distress. No direct effects of wind turbine noise on sleep disturbance or psychological stress has been demonstrated, which means that residents, who do not hear the sound, or do not feel disturbed, are not adversely affected. Copyright Copyright 2012 Elsevier B.V. All rights reserved.

Baliatsas, C., et al. (2016). "Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies." *Sci Total Environ* **557-558**: 163-169.

A systematic review of observational studies was conducted to assess the association between everyday life low-frequency noise (LFN) components, including infrasound and health effects in the general population. Literature databases Pubmed, Embase and PsycInfo and additional bibliographic sources such as reference sections of key publications and journal databases were searched for peer-reviewed studies published from 2000 to 2015. Seven studies met the inclusion criteria. Most of them examined subjective annoyance as primary outcome. The adequacy of provided information in the included papers and methodological quality of studies was also addressed. Moreover, studies were screened for meta-analysis eligibility. Some associations were observed between exposure to LFN and annoyance, sleep-related problems, concentration difficulties and headache in the adult population living in the vicinity of a range of LFN sources. However, evidence, especially in relation to chronic medical conditions, was very limited. The estimated pooled prevalence of high subjective annoyance attributed to LFN was about 10%. Epidemiological research on LFN and health effects is scarce and suffers from methodological shortcomings. Low frequency noise in the everyday environment constitutes an issue that requires more research attention, particularly for people living in the vicinity of relevant sources. Copyright © 2016 Elsevier B.V. All rights reserved.

Barnard, M. (2013). "Issues of wind turbine noise." *Noise Health* **15**(63): 150-152.

Bartusek, S. and A. Skácel (2014). Potential impacts of wind power plants on human health. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM.

In relation with the development of renewable sources of energy investors suggest in many locations the construction of wind power plants. One of the regulating factors is the impacts of the wind power plants on the environment and human health. During long-term operation of wind power plants the habitat can be loaded with increased noise, which may affect the psychological well-being of citizens, and in some cases even it can physiological damage the hearing. The paper describes the specific parameters that are used in the evaluation of the impact of wind power plants on the exposed population. The influence is evaluated on the basis of a mathematical model of noise spreading from facility operations and practical terrain measurement of noise, taking into account the background noise at the site prior to the implementation plan. On a model example were evaluated potential effects on human health in the area and the expression of specific health injury symptoms, which may be caused with the operating of wind power plant. The paper also contains a relationship between dose and effect of damage to individual acts of public health. © SGEM2014.

Bauwens, T. (2015). "Cooperative ownership and social acceptability of onshore wind power." *Reflète et Perspectives de la Vie Economique* **54**(1-2): 59-70.

Onshore wind power development in Belgium has provoked considerable opposition at the local level. To cope with this issue, wind power cooperatives seem to present important assets. This article explores the reasons why these organizations are likely to enhance social acceptability of this technology. Then it confronts these normative assumptions with empirical data. The results of this analysis confirm the positive effect of cooperative ownership on the social acceptability of onshore wind turbines. © De Boeck Supérieur. Tous droits réservés pour tous pays.

Beery, J. A. and J. E. Day (2015). "Community investment in wind farms: Funding structure effects in wind energy infrastructure development." *Environmental Science and Technology* **49**(5): 2648-2655.

Wind energy development is an increasingly popular form of renewable energy infrastructure in rural areas. Communities generally perceive socioeconomic benefits accrue and that community funding structures are preferable to corporate structures, yet lack supporting quantitative data to inform energy policy. This study uses the Everpower wind development, to be located in Midwestern Ohio, as a hypothetical modeling environment to identify and examine socioeconomic impact trends arising from corporate, community and diversified funding structures. Analysis of five National Renewable Energy Laboratory Jobs and Economic Development Impact models incorporating local economic data and review of relevant literature were conducted. The findings suggest that community and diversified funding structures exhibit 40-100% higher socioeconomic impact levels than corporate structures. Prioritization of funding sources and retention of federal tax incentives were identified as key elements. The incorporation of local shares was found to mitigate the negative effects of foreign private equity, local debt financing increased economic output and opportunities for private equity investment were identified. The results provide the groundwork for energy policies focused to maximize socioeconomic impacts while creating opportunities for inclusive economic participation and improved social acceptance levels fundamental to the deployment of renewable energy technology.

Berger, R. G., et al. (2015). "Health-based audible noise guidelines account for infrasound and low-frequency noise produced by wind turbines." *Frontiers in public health* **3**.

Berger, R. G., et al. (2015). "Health-based audible noise guidelines account for infrasound and low-frequency noise produced by wind turbines." *Front. public health* **3**: 31.

Setbacks for wind turbines have been established in many jurisdictions to address potential health concerns associated with audible noise. However, in recent years, it has been suggested that infrasound (IS) and low-frequency noise (LFN) could be responsible for the onset of adverse health effects self-reported by some individuals living in proximity to wind turbines, even when audible noise limits are met. The purpose of this paper was to investigate whether current audible noise-based guidelines for wind turbines account for the protection of human health, given the levels of IS and LFN typically produced by wind turbines. New field measurements of indoor IS and outdoor LFN at locations between 400 and 900m from the nearest turbine, which were previously underrepresented in the scientific

literature, are reported and put into context with existing published works. Our analysis showed that indoor IS levels were below auditory threshold levels while LFN levels at distances >500m were similar to background LFN levels. A clear contribution to LFN due to wind turbine operation (i.e., measured with turbines on in comparison to with turbines off) was noted at a distance of 480m. However, this corresponded to an increase in overall audible sound measures as reported in dB(A), supporting the hypothesis that controlling audible sound produced by normally operating wind turbines will also control for LFN. Overall, the available data from this and other studies suggest that health-based audible noise wind turbine siting guidelines provide an effective means to evaluate, monitor, and protect potential receptors from audible noise as well as IS and LFN.

Berrill, P., et al. (2016). "Environmental impacts of high penetration renewable energy scenarios for Europe." Environmental Research Letters **11**(1).

The prospect of irreversible environmental alterations and an increasingly volatile climate pressurises societies to reduce greenhouse gas emissions, thereby mitigating climate change impacts. As global electricity demand continues to grow, particularly if considering a future with increased electrification of heat and transport sectors, the imperative to decarbonise our electricity supply becomes more urgent. This letter implements outputs of a detailed power system optimisation model into a prospective life cycle analysis framework in order to present a life cycle analysis of 44 electricity scenarios for Europe in 2050, including analyses of systems based largely on low-carbon fossil energy options (natural gas, and coal with carbon capture and storage (CCS)) as well as systems with high shares of variable renewable energy (VRE) (wind and solar). VRE curtailments and impacts caused by extra energy storage and transmission capabilities necessary in systems based on VRE are taken into account. The results show that systems based largely on VRE perform much better regarding climate change and other impact categories than the investigated systems based on fossil fuels. The climate change impacts from Europe for the year 2050 in a scenario using primarily natural gas are 1400 Tg CO₂-eq while in a scenario using mostly coal with CCS the impacts are 480 Tg CO₂-eq. Systems based on renewables with an even mix of wind and solar capacity generate impacts of 120-140 Tg CO₂-eq. Impacts arising as a result of wind and solar variability do not significantly compromise the climate benefits of utilising these energy resources. VRE systems require more infrastructure leading to much larger mineral resource depletion impacts than fossil fuel systems, and greater land occupation impacts than systems based on natural gas. Emissions and resource requirements from wind power are smaller than from solar power. © 2016 IOP Publishing Ltd.

Bidwell, D. and M. Affairs (2015). Public acceptance of offshore wind energy: Relationships among general and specific attitudes. OCEANS 2015 - MTS/IEEE Washington.

As interest in implementing offshore wind energy has grown in the United States, so has the desire of social scientists to better understand public responses to the technology. One theme in the literature has been the roles of general attitudes towards renewable energy and perceptions of specific projects in shaping public acceptance of offshore wind farms. A survey of 196 residents of two Rhode Island communities that would be most affected by a proposed wind farm off the coast of Block Island reveals that support for the project is shaped by both general attitudes and project-specific beliefs. General attitudes also have substantial influence on project-specific beliefs. Planning processes should engage the public in discussions of both specific project characteristics and larger issues regarding renewable energy. © 2015 MTS.

Blanes-Vidal, V. and J. Schwartz (2016). "Wind turbines and idiopathic symptoms: The confounding effect of concurrent environmental exposures." Neurotoxicology and Teratology **55**: 50-57.

Whether or not wind turbines pose a risk to human health is a matter of heated debate. Personal reactions to other environmental exposures occurring in the same settings as wind turbines may be responsible of the reported symptoms. However, these have not been accounted for in previous studies. We investigated whether there is an association between residential proximity to wind turbines and idiopathic symptoms, after controlling for personal reactions to other environmental co-exposures. We assessed wind turbine exposures in 454 residences as the distance to the closest wind turbine (Dw) and number of wind turbines <1000 m (Nw1000). Information on symptoms, demographics and personal reactions to exposures was obtained by a blind questionnaire. We identified confounders using confounders' selection criteria and used adjusted logistic regression models to estimate associations. When controlling only for socio-demographic characteristics, log10Dw was associated with "unnatural fatigue" (ORadj = 0.38, 95%CI = 0.15-1.00) and "difficulty concentrating" (ORadj = 0.26, 95%CI =

0.08-0.83) and Nw1000 was associated with "unnatural fatigue" (ORadj = 1.35, 95%CI = 1.07-1.70) and "headache" (ORadj = 1.26, 95%CI = 1.00-1.58). After controlling for personal reactions to noise from sources different from wind turbines and agricultural odor exposure, we did not observe a significant relationship between residential proximity to wind turbines and symptoms and the parameter estimates were attenuated toward zero. Wind turbines-health associations can be confounded by personal reactions to other environmental co-exposures. Isolated associations reported in the literature may be due to confounding bias.

Bockstael, A., et al. (2013). Exploring underlying mechanisms for human response to wind turbine noise C3 - 42nd International Congress and Exposition on Noise Control Engineering 2013, INTER-NOISE 2013: Noise Control for Quality of Life. 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, Innsbruck, OAL-Osterreichischer Arbeitsring fur Larmbekampfung.

This paper investigates underlying mechanisms for human response to wind turbine noise by studying the effects in terms of source detection, recognition and annoyance with and without road traffic noise. Recordings from a single 1.8-MW wind turbine have been mixed with samples of highway noise and of local roads at different signal-to-noise ratios. These fragments have been presented to 50 normal-hearing participants in a two-stage experiment. First, annoyance and source recognition have been evaluated during quiet leisure activities in background noise, with people unaware of the actual purpose. Secondly, wind turbine noise had to be identified in a paired comparison test. The second focused identification task indicates that wind turbine noise detectability in background noise at different signal-to-noise ratios is clearly different in highway noise than in noise from local roads. Furthermore, individuals with higher detection scores are also more capable to recognize wind turbine noise in the non-focused listening experiment, and better recognition could be linked with higher annoyance reports. These findings suggest that higher level appraisal, emotional and/or cognitive processes contribute to reported wind turbine noise annoyance, but further research is needed to consolidate this hypothesis.

Bolin, K., et al. (2014). "Long term estimations of low frequency noise levels over water from an off-shore wind farm." J Acoust Soc Am **135**(3): 1106-1114.

This article focuses on computations of low frequency sound propagation from an off-shore wind farm. Two different methods for sound propagation calculations are combined with meteorological data for every 3 hours in the year 2010 to examine the varying noise levels at a reception point at 13km distance. It is shown that sound propagation conditions play a vital role in the noise impact from the off-shore wind farm and ordinary assessment methods can become inaccurate at longer propagation distances over water. Therefore, this paper suggests that methodologies to calculate noise immission with realistic sound speed profiles need to be combined with meteorological data over extended time periods to evaluate the impact of low frequency noise from modern off-shore wind farms.

Bolin, K., et al. (2011). "Infrasound and low frequency noise from wind turbines: Exposure and health effects." Environmental Research Letters **6**(3).

Wind turbines emit low frequency noise (LFN) and large turbines generally generate more LFN than small turbines. The dominant source of LFN is the interaction between incoming turbulence and the blades. Measurements suggest that indoor levels of LFN in dwellings typically are within recommended guideline values, provided that the outdoor level does not exceed corresponding guidelines for facade exposure. Three cross-sectional questionnaire studies show that annoyance from wind turbine noise is related to the immission level, but several explanations other than low frequency noise are probable. A statistically significant association between noise levels and self-reported sleep disturbance was found in two of the three studies. It has been suggested that LFN from wind turbines causes other, and more serious, health problems, but empirical support for these claims is lacking. © 2011 IOP Publishing Ltd.

Bolin, K., et al. (2011). "Infrasound and low frequency noise from wind turbines: exposure and health effects." Environmental Research Letters **6**(3): 035103.

Bolin, K., et al. (2014). "Listening test comparing A-weighted and C-weighted sound pressure level as indicator of wind turbine noise annoyance." Acta Acustica united with Acustica **100**(5): 842-847.

A listening test was conducted to investigate whether A- or C- weighted sound levels are most suitable as indicator of annoyance due to wind turbine noise. The tests consisted of fifteen different wind turbine noises presented at eight sound levels together with pink noise signals as reference sounds. A total

number of 31 persons performed the listening test divided into two subgroups. The first group comprising of 20 students conducted the test in a semi anechoic chamber, and the second group of 11 residents annoyed by wind turbine noise in their homes, conducted the test in their own homes. Results from both subgroups showed that A-weighted sound levels were a more accurate description of wind turbine noise annoyance than C-weighted sound levels. The residents found the same wind turbine noises more annoying than the students, indicating a higher sensitivity to wind turbine noise among persons a priori annoyed by this noise and exposed to this source in their residential settings.

Bolin, K., et al. (2012). "The influence of background sounds on loudness and annoyance of wind turbine noise." Acta Acustica united with Acustica **98**(5): 741-748.

Natural sounds may create pleasant soundscapes that mask wind turbine noise. To explore this, a listening test was performed to investigate the influence of background sounds on perceived loudness and annoyance of wind turbine noise. A magnitude estimation method was used to measure perceived loudness and annoyance of wind turbine noise heard together with and without natural ambient sounds. Results indicate that decreased loudness and annoyance occurs if the level of the background sound exceeds the level of the wind turbine noise. The loudness experiment revealed that ambient sounds influenced the perception of wind turbine noise to a higher degree than predicted from a model of energetic masking. Annoyance ratings were less altered by background sound than perceived loudness. The results of the present listening study indicates that masking of wind turbine noise by positive natural sounds may be used as a complement to conventional noise control measures to improve the sound environment in areas exposed to wind turbine noise. © S. Hirzel Verlag EAA.

Botterill, L. C. and G. Cockfield (2016). "The Relative Importance of Landscape Amenity and Health Impacts in the Wind Farm Debate in Australia." Journal of Environmental Policy and Planning **18**(4): 447-462.

In recent years, Australia has experienced public debate around the growth in wind farms as part of government and community strategies to move from fossil fuels to renewable energy. Many of the arguments put forward by opponents and supporters are similar to those that have been evident in North America and Western Europe, including possible environmental impacts on wildlife, noise levels and, perhaps most prominently adverse changes in 'landscape amenity'. A concern of increasing prominence is that of adverse human health impacts from proximity to operating turbines. Using analysis of submissions to public inquiries and a small number of detailed interviews, we consider the increased focus in Australia on the health impacts of wind farms. We note that health impacts, as elsewhere in the world, are often part of a suite of objections to wind farm developments but conclude that for some people near such developments, these are the main concern and not a cover or proxy for other concerns, such as changes in landscape amenity and aesthetics. © 2016 Informa UK Limited, trading as Taylor & Francis Group.

Bowdler, D., et al. (2012). "Wind turbine noise." J Acoust Soc Am **132**(2): 1233.

Brennan, N. and T. M. Van Rensburg (2016). "Wind farm externalities and public preferences for community consultation in Ireland: A discrete choice experiments approach." Energy Policy **94**: 355-365.

In Ireland the deployment of onshore wind turbines has become progressively more difficult in some areas because of the potential negative externalities associated with their operation. Using a discrete choice experiment (DCE) we employ a willingness to accept framework to estimate the external effects of wind turbines on local residents with the inclusion of community consultation and to quantify the compensation required to permit wind farms to be built in Ireland. Our findings reveal that the majority of respondents are willing to make (monetary) tradeoffs to allow for wind power initiatives and we find that respondents require less compensation if provision is made for a community representative and setback distance is increased. © 2016 Elsevier Ltd.

Broner, N. (2010). "A simple criterion for low frequency noise emission assessment." Journal of Low Frequency Noise Vibration and Active Control **29**(1): 1-13.

There are many sources of Low Frequency Noise (LFN) in the environment and complaints about the effect of higher level LFN in the form of "rumble", a "feeling of pressure" and the resultant headaches and nausea have been known for decades. A number of different European methods have been suggested for assessment of LFN, all based on measured indoor noise levels. The administrative procedures used in individual countries to enforce any LFN criteria are quite different but they are all generally based on the assumption that the annoyance due to LFN is dependent on the relative SPL

when compared to the threshold of audibility. In terms of simplicity of application, the determination of an overall noise level that could be used for assessment of LFN would be the optimum approach rather than requiring any detailed spectrum analysis and calculations. Ideally, LFN criteria should be set indoors where the LFN complaints normally occur. However, in planning terms, it is much easier to set criteria for the outside of residences. In this paper, we therefore propose criteria for the prevention of LFN complaints for both residential and commercial premises based on the measured overall C-weighted SPL. We also consider the impact of LFN SPL fluctuations.

Brownlee, M. T. J., et al. (2015). "Place attachment and marine recreationists' attitudes toward offshore wind energy development." *Journal of Leisure Research* **47**(2): 263-284.

Renewable energy initiatives are increasing and many locations selected for offshore wind farms are close to recreation resources. Public involvement processes to assess project support are standard in offshore wind energy planning. However, often missing from these assessments are investigations into subpopulations, such as marine recreationists. Using mixed methods, researchers evaluated a scale that measures marine recreationists' (n = 483) attitudes toward offshore wind energy. Researchers also examined the relationships between place attachment and opposition and support for the proposed projects. Results suggest that place attachment can assist in predicting attitudes toward offshore wind energy development, but the explanatory power and the nature of the relationships differed between two communities. Implications for communication, outreach, and recreation management are discussed.

Bush, D. and P. Hoagland (2016). "Public opinion and the environmental, economic and aesthetic impacts of offshore wind." *Ocean and Coastal Management* **120**: 70-79.

During ten-plus years of debate over the proposed Cape Wind facility off Cape Cod, Massachusetts, the public's understanding of its environmental, economic, and visual impacts matured. Tradeoffs also have become apparent to scientists and decision-makers during two environmental impact statement reviews and other stakeholder processes. Our research aims to show how residents' opinions changed during the debate over this first-of-its-kind project in relation to understandings of project impacts. Our methods included an examination of public opinion polls and the refereed literature that traces public attitudes and knowledge about Cape Wind. Next we conducted expert elicitations to compare trends with the level of understanding held by small groups of scientists and Cape Cod stakeholders. Our review found that Massachusetts residents became more supportive of the project while our research demonstrated the gap between scientific and lay knowledge diminished late in the debate. To facilitate planning for other offshore energy projects, we recommend steps to move the public to an informed position more quickly. © 2015 Elsevier Ltd.

Campbell, J. and E. Romich (2015). "Residents' perceptions toward utility-scale wind farm development." *Journal of Extension* **53**(6).

Increased development of wind farms in the U.S. has fostered debates surrounding the siting and support for the projects. Prior research demonstrates the importance of understanding the attitudes and opinions of community members when developing projects. This article reviews a case study of an Ohio community that integrated a local survey to measure local knowledge, support, attitudes, and opinions of community residents on a proposed wind farm into the local conversation and decisionmaking. Ultimately the survey results informed local programming needs and an outreach and engagement strategy and provided elected officials data to guide informed decision making on the project. © by Extension Journal, Inc.

Cand, M., et al. (2012). *Wind turbine amplitude modulation: research to improve understanding as to its cause & effect*. Acoustics 2012.

Caporale, D. and C. De Lucia (2015). "Social acceptance of on-shore wind energy in Apulia Region (Southern Italy)." *Renewable and Sustainable Energy Reviews* **52**: 1378-1390.

Over the last decades, the increase in energy production from renewable sources has grown rapidly. In Italy, about 30% of the national energy production uses renewable sources. Wind energy, in particular, is one of the most promising clean energy markets. The presence of a favourable climatic condition for wind power in the Apulia Region in Southern Italy has pushed towards the development of one of the greatest on-shore areas in the country and Europe. Nonetheless, the high concentration of on-shore wind farms on the territory of the Apulia Region has posed serious problems over time. Despite the undoubted advantages of wind energy in terms of carbon and fossil fuel savings, there has been an

increasing public awareness for landscape preservation. The majority of people living nearby on-shore wind farms seem to suffer from the change of 'their' landscape. This paper contributes to an understanding of the public awareness for the existing trade-off between landscape conservation and wind energy. With the use of a choice experiment approach, we infer on the social acceptance of on-shore wind energy in Apulia Region. Main results enable us: (i) to analyse consumers' willingness to pay for a hypothetical re-development of on-shore wind farms; (ii) to determine the potential trade-offs between on-shore wind farms, landscape conservation and socio-economic issues; (iii) to discuss the existence and overcome the problems of an asymmetric information between producers, consumers and policy makers on the implementation of on-shore wind farms on the territory. © 2015 Elsevier Ltd.

Carey, M. (2014). "What is the evidence for potential health impacts from wind power?" Proceedings of the Royal Society of Victoria **126**(1-2): 35-37.

Carpita, S., et al. (2016). Validation of the Italian wind turbine noise assessment procedure through simulated case studies. ICSV 2016 - 23rd International Congress on Sound and Vibration: From Ancient to Modern Acoustics.

A specific procedure for wind turbine noise assessment is required in the framework of the National Law on environmental noise revision. The procedure was developed in 2013 by the Italian environmental protection agencies in order to estimate the noise produced by a wind farm at the receivers. The method does not require the farm shut-down to achieve its goal relying on a long term measurement of noise and weather data and a subsequent computational analysis. Several steps are mandatory in order to evaluate the effectiveness and uncertainty of this procedure: further focused measurement campaigns in different environmental conditions, a numerical evaluation of the uncertainty and sensitivity of the input parameters, the validation on virtual and real scenarios. Some preliminary results of these steps are presented in this paper, focusing on the implementation of a computational model used for the validation on simulated scenarios. A better understanding of the influence of various background noise and wind turbine emission on the procedure results is earned this way.

Chao, P. C., et al. (2012). "Effect of low frequency noise on the echocardiographic parameter E/A ratio." Noise Health **14**(59): 155-158.

The hearing condition of the Taiwanese aerospace maintenance workers affected by the low frequency noise had not been reported. The purpose of this research is to clarify the maintenance workers' health effect when exposed to low frequency and/or general noises and to understand the relationship between the variations of the worker's echocardiographic E/A ratio and the low frequency noise. The low frequency noise monitoring and echocardiographic E/A ratio results obtained for 213 aerospace maintenance workers indicated that the workers' hearing loss was more serious at high frequency 4k and 6k when exposed to the low frequency noise and could be more than 40 dB. The abnormality of echocardiographic E/A ratio was also higher than that of control group.

Chapman, S. (2011). "Wind farms and health: who is fomenting community anxieties?" Med J Aust **195**(9): 495.

Chapman, S. (2012). "Editorial ignored 17 reviews on wind turbines and health." Bmj **344**: e3366; author reply e3367.

Chapman, S. (2014). "Factoid forensics: have 'more than 40' Australian families abandoned their homes because of wind farm noise?" Noise Health **16**(71): 208-212.

Anti-wind farm activists repeatedly claim that families said to be adversely affected by noise from wind turbines "abandon" their homes. In Australia, a claim of "more than 40 families" has been made by a prominent anti-wind farm activist. Six sources (parliamentary submissions, media reports, an anti-wind farm website, wind industry sources, correspondence with known anti-wind farm activists and with three politicians opposed to wind farms) were used to find evidence of home "abandonments." Claims about 12 Australian households permanently (n = 10) or periodically (n = 2) leaving their homes were found. However, no house appears to have been permanently "abandoned" without sale, as the expression implies. These 12 cases need contextualizing against considerations that several of those involved were either dedicated activists against wind farms from times sometimes pre-dating their construction, were engaged in protracted negotiations for home purchase with wind companies, had pre-existing health problems, grievances with the wind company over employment or had left the area for unrelated reasons of employment elsewhere. The statement that "more than 40" houses have been "abandoned"

because of wind turbines in Australia is a factoid promoted by wind farm opponents for dramatic, rhetorical impact. Other considerations are often involved in abandonment unrelated to the claims made about wind farm noise.

Chapman, S. and K. Joshi (2015). "Corrigendum: Fomenting Sickness: Nocebo Priming of Residents about Wind Farm Health Harms.[Erratum for *Front Public Health*. 2014;2:279; PMID: 25566521]." *Front. public health* 3: 234. [This corrects the article on p. 279 in vol. 2, PMID: 25566521].

Chapman, S., et al. (2014). "Fomenting Sickness: Nocebo Priming of Residents about Expected Wind Turbine Health Harms." *Front. public health* 2: 279.

A nocebo effect hypothesis has been proposed to explain variations in where small minorities of exposed residents complain about noise and health effects said to be caused by wind farm turbines. The hypothesis requires that those complaining have been exposed to negative, potentially frightening information about the impact of proposed wind farms on nearby residents, and that this information conditions both expectations about future health impacts or the etiology of current health problems where wind farms are already operational. This hypothesis has been confirmed experimentally under laboratory conditions, but case studies of how this process can operate in local communities are lacking. In this paper, we present a case study of the apparent impact of an anti-wind farm public meeting on the generation of negative news media and the subsequent expression of concerns about anticipated health and noise impacts to a planning authority approval hearing in Victoria, Australia. We present a content analysis of the negative claims disseminated about health and noise in the news media and available on the internet prior to the hearing, and another content analysis of all submissions made to the planning authority by those opposing the development application.

Chapman, S., et al. (2014). "Fomenting sickness: nocebo priming of residents about expected wind turbine health harms." *Frontiers in public health* 2: 279.

Chapman, S. and A. St George (2013). "How the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'." *Aust N Z J Public Health* 37(3): 244-249.

OBJECTIVE: In recent years, claims have proliferated in cyberspace that wind turbines cause a large variety of symptoms and diseases. One of these, "vibroacoustic disease" (VAD) is frequently mentioned. The aim of this study is to examine the quality of the evidence on how VAD came to be associated with wind turbine exposure by wind farm opponents.

METHODS: Searches of the web (Google advanced) and major research databases for papers on VAD and wind turbines. Self-citation analysis of research papers on VAD.

RESULTS: Google returned 24,700 hits for VAD and wind turbines. Thirty-five research papers on VAD were found, none reporting any association between VAD and wind turbines. Of the 35 papers, 34 had a first author from a single Portuguese research group. Seventy-four per cent of citations to these papers were self-citations by the group. Median self-citation rates in science are around 7%. Two unpublished case reports presented at conferences were found asserting that VAD was "irrefutably demonstrated" to be caused by wind turbines. The quality of these reports was abject.

CONCLUSIONS: VAD has received virtually no scientific recognition beyond the group who coined and promoted the concept. There is no evidence of even rudimentary quality that vibroacoustic disease is associated with or caused by wind turbines.

IMPLICATIONS: The claim that wind turbines cause VAD is a factoid that has gone 'viral' in cyberspace and may be contributing to nocebo effects among those living near turbines. Copyright 2013 The Authors. ANZJPH 2013 Public Health Association of Australia.

Chapman, S., et al. (2013). "The pattern of complaints about Australian wind farms does not match the establishment and distribution of turbines: support for the psychogenic, 'communicated disease' hypothesis." *PLoS ONE* 8(10): e76584.

BACKGROUND AND OBJECTIVES: With often florid allegations about health problems arising from wind turbine exposure now widespread, nocebo effects potentially confound any future investigation of turbine health impact. Historical audits of health complaints are therefore important. We test 4 hypotheses relevant to psychogenic explanations of the variable timing and distribution of health and noise complaints about wind farms in Australia.

SETTING: All Australian wind farms (51 with 1634 turbines) operating 1993-2012.

METHODS: Records of complaints about noise or health from residents living near 51 Australian wind farms were obtained from all wind farm companies, and corroborated with complaints in submissions to 3 government public enquiries and news media records and court affidavits. These are expressed as proportions of estimated populations residing within 5 km of wind farms.

RESULTS: There are large historical and geographical variations in wind farm complaints. 33/51 (64.7%) of Australian wind farms including 18/34 (52.9%) with turbine size >1 MW have never been subject to noise or health complaints. These 33 farms have an estimated 21,633 residents within 5 km and have operated complaint-free for a cumulative 267 years. Western Australia and Tasmania have seen no complaints. 129 individuals across Australia (1 in 254 residents) appear to have ever complained, with 94 (73%) being residents near 6 wind farms targeted by anti wind farm groups. The large majority 116 (90%) of complainants made their first complaint after 2009 when anti wind farm groups began to add health concerns to their wider opposition. In the preceding years, health or noise complaints were rare despite large and small-turbine wind farms having operated for many years.

CONCLUSIONS: The reported historical and geographical variations in complaints are consistent with psychogenic hypotheses that expressed health problems are "communicated diseases" with nocebo effects likely to play an important role in the aetiology of complaints.

Chen, C. F., et al. (2015). Prospect of structural health monitoring application for offshore wind farm in Taiwan. Structural Health Monitoring 2015: System Reliability for Verification and Implementation - Proceedings of the 10th International Workshop on Structural Health Monitoring, IWSHM 2015.

For the recent surge of interests in Taiwan's offshore wind farm program, the government takes the initiatives promoting pilot wind farm projects and developing strategy for 600 wind turbines off Taiwan's west coast by 2030. Together with 450 land based turbines at the time, it anticipates a total power capacity of 4.2 GW. The announcement of this ambitious offshore energy program has stimulated significant interests among various industrial sectors, as well as academic and R&D institutions in Taiwan. The offshore wind turbines are exposed to extreme environmental conditions and high dynamic stresses. Incipient damage must be detected at the earliest stage possible in order to plan and take reasonable repair measures in due time. This can prevent the development of severe damage and thus lower the repair costs. Periodic inspections are not sufficient for an early detection of damage. Continuous monitoring ensures a higher level of safety. Wireless structural health monitoring (SHM) and risk-based reliability management (RRM) are cost-effective, infrastructural solutions to stable and increased energy yield. This paper presents an overview and prospect on the development of indigenous SHM/RRM for Taiwan offshore wind turbines to be erected in the coastal regions west of Taiwan. A strategic plan is discussed to use the demonstration wind turbines as a test platform for further technology enhancement for field applications, and to consolidate SHM/RRM into wind farm technology core R&D programs for academic research and industrial applications. Copyright © 2015 by DEStech Publications, Inc.

Chen, J. L., et al. (2015). "Strategic planning to reduce conflicts for offshore wind development in Taiwan: A social marketing perspective." Marine Pollution Bulletin 99(1-2): 195-206.

This study aims to improve the current inefficiency and ineffectiveness of communications among stakeholders when planning and constructing offshore wind farms (OWFs). An analysis using a social marketing approach with segmentation techniques is used to identify the target market based on stakeholders' perceptions. The empirical results identify three stakeholder segments: (1) impact-attend group; (2) comprehensive group; and (3) benefit-attend group. The results suggest that communication should be implemented to alter stakeholders' attitudes toward the construction of OWFs. Furthermore, based on the results of segmentation, target markets are identified to plan the communication strategies for reducing the conflicts among stakeholders of OWF construction. The results also indicated that in the planning phase of construction for OWFs, effective stakeholder participation and policy communication can enhance the perception of benefits to reduce conflict with local communities and ocean users.

Chen, J. L., et al. (2015). "The factors affecting stakeholders' acceptance of offshore wind farms along the western coast of Taiwan: Evidence from stakeholders' perceptions." Ocean and Coastal Management 109: 40-50.

Stakeholder participation is an important concept in marine environmental management; thus, their acceptance and opinions might influence policy decision making and effectiveness. This paper explores the factors that affect stakeholders' (traditional ocean users, including fishers and aquaculture farmers) acceptance and conducts an empirical analysis to determine the relationship among stakeholders'

perceptions and acceptance. A total of 238 respondents completed a survey that was conducted in six coastal counties in western Taiwan. We used principle component analysis and two logistic regression models for the analysis: one model does not consider perception factors, while the other model estimates perception factors. The empirical results reveal that three perception factors related to the benefits of offshore wind farms significantly affect stakeholders' acceptance. Furthermore, the explanatory power, goodness-of-fit, and the predicted probability are greater when perception factors are considered in the logistic model. As a result, stakeholders' perceptions are important factors that influence their acceptance of OWFs along the western coast of Taiwan. According to our findings, recommendations are offered to resolve the user conflicts regarding OWF turbine construction and operation, including (1) communicating effectively and integrating stakeholder participation and (2) offering benefits to ocean users and local communities. © 2015 Elsevier Ltd.

Chen, Y., et al. (2012). Structural health monitoring of wind turbine blade using fiber Bragg grating sensors and fiber optic rotary joint. Proceedings of SPIE - The International Society for Optical Engineering, San Diego, CA.

Wind energy utilization as a reliable energy source has become a large industry in the last 20 years. Nowadays, wind turbines can generate megawatts of power and have rotor diameters that are on the order of 100 meters in diameter. One of the key components in a wind turbine is the blade which could be damaged by moisture absorption, fatigue, wind gusts or lightning strikes. The wind turbine blades should be routinely monitored to improve safety, minimize downtime, lower the risk of sudden breakdowns and associated huge maintenance and logistics costs, and provide reliable power generation. In this paper, a real-time wind turbine blade monitoring system using fiber Bragg grating (FBG) sensors with the fiber optic rotary joint (FORJ) is proposed, and applied to monitor the structural responses of a 600 W small scale wind turbine. The feasibility and effectiveness of the FORJ is validated by continuously transmitting the optical signals between the FBG interrogator at the stationary side and the FBG sensors on the rotating part. A comparison study between the measured data from the proposed system and those from an IMote2-based wireless strain measurement system is conducted. © 2012 SPIE.

Chias, P. and T. Abad (2014). Impact assessment of the renewable energies in the cultural heritage: The case of the way of St. James in Spain. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives.

Medieval town centres and landscapes along the Way of St. James are being affected by renewable energy sources at the architectural, urban and territorial scales. The impact is not only visual, but thermal, acoustic and electromagnetic. Visual impact of solar photovoltaic power plants-which are placed over traditional crops close to the urban borders-, and also wind farms located at the hilltops, are sometimes remarkable. Solar photovoltaic modules are integrated into ancient roofs, and small scale wind turbines are taking up the ancient urban spaces. Among other effects on animal life and vegetation, the rise in temperature, radioelectric interferences, as well as changes in the traditional land uses are noticeable, and a deep analysis is needed. Our main target is to define an integrated methodology which considers all these effects. As a part of our project premises, we work with Open Source programs. We obtained a digital terrain model -25 m spatial resolution-, and from Corine Land Cover images we got different raster files according to our research targets. Databases were implemented from both remote sensing and measures obtained directly in the field work. We applied GIS based multicriteria decision analysis and weighted linear combination, and then we adapted GRASS tools for a better usability. Our case studies are particularly interesting due to their situation along the Spanish Way of St. James, which is an itinerary named one of UNESCO's World Heritage Sites.

Christidis, T. and J. Law (2012). "Annoyance, health effects, and wind turbines: Exploring Ontario's planning processes." Canadian Journal of Urban Research 21(1 SUPPL.): 81-105.

Citizens of communities in Ontario where wind turbines have been built tend to have negative opinions of the developments and complain of health effects. The Green Energy Act in Ontario is a "top-down" policy which aims to meet renewable energy goals. This review paper will discuss the current planning process used in Ontario for wind energy and make the case for a connection between the wind energy planning process and negative perceptions and complaints of annoyance. A review of the academic literature examining wind turbine planning, perceptions of wind turbines, and impacts on the community will be complemented with a review and discussion of the Green Energy Act and Renewable Energy Approvals Process. It is speculated in this paper that the "top-down" approach is one of the factors leading to negative opinions and annoyance. Incorporating collaborative planning approaches

into the Renewable Energy Approvals process is suggested for Ontario2. © 2012 by the Institute of Urban Studies.

Chun, C., et al. (2016). Development of combined noise annoyance model based on the partial loudness model. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

Many studies have been conducted to evaluate the annoyance of combined noise. However, the previous models were noise source dependent and not considered about the frequency spectrum of the noise elements. For these reasons, this research proposes the new annoyance evaluation model that is source independent and taking account of the frequency characteristics. The experiment had been carried out to the subjects to ask about the annoyance of combined noise with various levels. Aircraft noise and road traffic noise are used as the test sources. Next, the levels of noise sources are converted to the loudness, with the help of Moore's partial loudness model. By evaluating the relationship between the loudness of the noises and the experimental annoyance results with logistic regression, the model that explains the annoyance of combined noise is deducted. To extend the application of this model, other noise sources, such as train noise and wind turbine noise, need to be tested for the validation. © 2016, German Acoustical Society (DEGA). All rights reserved.

Cohen, J. J., et al. (2014). "Re-focussing research efforts on the public acceptance of energy infrastructure: A critical review." Energy **76**: 4-9.

One of the key issues in adopting a sustainable and renewable energy system is gaining social acceptance for technological change. Many technological changes can adversely affect residents and lead to opposition. Extensive development of electricity infrastructure has been met with especially strong resistance from local stakeholders. An abundance of research has been conducted to study the process and driving factors of social acceptance in the context of these infrastructural developments. This paper develops a conceptual definition of social acceptance that is both explicit and allows for quantitative assessment. This definition will aid future literature by clearly defining the goal of social acceptance research from the outset. As examples of the problems faced in electricity system change, factors of discontent surrounding the social acceptance of wind farms, transmission lines, and pump-hydro-storage facilities are identified and synthesized. Policy relevant conclusions from previous research are summarized for these three infrastructure types. It is concluded that while research has done well in understanding the causes of opposition, more work is needed to grasp the efficacy and implementation of acceptance improving strategies. Future research should be focused on devising procedures to facilitate quick and efficient negotiations between infrastructure developers and local groups.

Coleby, A. M., et al. (2009). "Public attitudes and participation in wind turbine development." Journal of Environmental Assessment Policy and Management **11**(1): 69-95.

Research for this paper was undertaken into the relationship between public opinion on wind power and public participation in turbine site planning and design. The research focussed on the contribution of environmental attitude studies to participatory environmental impact assessment of renewable energy policy and land use. A questionnaire survey was undertaken at wind farm sites at three stages in the site planning process and at three public events where the application of wind power was a topic of discussion. The attitudinal data produced was subjected to a series of statistical tests to determine which of the attitudes revealed could be quantified significantly in terms of public opinion. The most significant responses related to the proximity of wind turbines to respondents' homes with the proposition that wind turbine designers should seek community input of the highest significance. Respondents also indicated a preference for traditional turbine structures that blended in with the landscape and remained out of sight. Respondents' personal perception of land use change regarding wind power near them was mostly significant relative to respondent age with younger respondents tending to be more accepting of wind turbine land use whilst older respondents objected. Living place was also found to be significant with urban respondents more accepting of wind power than rural ones. Fundamentally respondents although polarised for or against on certain issues, all shared a wish for more public input and participation in local land use for wind power. © Imperial College Press.

Cooper, K., et al. (2014). "Health effects associated with working in the wind power generation industry: A comprehensive systematic review." JB Library of Systematic Reviews **12**(11): 327-373.

Background The onshore wind power generation sector is set to expand its workforce dramatically in the next decade. As the industry matures, it will be increasingly important to understand the potential health effects of the work carried out by wind technicians who are required to ascend and descend wind turbines, often taking equipment with them, several times daily. Whilst most risks are mitigated via fall-arrest and other equipment, together with safe working systems, there are still some risks, especially the potential for musculoskeletal disorders from chronic exposure to ladder climbing and cramped work spaces. **Objectives** To identify the known and/or potential musculoskeletal risks of working in the wind power generation industry, specifically relating to vertical ladder climbing and working in confined spaces. **Inclusion criteria** Participants Adult onshore wind technicians, and in the absence of studies pertaining to these professionals, participants from telecommunications, offshore, construction, fire-fighting, military and other occupations. **Phenomena of interest** The musculoskeletal and other physical health risks to onshore wind technicians and others associated with the repeated climbing of vertical ladders and working in confined spaces. **Types of studies** Any relevant quantitative or qualitative study or text-based opinion article. **Types of outcomes** Prevalence; incidence; type and severity of musculoskeletal and related physical disorders. **Data collection and synthesis** Three thousand two hundred and thirty-three studies in English were identified following the searching of 24 databases. Seventeen were critically appraised by two independent reviewers and findings from ten were extracted using Joanna Briggs Institute critical appraisal and data extraction tools. There was a high degree of heterogeneity between the ten quantitative studies included, rendering meta-analysis inappropriate; therefore results are presented in narrative form. **Results** Despite finding no published evidence on wind technicians as an occupational group, evidence from similar professions informed the study objective. Ladder-related injuries are common, and amongst different types of ladder injury, falls are most likely to be associated with fracture. Rest breaks may protect workers by preserving conditions in which a fall is less likely, and thus delaying a time-point, however unlikely, of a fall occurring within a shift, by delaying the possibility of falls occurring during a shift. In professions similar to wind technicians, musculoskeletal disorders are widespread and account for 47% of work-related injuries in Norwegian offshore workers. Adopting stooping and kneeling postures has a dose-response relationship with severe low back pain. There is limited evidence on its association with knee osteoarthritis, but in regards to its association with hip osteoarthritis, no evidence was found. However, those in manual occupations in general are associated with roughly a two-fold increase in odds of developing knee osteoarthritis, and there is clear evidence of a link between the risk of knee osteoarthritis and a high Body Mass Index. **Conclusions** Ladder climbing is associated with an increased risk of musculoskeletal disorder, low back pain and knee osteoarthritis, and this may be exacerbated by workers adopting prolonged kneeling or stooping postures, and having a high Body Mass Index.

Cooper, S. (2014). "The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm." The Acoustics Group.

Corscadden, K., et al. (2012). "Social license and consultation criteria for community wind projects." Renewable Energy **44**: 392-397.

Nova Scotia has an aggressive energy strategy which if successful will result in 40% of electricity generated from renewable sources by 2020. A significant portion of this target, 100 MW generating capacity, is to be met using large small-scale wind projects developed by community residents and cooperatives. The expected community participation prompts a renewed interest in, and importance of social acceptance of wind power development. This paper identifies important criteria that should be considered relating to community consultation and essential components for the development of consultation guidelines, which will ultimately impact social acceptance of community scale renewable energy projects. © 2012 .

Coulon, M. (2014). "The complex wind speed referencing system in wind farm noise assessment." Acoustics Bulletin **39**(4): 30-35.

Wind farm noise assessments are a complex mix of acoustic and wind resource work. Wind speed and noise data needs to be measured and analysed, and both need to be correlated. The noise measurement location during a background survey is an agreed parameter in the industry, using a microphone (covered with a suitable wind shield) recording at 1.2-1.5m height above the ground installed at a number of representative receptors which are typically residences surrounding a proposed wind farm. However, the measurement of wind speed is still widely discussed. It is considered accepted practice for wind speed measurements to be undertaken within the wind farm site. In 1996, ETSU-R-971

introduced 10m height wind speed measurements as a requirement in the standard for background surveys for wind farms in the UK. As wind turbines increased in size, it was acknowledged that it was essential to account for site specific wind shear, that is the difference in wind speed which exists between 10m height and the proposed (or operational) turbine hub height. The hub height is the height determining the speed of the turbines and the level of noise emitted. Various methods were used between 2004² and 2009 to account for this effect. In 2009, a method for assessments where large mast data are available during the noise survey was proposed in an article in 2009 in *Acoustics Bulletin*³ which was then adopted by most practitioners and accepted by planning inspectors to represent good practice. When no large mast data are available and only 10m masts are available during a background survey, other alternative methods have to be employed. The method put forward in article was reiterated in May 2013 in a more official form in the Institute of Acoustics' Good Practice Guide⁴ (IOA GPG) which was endorsed by Government. So between 2009 and 2013, wind shear and the methods for wind speed measurements were hot topics in the wind farm industry. As illustrated by two articles in *Acoustics Bulletin* (September-October 2013 and November-December 2013), where opposing views are expressed, the merits of alternative approaches continue to be debated. This technical contribution takes a small step back from the ongoing debate, to look at the concept of wind speed measurements for a wind farm noise assessment and thereafter relates to how these concepts are applied in practice. © 2015, Institute of Acoustics. All rights reserved.

Crichton, F., et al. (2014). "The Link between Health Complaints and Wind Turbines: Support for the Nocebo Expectations Hypothesis." *Front. public health* 2: 220.

The worldwide expansion of wind energy has met with opposition based on concerns that the infrasound generated by wind turbines causes health problems in nearby residents. In this paper, we argue that health complaints are more likely to be explained by the nocebo response, whereby adverse effects are generated by negative expectations. When individuals expect a feature of their environment or medical treatment to produce illness or symptoms, then this may start a process where the individual looks for symptoms or signs of illness to confirm these negative expectations. As physical symptoms are common in healthy people, there is considerable scope for people to match symptoms with their negative expectations. To support this hypothesis, we draw an evidence from experimental studies that show that, during exposure to wind farm sound, expectations about infrasound can influence symptoms and mood in both positive and negative directions, depending on how expectations are framed. We also consider epidemiological work showing that health complaints have primarily been located in areas that have received the most negative publicity about the harmful effects of turbines. The social aspect of symptom complaints in a community is also discussed as an important process in increasing symptom reports. Media stories, publicity, or social discourse about the reported health effects of wind turbines are likely to trigger reports of similar symptoms, regardless of exposure. Finally, we present evidence to show that the same pattern of health complaints following negative information about wind turbines has also been found in other types of environmental concerns and scares.

Crichton, F., et al. (2014). "The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound." *Health Psychol* 33(12): 1588-1592.

OBJECTIVE: Wind farm developments have been hampered by claims that sound from wind turbines causes symptoms and negative health reports in nearby residents. As scientific reviews have failed to identify a plausible link between wind turbine sound and health effects, psychological expectations have been proposed as an explanation for health complaints. Building on recent work showing negative expectations can create symptoms from wind turbines, we investigated whether positive expectations can produce the opposite effect, in terms of a reduction in symptoms and improvements in reported health.

METHOD: 60 participants were randomized to either positive or negative expectation groups and subsequently exposed to audible wind farm sound and infrasound. Prior to exposure, negative expectation participants watched a DVD incorporating TV footage about health effects said to be caused by infrasound produced by wind turbines. In contrast, positive expectation participants viewed a DVD that outlined the possible therapeutic effects of infrasound exposure.

RESULTS: During exposure to audible windfarm sound and infrasound, symptoms and mood were strongly influenced by the type of expectations. Negative expectation participants experienced a significant increase in symptoms and a significant deterioration in mood, while positive expectation participants reported a significant decrease in symptoms and a significant improvement in mood.

CONCLUSION: The study demonstrates that expectations can influence symptom and mood reports in both positive and negative directions. The results suggest that if expectations about infrasound are framed in more neutral or benign ways, then it is likely reports of symptoms or negative effects could be nullified.

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Crichton, F., et al. (2014). "Can expectations produce symptoms from infrasound associated with wind turbines?" *Health Psychol* **33**(4): 360-364.

OBJECTIVE: The development of new wind farms in many parts of the world has been thwarted by public concern that subaudible sound (infrasound) generated by wind turbines causes adverse health effects. Although the scientific evidence does not support a direct pathophysiological link between infrasound and health complaints, there is a body of lay information suggesting a link between infrasound exposure and health effects. This study tested the potential for such information to create symptom expectations, thereby providing a possible pathway for symptom reporting.

METHOD: A sham-controlled double-blind provocation study, in which participants were exposed to 10 min of infrasound and 10 min of sham infrasound, was conducted. Fifty-four participants were randomized to high- or low-expectancy groups and presented audiovisual information, integrating material from the Internet, designed to invoke either high or low expectations that exposure to infrasound causes specified symptoms.

RESULTS: High-expectancy participants reported significant increases, from preexposure assessment, in the number and intensity of symptoms experienced during exposure to both infrasound and sham infrasound. There were no symptomatic changes in the low-expectancy group.

CONCLUSIONS: Healthy volunteers, when given information about the expected physiological effect of infrasound, reported symptoms that aligned with that information, during exposure to both infrasound and sham infrasound. Symptom expectations were created by viewing information readily available on the Internet, indicating the potential for symptom expectations to be created outside of the laboratory, in real world settings. Results suggest psychological expectations could explain the link between wind turbine exposure and health complaints.

Crichton, F., et al. (2015). "Framing sound: Using expectations to reduce environmental noise annoyance." *Environ Res* **142**: 609-614.

BACKGROUND: Annoyance reactions to environmental noise, such as wind turbine sound, have public health implications given associations between annoyance and symptoms related to psychological distress. In the case of wind farms, factors contributing to noise annoyance have been theorised to include wind turbine sound characteristics, the noise sensitivity of residents, and contextual aspects, such as receiving information creating negative expectations about sound exposure.

OBJECTIVE: The experimental aim was to assess whether receiving positive or negative expectations about wind farm sound would differentially influence annoyance reactions during exposure to wind farm sound, and also influence associations between perceived noise sensitivity and noise annoyance.

METHOD: Sixty volunteers were randomly assigned to receive either negative or positive expectations about wind farm sound. Participants in the negative expectation group viewed a presentation which incorporated internet material indicating that exposure to wind turbine sound, particularly infrasound, might present a health risk. Positive expectation participants viewed a DVD which framed wind farm sound positively and included internet information about the health benefits of infrasound exposure. Participants were then simultaneously exposed to sub-audible infrasound and audible wind farm sound during two 7 min exposure sessions, during which they assessed their experience of annoyance.

RESULTS: Positive expectation participants were significantly less annoyed than negative expectation participants, while noise sensitivity only predicted annoyance in the negative group.

CONCLUSION: Findings suggest accessing negative information about sound is likely to trigger annoyance, particularly in noise sensitive people and, importantly, portraying sound positively may reduce annoyance reactions, even in noise sensitive individuals. Copyright © 2015 Elsevier Inc. All rights reserved.

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Crichton, F. and K. J. Petrie (2015). "Health complaints and wind turbines: The efficacy of explaining the nocebo response to reduce symptom reporting." *Environ Res* **140**: 449-455.

BACKGROUND: A number of people are reporting an environmental sensitivity to sub-audible windfarm sound (infrasound), characterised by the experience of recurrent non-specific symptoms. A causal link between exposure and symptoms is not indicated by empirical evidence. Research indicates symptoms may be explained by the nocebo response, whereby health concerns and negative expectations, created from social discourse and media reports, trigger symptom reporting.

OBJECTIVE: The experimental aim was to test whether providing a nocebo explanation for symptoms, to individuals reporting symptomatic experiences during infrasound exposure, would ameliorate symptoms during further exposure.

METHOD: Sixty-six volunteers were randomly assigned to nocebo explanation or biological explanation groups. Participants were concurrently exposed to infrasound and audible windfarm sound, while reporting on current symptoms and mood, during two exposure sessions. Preceding session one, participants watched a presentation integrating media warnings about purported health risks posed by windfarm infrasound. Before session two, nocebo explanation participants viewed material outlining how nocebo responding could explain symptom reporting. Instead biological explanation participants watched material presenting pathophysiological theories for symptoms.

RESULTS: During session one, participants reported increased symptoms and mood deterioration from baseline assessment. During session two symptom reporting and mood deterioration was maintained by biological explanation participants, while mood and symptoms reported by placebo explanation participants returned to baseline levels.

CONCLUSION: Results indicate that providing an explanation of the placebo response, followed by exposure to infrasound, has the potential to operate as an intervention to reduce symptomatic experiences in people reporting symptoms attributed to windfarm generated infrasound. Copyright © 2015 Elsevier Inc. All rights reserved.

Cuevas, M. D. P. D., et al. (2016). "Wind energy and landscape. Identification and quantification of landscapes affected by wind farms in Andalusia." Boletín de la Asociación de Geógrafos Españoles **2016**(71): 397-430.

This article analyzes the spatial and landscape distribution of wind farms in the region of Andalusia, Spain, and identifies and quantifies the surface area affected by landscape changes resulting from the implementation of this type of infrastructure. This is done by creating a geodatabase of renewable energies that includes detailed spatial information of these infrastructures with a scale of accuracy that is unprecedented in Andalusia. By using the analytical abilities of Geographical Information Systems it has been possible to define and create new landscape indicators linked to the installation of wind farms that have not been applied previously in the Andalusian Autonomous Community.

Cuevas, M. D. P. D., et al. (2016). "Wind power and landscape. Identification and quantification of landscapes affected by wind power plants in andalusia." Boletín de la Asociación de Geógrafos Españoles **71**: 541-546.

Cummings, J. (2012). "Extrapolating beyond chinchillas: behavioral response ambiguity through the lens of variable human responses to moderate wind farm noise." Adv Exp Med Biol **730**: 501-504.

Currie, M., et al. (2013). "Structural health monitoring for wind turbine foundations." Proceedings of Institution of Civil Engineers: Energy **166**(4): 162-169.

The construction of onshore wind turbines has been increasing rapidly as the UK attempts to meet its renewable energy targets. As the UK's future energy depends increasingly on wind farms, safety and security are critical to the success of this renewable energy source. Structural integrity of the tower and its components is a critical element of this security of supply. With the stochastic nature of the load regime, a bespoke structural health monitoring system is required to monitor the integrity of the concrete foundations supporting the tower. This paper presents an assessment of 'embedded can'-style foundation failure modes in large onshore wind turbines and proposes a novel condition-based monitoring solution to aid in early warning of failure.

Dai, Y. J., et al. (2016). "Experimental study on the distribution law of the wind turbine noise source which is harmful to the health of human body." Basic and Clinical Pharmacology and Toxicology **118**: 90.

Objectives: The aerodynamic noise of the wind turbine will have adverse effects on human health. It focused on the distribution and variation of high-frequency aerodynamic noise sources in the blade tip region of wind turbines. In the experiment, we explore the distribution and variation of high-frequency aerodynamic noise sources in the blade tip region. This experiment will provide experimental data and technical support for the design of low-noise wind turbines. **Methods:** The wind tunnel test was conducted at the exit section of the low-speed wind tunnel, B1/K2. A sound array method was used to test the three-dimensional blade tip region under different wind speeds and tip speed ratios. **Results:** The distribution of the sound source was mainly concentrated in the $r/R = 0.74-0.80$ area. In the high-frequency band, the positions of the sound source on the blades did not change with the change in the wind speed and the tip speed ratio. The sound source distribution was asymmetric, and was caused by the directionality of the sound source and the fluctuation in the tip speed ratio in the operating wind wheel. **Conclusions:** The conclusions showed that the positions of the high-frequency sound source on the blades were mainly concentrated in the $r/R = 0.74-0.80$ area. The distribution of the sound source was asymmetrical, and the positions of the sound source on the blade did not vary with the changes in the tip speed ratios and wind speed.

Dawson, B. and N. Mackenzie (2013). Meteorological stability impacts on wind turbine noise assessments C3 - Annual Conference of the Australian Acoustical Society 2013, Acoustics 2013: Science, Technology and Amenity. Annual Conference of the Australian Acoustical Society 2013: Science, Technology and Amenity, Acoustics 2013, Victor Harbor, SA, Australian Acoustical Society.

Current wind farm noise regulations stipulate wind speed dependant criteria (referenced to wind speed at the hub height of the turbines), under the assumption that during high-wind speed conditions (when wind turbines generate higher noise levels), there will be a corresponding high wind speed and masking noise level at nearby receivers. However, under very stable conditions, high wind speeds at the turbine hub height will create significant noise, while low wind speeds at the receiver will not be sufficient to provide a masking effect. This has been considered in assessment guidelines by filtering day/night background data, but this approach ignores the impact of changes in the level and spectral content of turbine noise due to high shear velocities across turbine blades. This paper examines meteorological data in the vicinity of an undisclosed future wind farm site in South Australia, which was used to filter noise and wind speed data based on stability criterion, and discusses the potential impact on the noise criteria used for wind farm developments. © (2013) by the Australian Acoustical Society.

De Groot, J. and I. Bailey (2016). "What drives attitudes towards marine renewable energy development in island communities in the UK?" *International Journal of Marine Energy* **13**.

Island communities represent key potential arenas for marine renewable energy (MRE) because of their tidal, wave and off-shore wind resources. However, although MRE developments could offer remote island communities significant economic benefits, limited research exists on community attitudes towards MRE or, crucially, the main factors shaping responses. Research in the Shetlands, Orkneys and Scillies (UK) revealed generally positive attitudes towards MRE but also that attitudes were strongly shaped by place-related values, not just the direct socio-economic and environmental credentials of proposed locations. Developments that complemented established place values were more likely to gain acceptance whereas conflicts with these values was often a major reason for concerns about MRE. The results are used to argue for greater attention to place-related values in decision-making and community engagement on MRE developments. © 2016.

de Sousa, A. J. G. and E. Kastenholtz (2015). "Wind farms and the rural tourism experience – problem or possible productive integration? The views of visitors and residents of a Portuguese village." *Journal of Sustainable Tourism* **23**(8-9): 1236-1256.

Wind energy is recognized as a relevant alternative and renewable energy source, frequently exploited in rural areas, and potentially competing for land and resources with rural tourism. This study reviews the growing but limited research literature on the interactions between wind farms and rural tourism. Using results from a Portuguese village case study, it presents new and often complex insights regarding the potential impacts of these structures on the tourist experience, giving new understanding of the impact of wind farms on a rural tourism destination from the viewpoint of both visitors and residents who actively participate in experience co-creation and are directly affected by investment in both tourism and wind energy, with comparisons between national and international visitors, and between visitors and residents. Possible managerial actions of universal relevance are discussed, exploring the potential for integrating tourism with wind energy production, including tourism-research-related guidelines for wind farm planners, quality and market-targeted information and interpretation development, and efforts to include wind farms in tourist experience planning such as guided tours and event creation. More research is needed to promote wind farms as "green destinations", capable of attracting a growing number of environmentally concerned visitors. © 2015 Taylor & Francis.

Deignan, B., et al. (2013). "Fright factors about wind turbines and health in Ontario newspapers before and after the Green Energy Act." *Health, Risk and Society* **15**(3): 234-250.

In this article, we analyse coverage of the health effects of wind turbines in Ontario newspapers relative to the Green Energy Act using published risk communication fright factors. Our aim was to provide insights into the health risk information presented in newspapers serving Ontario communities where wind turbines are located. We selected five geographically discontinuous wind energy installations in Ontario and their surrounding communities based on 2006 Canadian Census data. We identified the newspapers serving each community and searched for articles from May 2007 to April 2011 on wind turbine technology and human health, identifying a total of 421 articles from 13 community and 4 national/provincial newspapers. We found that most newspaper articles included the fright factor of 'dread' (94%) and well over half (58%) included the fright factor of 'poorly understood by science'. 'Involuntary exposure' and 'inequitable distribution' were fright factors occurring in somewhat fewer than half of the newspaper articles (45% and 42%, respectively). Of note was that four of the fright factors-'dread', 'poorly understood by science', 'inequitable distribution' and 'inescapable

exposure'-occurred more frequently in community newspaper articles than in national/provincial ones ($p < 0.001$). Although the total number of occurrences of each fright factor increased following the Green Energy Act, only 'dread' ($p < 0.05$) and 'poorly understood by science' ($p < 0.01$) increased significantly. We conclude that Ontario newspapers contain fright factors in articles about wind turbines and health that may produce fear, concern and anxiety for readers. © 2013 Taylor & Francis.

Deignan, B. and L. Hoffman-Goetz (2015). "Emotional tone of Ontario newspaper articles on the health effects of industrial wind turbines before and after policy change." *J Health Commun* 20(5): 531-538.

Newspapers are often a primary source of health information for the public about emerging technologies. Information in newspapers can amplify or attenuate readers' perceptions of health risk depending on how it is presented. Five geographically distinct wind energy installations in Ontario, Canada were identified, and newspapers published in their surrounding communities were systematically searched for articles on health effects from industrial wind turbines from May 2007 to April 2011. The authors retrieved 421 articles from 13 community, 2 provincial, and 2 national newspapers. To measure the emotional tone of the articles, the authors used a list of negative and positive words, informed from previous studies as well as from a random sample of newspaper articles included in this study. The majority of newspaper articles (64.6%, $n = 272$) emphasized negative rather than positive/neutral tone, with community newspapers publishing a higher proportion of negative articles than provincial or national newspapers, $\chi^2(2) = 15.1$, $p < .001$. Articles were more likely to be negative when published 2 years after compared with 2 years before provincial legislation to reduce dependence on fossil fuels (the Green Energy Act), $\chi^2(3) = 9.7$, $p < .05$. Repeated public exposure to negative newspaper content may heighten readers' health risk perceptions about wind energy.

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Delicado, A., et al. (2016). "Community perceptions of renewable energies in Portugal: Impacts on environment, landscape and local development." *Energy Research and Social Science* 13: 84-93.

This article aims to contribute to the debate on energy transitions in Europe, by focusing on community perceptions in a southern European country marked by a significant development of renewable energy in recent years, Portugal. Three main dimensions of community perceptions of the impact, both positive and negative, of renewables are addressed: environmental, landscape and socioeconomic. The article is based on case studies of communities living in the vicinities of three wind farms and a solar power plant. The results show that not only community perceptions are heterogeneous but also that, in order to better understand the factors for social acceptance, it is crucial to examine perceptions not just at the planning stage but also once the energy infrastructures are constructed and functioning. © 2015 Elsevier Ltd. All rights reserved.

Depellegrin, D. (2016). "Assessing cumulative visual impacts in coastal areas of the Baltic Sea." *Ocean and Coastal Management* 119: 184-198.

Anthropogenic activity such as offshore wind energy farm development, shipping activity, resource extraction platforms or marine aquaculture can have adverse impacts on the visual quality of coastal landscapes. GIS-based viewshed analysis is the most widely used technique to address visual impacts.

However, despite the wide application its spatial extent remains limited to local and regional studies. This study presents a GIS-based model for cumulative visual impact assessment on macro-regional scale based on a case study for the Baltic Sea. The viewshed model was deployed over a visibility zone covering 54% (223.641 km²) of the Baltic Sea space using a database of 63,672 observation points integrated by geospatial data on existing and planned sea uses representing potential visual stressors. Results show that areas of highest potential visual impact are sheltered coastal areas with complex geomorphological features such as barrier islands, peninsulas, straits, archipelagos and lagoons in combination with intensive anthropogenic activity and presence of nature protected areas. The methodology can be applied to any coastal area of the world to classify coastal areas due to their cumulative viewshed characteristics and as early monitoring tool for visual impact assessment on transboundary scale. © 2015 Published by Elsevier Ltd.

Depellegrin, D., et al. (2014). "An integrated visual impact assessment model for offshore windfarm development." *Ocean and Coastal Management* **98**: 95-110.

Visual impacts belong to the most common concerns about wind energy development projects in Europe. In methodological terms, visual impact assessments are lacking in objective valuation systems capable to provide planners and decision makers with scientific - based solutions for the estimation of visual interference of offshore wind facilities with seascapes. The aim of this study is to present a GIS based model for visual sensitivity assessment from human induced landscape changes based on a case study in the Lithuanian sea, where Offshore Wind Energy (OWE) parks are under Environmental Impact Assessment (EIA) and included into the national MSP implementation process as potentially emerging future use of the sea space. The approach is composed of two models: The first model is a land-sea visibility model (LS-VisM), which assesses the cumulative viewshed of landward key observation points such as beach access points, residential and non-residential buildings and most important visitor aggregation areas in the coastal zone. In addition the model assesses environmental and socio-economic assets at highest visual impact risk from coastal and marine landscape change. The second model is a scenario based sea-land visibility model (SL-VisM), which addresses cumulative visual impacts of turbines within a wind park on the coastal zone. Both model components support decision makers on the analysis of visual impacts from any sea based infrastructure on the coastline and coastal hinterland. © 2014 Elsevier Ltd.

Di, G. Q., et al. (2011). "Proposed revision to emission limits of structure-borne noise from fixture transmitted into room: An investigation of people's annoyance." *Acta Acustica united with Acustica* **97**(6): 1034-1040.

In order to get more reasonable Emission Limits of Structure-Borne Noise from Fixture Transmitted into Room (ELSBNFTR), a subjective response experiment was carried out. In this experiment, the original samples (OS) were generated based on the current ELSBNFTR, while the adjusted samples (AS) were based on the proposed ELSBNFTR. Subjects were asked to make comparison between OS and AS on the basis of relative annoyance. The effect of Quality Assessment Index (QAI) on dealing with room noise complaints was discussed. As shown in the results, for each compared group, more than 72.0% of subjects chose "OS were more annoying than AS". The spectra of OS were more imbalanced, due to the higher proportion of low frequency noise energy, which led to a more rumble character. It is proposed that QAI should be introduced into ELSBNFTR, in order to reduce complaints mainly caused by room noise (including structure-borne noise from fixture and background noise) with an imbalanced spectrum, while the structure-borne noise is still within ELSBNFTR. Besides, it is suggested that the evaluation of the difference values between room noise and background noise at different octave bands should be added in the procedure for the assessment of complaints, and 5 dB could be considered as a limit. © S. Hirzel Verlag. EAA.

Di, G. Q., et al. (2015). "Annoyance response to low frequency noise with tonal components: A case study on transformer noise." *Applied Acoustics* **91**: 40-46.

In order to study how acoustical factors influence annoyance responses to low frequency noise with tonal components, this research has selected 220 kV and 500 kV transformer noises as examples and an 11-point numerical scale as an evaluation tool, in which the percentage of highly annoyed (%HA) and mean annoyance (MA) are chosen to represent annoyance caused by noises. Results show that a logistic curve is well suited for describing the exposure-response relationship between the A-weighted equivalent sound pressure level (LAeq) and %HA (or MA) of the transformer noise. With the same LAeq, 220 kV transformer noise is more annoying than 500 kV transformer noise in terms of %HA and MA, which is related to different sharpness, roughness and tonality of the noises caused by transformers of

the two voltage levels. Based on stepwise regression analysis, multiple linear regression models are further developed by using LAeq and roughness as acoustical parameters to predict the %HA and MA of transformer noise. Compared with the linear regression model that considered only LAeq values, multiple linear regressions can efficiently account for the different annoyance ratings of the two transformer noises at the same LAeq values. © 2014 Elsevier Ltd. All rights reserved.

Di, G. Q., et al. (2015). "Annoyance response to low frequency noise with tonal components: A case study on transformer noise." *Applied Acoustics* **91**: 40-46.

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Doolan, C. (2013). "A review of wind turbine noise perception, annoyance and low frequency emission." *Wind Engineering* **37**(1): 97-104.

Current literature concerning the perception, annoyance and emission of low-frequency noise from wind turbines are reviewed. Wind turbine noise has been shown to be annoying to people with annoyance related to noise load. Other factors, such as those related to visual, economic and psychological effects, were also shown to affect a person's annoyance of wind turbine noise. Published infrasound (noise at frequencies less than 20 Hz) measurements show that levels at typical residential set-back distances are too low to be directly audible, but may be perceived via window rattling. On the other hand, low-frequency noise levels, in the frequency range of 20-200 Hz may exceed audibility thresholds and it is postulated they may be correlated with annoyance. A review of general low-frequency noise annoyance studies is presented and highlights the similarities of many wind turbine noise complaints with those due to low-frequency noise. The paper concludes with a suggestion to develop a new methodology that can simultaneously acquire annoyance and noise data at the time a person believes they are annoyed by wind turbine noise.

Doolan, C. J., et al. (2012). "Wind turbine noise mechanisms and some concepts for its control." *Acoustics Australia* **40**(1): 7-13.

Drexler, M., et al. (2016). "Responses of the Human Inner Ear to Low-Frequency Sound." *Adv Exp Med Biol* **894**: 275-284.

The perceptual insensitivity to low frequency (LF) sound in humans has led to an underestimation of the physiological impact of LF exposure on the inner ear. It is known, however, that intense, LF sound causes cyclic changes of indicators of inner ear function after LF stimulus offset, for which the term "Bounce" phenomenon has been coined. Here, we show that the mechanical amplification of hair cells (OHCs) is significantly affected after the presentation of LF sound. First, we show the Bounce phenomenon in slow level changes of quadratic, but not cubic, distortion product otoacoustic emissions (DPOAEs). Second, Bouncing in response to LF sound is seen in slow, oscillating frequency and correlated level changes of spontaneous otoacoustic emissions (SOAEs). Surprisingly, LF sound can induce new SOAEs which can persist for tens of seconds. Further, we show that the Bounce persists under free-field conditions, i.e. without an in-ear probe occluding the auditory meatus. Finally, we show that the Bounce is affected by contralateral acoustic stimulation synchronised to the ipsilateral LF sound. These findings clearly demonstrate that the origin of the Bounce lies in the modulation of cochlear amplifier gain. We conclude that activity changes of OHCs are the source of the Bounce, most likely caused by a temporary disturbance of OHC calcium homeostasis. In the light of these findings, the effects of long-duration, anthropogenic LF sound on the human inner ear require further research.

Drexl, M., et al. (2016). "Low-frequency sound exposure causes reversible long-term changes of cochlear transfer characteristics." *Hear Res* **332**: 87-94.

Intense, low-frequency sound presented to the mammalian cochlea induces temporary changes of cochlear sensitivity, for which the term 'Bounce' phenomenon has been coined. Typical manifestations are slow oscillations of hearing thresholds or the level of otoacoustic emissions. It has been suggested that these alterations are caused by changes of the mechano-electrical transducer transfer function of outer hair cells (OHCs). Shape estimates of this transfer function can be derived from low-frequency-biased distortion product otoacoustic emissions (DPOAE). Here, we tracked the transfer function estimates before and after triggering a cochlear Bounce. Specifically, cubic DPOAEs, modulated by a low-frequency biasing tone, were followed over time before and after induction of the cochlear Bounce. Most subjects showed slow, biphasic changes of the transfer function estimates after low-frequency sound exposure relative to the preceding control period. Our data show that the operating point changes biphasically on the transfer function with an initial shift away from the inflection point followed by a shift towards the inflection point before returning to baseline values. Changes in transfer function and operating point lasted for about 180 s. Our results are consistent with the hypothesis that intense, low-frequency sound disturbs regulatory mechanisms in OHCs. The homeostatic readjustment of these mechanisms after low-frequency offset is reflected in slow oscillations of the estimated transfer functions. Copyright © 2015 Elsevier B.V. All rights reserved.

D'Souza, C. and E. K. Yiridoe (2014). "Social acceptance of wind energy development and planning in rural communities of Australia: A consumer analysis." *Energy Policy* **74**(C): 262-270.

Social acceptance is necessary for widespread adoption of new renewable energy technologies. A lack of social acceptance by local community residents is a barrier to increasing the renewable energy mix and targets in Australia. This study empirically evaluated predictor importance of key constructs of social acceptance, using responses from a sample of 226 survey respondents in Australia. Regression analysis suggest that 'Concerns with wind turbines' was the predictor most strongly correlated with Social Acceptance, followed by 'Annoyance with wind turbines', and then 'Consultation with stakeholders'. Implications of the study and recommendations for consideration by various interest groups (such as policy makers, and potential entrepreneurs) are discussed. This research contributes to theory building rather than theory testing of social acceptance of wind energy development. © 2014 Elsevier Ltd.

Dyas, S. J., et al. (2012). Structural health monitoring of wind turbine blades under fatigue loads. Conference Proceedings of the Society for Experimental Mechanics Series, Jacksonville, FL.

This paper presents the results of dynamic characterization and preparation of a full-scale fatigue test of a 9 m CX-100 blade. Sensors and actuators utilized include accelerometers and piezoelectric sensors. To dynamically characterize a 9 m CX-100 blade, full scale modal analyses were completed with varying boundary conditions and blade orientations. Also, multi-scale sensing damage detection techniques were explored; high frequency active-sensing was used in identifying fatigue damage initiation, while low frequency passive-sensing was used in assessing damage progression. Ultimately, high and low frequency response functions, wave propagations, and sensor diagnostic methods were utilized to monitor and analyze the condition of the wind turbine blade under fatigue loading. © The Society for Experimental Mechanics, Inc. 2012.

Dzhambov, A. and D. Dimitrova (2014). "Neighborhood noise pollution as a determinant of displaced aggression: a pilot study." *Noise Health* **16**(69): 95-101.

Noise pollution is still a growing public health problem with a significant impact on psychological health and well-being. The aim of this study was to investigate the impact of noise on displaced aggression (DA) in different subgroups of residents in one of the neighborhoods of Plovdiv city. A cross-sectional semi-structured interview survey was conducted using specially designed data registration forms and 33 close-ended and open-ended questions, divided into two major panels - one original and a modified version of the Displaced Aggression Questionnaire (DAQ). The mean score for DA was 61.12 (+/-19.97). Hearing noises above the perceived normal threshold, higher noise sensitivity and continuous noises were associated with higher levels of DA. Low frequency and high intensity noises were also associated with higher DA scores. Multiple regression model supported these findings. Contradictory to previous research age was positively correlated with noise sensitivity and aggression. We speculated that this might be due to the relatively lower socio-economic standard and quality of life in Bulgaria. Therefore, social climate might be modifying the way people perceive and react to environmental noise. Finally, the

DAQ proved to be a viable measurement tool of these associations and might be further implemented and modified to suit the purposes of psychoacoustic assessment.

Ek, K. and S. Matti (2015). "Valuing the local impacts of a large scale wind power establishment in northern Sweden: public and private preferences toward economic, environmental and sociocultural values." Journal of Environmental Planning and Management **58**(8): 1327-1345.

This paper estimates public and private preferences towards economic, environmental and sociocultural values associated with a planned large-scale onshore wind-power development in northern Sweden, and analyses the most important determinants of the individual's Willingness to Pay (WTP) for reducing the negative impact associated with the establishment. Sociocultural effects were deemed the most important in the private sample, whereas new job opportunities are valued most highly in the public sample. We further find that ascription to moral and social norms together with individuals' perceptions related to general and institutional trust constitutes significant determinants of WTP. © 2014 University of Newcastle upon Tyne.

Ellenbogen, J. M., et al. (2012). Wind Turbine Health Impact Study: Report of Independent Expert Panel Massachusetts Department of Environmental Protection and Massachusetts Department of Public Health.

Ellis, G., et al. (2009). "Expanding wind power: A problem of planning, or of perception?" Planning Theory and Practice **10**(4): 523-532.

Enevoldsen, P. and B. K. Sovacool (2016). "Examining the social acceptance of wind energy: Practical guidelines for onshore wind project development in France." Renewable and Sustainable Energy Reviews **53**: 178-184.

This study investigates methods for increasing the local social acceptance of onshore wind projects in France. It is based on input from semi-structured research interviews and insight from a French wind energy company. That company had noted that a lack of local social acceptance of wind projects increased the risk of failures, cost escalation, and project delays. In this study, we first summarize recent scholarship concerning local social opposition and acceptance of wind energy through a selected literature review and case studies of wind projects throughout Europe. We then use this data to create guidelines on how to increase the likelihood of social acceptance for onshore wind project development in France, and to inform current debates in the energy studies literature over the acceptance of wind energy and energy transitions. © 2015 Elsevier Ltd. All rights reserved.

Engel, A. M. (2014). "Legal requirements for human-health based appeals of wind energy projects in ontario." Front. public health **2**: 248.

In 2009, the government of the province of Ontario, Canada passed new legislation to promote the development of renewable energy facilities, including wind energy facilities in the province. Throughout the legislative process, concerns were raised with respect to the effect of wind energy facilities on human health. Ultimately, the government established setbacks and sound level limits for wind energy facilities and provided Ontario residents with the right to appeal the approval of a wind energy facility on the ground that engaging in the facility in accordance with its approval will cause serious harm to human health. The first approval of a wind facility under the new legislation was issued in 2010 and since then, Ontario's Environmental Review Tribunal as well as Ontario's courts has been considering evidence proffered by appellants seeking revocation of approvals on the basis of serious harm to human health. To date, the evidence has been insufficient to support the revocation of a wind facility approval. This article reviews the legal basis for the dismissal of human-health based appeals.

Eulitz, C., et al. (2014). "Adverse effects on the environment due to distinctly low-frequency sounds: Findings from a feasibility study on effects of infrasound on behalf of the Federal Environment Agency." Umweltmedizin in Forschung und Praxis **19**(6): 478-485.

Citizens have increasingly complained about detrimental effects caused by infrasound in the recent years. The Federal Environment Agency Germany (Umweltbundesamt) has therefore commissioned a "Feasibility study on infrasound effects - Development of research designs to assess the impact of infrasound on humans by different sources". The feasibility study evaluated the state of knowledge about the effects of infrasound on human beings, the identification of infrasound sources and the potential concerns in Germany due to infrasound. Furthermore, a study design was developed for a noise impact study concerning infrasound immissions. Based on these findings, recommendations for the further development of regulations on immission control were made. This

article summarizes the main findings of the feasibility study. © ecomed Medizin, Verlagsgruppe Hüthig Jehle Rehm GmbH, Landsberg.

Farboud, A., et al. (2013). "'Wind turbine syndrome': fact or fiction?" *J Laryngol Otol* **127**(3): 222-226.

OBJECTIVE: Symptoms, including tinnitus, ear pain and vertigo, have been reported following exposure to wind turbine noise. This review addresses the effects of infrasound and low frequency noise and questions the existence of 'wind turbine syndrome'.

DESIGN: This review is based on a search for articles published within the last 10 years, conducted using the PubMed database and Google Scholar search engine, which included in their title or abstract the terms 'wind turbine', 'infrasound' or 'low frequency noise'.

RESULTS: There is evidence that infrasound has a physiological effect on the ear. Until this effect is fully understood, it is impossible to conclude that wind turbine noise does not cause any of the symptoms described. However, many believe that these symptoms are related largely to the stress caused by unwanted noise exposure.

CONCLUSION: There is some evidence of symptoms in patients exposed to wind turbine noise. The effects of infrasound require further investigation.

Farboud, A., et al. (2013). "'Wind turbine syndrome': fact or fiction?" *The Journal of Laryngology & Otology* **127**(03): 222-226.

Fast, S. (2013). "Social Acceptance of Renewable Energy: Trends, Concepts, and Geographies." *Geography Compass* **7**(12): 853-866.

As global production of energy from renewable sources has grown over the last 25 years, so too has research on social acceptance of renewable energy. This article reports findings from a systematic review of peer-reviewed articles related to this subject. There has been a rapid increase in the frequency of these studies and a shift in orientation away from market and socio-political measures of securing policy support for renewables toward a sympathetic reporting of community opposition to wind turbines. Well-developed conceptual and empirical critiques of the "Not-in-My-Backyard" concept have emerged on the basis of Western European case studies, notably from the UK. Drawing from experiences across the globe with varied sizes and types of new energy infrastructure researchers have documented complex social responses that go beyond simplistic designations of opponent or supporter. Geographical concepts including place, landscape, distance decay, territory, and others have been gainfully employed in this interdisciplinary literature, and there is ample opportunity for greater contributions from the discipline to this area of growing popular and academic interest. © 2013 The Author(s). Geography Compass © 2013 John Wiley & Sons Ltd.

Fast, S., et al. (2015). "The changing cultural and economic values of wind energy landscapes." *Canadian Geographer* **59**(2): 181-193.

We combine a socio-cultural and economic approach to investigate how wind turbines change the manner in which rural landscapes are valued. Interviews with residents of communities hosting wind projects on the shores of eastern Lake Ontario reveal two main impressions of landscape change: one is to see turbines as irrevocably industrializing and thereby ruining the peace and quiet of rural life and the second downplays visual concerns as negligible. Using photographs as visual aids we find that participants often perceive rural landscapes as devoid of human activity. This is one reason to suspect that cultural celebration of wind technology as part of a new middle landscape is unlikely. Furthermore, our analysis of property value reductions tentatively suggests more frequent than expected reductions for recreational properties and for properties within 2 km to 5 km of turbines but not within 1 km of turbines. We argue the consideration of landscape issues in wind energy approval processes in Ontario is overly narrow and will continue to act as a point of dispute in wind project development. © 2015 Canadian Association of Geographers / L' Association canadienne des géographes.

Feder, K., et al. (2015). "An assessment of quality of life using the WHOQOL-BREF among participants living in the vicinity of wind turbines." *Environ Res* **142**: 227-238.

Living within the vicinity of wind turbines may have adverse impacts on health measures associated with quality of life (QOL). There are few studies in this area and inconsistent findings preclude definitive conclusions regarding the impact that exposure to wind turbine noise (WTN) may have on QOL. In the current study (officially titled the Community Noise and Health Study or CNHS), the World Health Organization QOL-BREF (WHOQOL-BREF) questionnaire provided an evaluation of QOL in relation to

WTN levels among randomly selected participants aged 18-79 (606 males, 632 females) living between 0.25 and 11.22 km from wind turbines (response rate 78.9%). In the multiple regression analyses, WTN levels were not found to be related to scores on the Physical, Psychological, Social or Environment domains, or to rated QOL and Satisfaction with Health questions. However, some wind turbine-related variables were associated with scores on the WHOQOL-BREF, irrespective of WTN levels. Hearing wind turbines for less than one year (compared to not at all and greater than one year) was associated with improved (i.e. higher) scores on the Psychological domain ($p=0.0108$). Lower scores on both the Physical and Environment domains ($p=0.0218$ and $p=0.0372$, respectively), were observed among participants reporting high visual annoyance toward wind turbines. Personal benefit from having wind turbines in the area was related to higher scores on the Physical domain ($p=0.0417$). Other variables significantly related to one or more domains, included sex, age, marital status, employment, education, income, alcohol consumption, smoking status, chronic diseases and sleep disorders. Collectively, results do not support an association between exposure to WTN up to 46 dBA and QOL assessed using the WHOQOL-BREF questionnaire. Crown Copyright © 2015. Published by Elsevier Inc. All rights reserved.

Fergen, J. and J. B. Jacquet (2016). "Beauty in motion: Expectations, attitudes, and values of wind energy development in the rural U.S." *Energy Research and Social Science* **11**: 133-141.

Attitudes towards wind energy development are influenced by a number of social, political, and geographic factors. Initial resident expectations for a development, and then the degree to which these expectations were later met can help explain support or opposition for wind energy. Yet, the role of met or unmet expectations is not well researched in explaining perceptions of and attitudes towards wind energy development. This study explores the relationship between met and unmet expectations and resident attitudes towards wind energy, as well as perceptions of wind turbine beauty, for rural residents near two wind energy projects in the U.S. state of South Dakota (SD). A survey ($n = 239$) administered in 2014 across two counties investigates the process of attitude and expectation formation towards the projects as they developed. Results show that the majority of residents had positive expectations, and these expectations are largely unmet; nonetheless, most residents retain positive attitudes towards both projects, although certain types of expectations are related to more positive or more negative attitudes. Furthermore, the survey results show that residents find turbines in motion to be more beautiful than static turbines - demonstrating the role of economic and environmental values in influencing wind energy attitudes and expectations.

Firestone, J., et al. (2015). "See me, Feel me, Touch me, Heal me: Wind turbines, culture, landscapes, and sound impressions." *Land Use Policy* **46**: 241-249.

Community-based wind energy projects, with their small-scale, yet sizeable presence, provide a valuable opportunity to understand how individuals make sense of changes to their communities and to the surrounding landscape. Here, we examine the results of a 2013 mail survey of individuals residing in the vicinity of a 2. MW wind turbine that is located on the edge of the historic coastal town of Lewes, Delaware in the United States, and adjacent to Delaware Bay and the Great Marsh Preserve. The wind turbine, which was constructed in 2010, primarily serves the University of Delaware's coastal campus, and to a lesser extent the town of Lewes. Seventy-eight percent hold positive or very positive attitudes toward the wind turbine, with only 10% having negative or very negative attitudes, and 82% like the look of the wind turbine. Socially constructed aspects find more resonance than physical ones (e.g., attractiveness) in explaining this latter finding, with the wind turbine being reflective of a transformation to a clean energy future for those residents who like the way the turbine looks. On the other hand, those objecting to its look, find the turbine does not fit the landscape. Policy implications of these findings and others related to wind turbine sound are considered, and recommendations for better understanding of proposed developments from the vantage point of the affected communities, including how a community views itself and its surrounding landscape, are made. © 2015 The Authors.

Firestone, J., et al. (2009). "Public acceptance of offshore wind power projects in the USA." *Wind Energy* **12**(2): 183-202.

Although a rich literature exists on public concern for the effect of land-sited wind power structures on cultural landscapes and the benefits of community involvement in this issue, less is known about how society perceives sea-based structures. Offshore wind power has existed for some time in Europe; in the USA, its development has been hampered by opponents of the Cape Wind project off of Massachusetts. At present, the developer of the proposed Cape Wind project and a second developer proposing a project off of Delaware each strive to erect the first offshore wind power project in the Americas. Here,

we examine public opinion. We first provide background on the case studies, then a review of prior studies of support and opposition of wind power projects in order to place the mail surveys within the context of the wider literature. After detailing the methods employed, we analyse the results and provide insights into the similarities and dissimilarities that are revealed in the data, with the intent of gaining a broader understanding of how individuals think about offshore wind power. The strikingly higher public support for offshore wind development in the mid-Atlantic, and especially off Delaware, suggests the possibility of substantially higher US public acceptance of offshore wind power than previously anticipated. Moreover, when offshore wind power is seen as transformative, we find substantial support even for residents near the first developments- residents who thus inherently take more risk. Potentially increasing acceptance of wind power, we argue, portends the shape of things to come. Copyright © 2009 John Wiley & Sons, Ltd.

Firestone, J., et al. (2012). "Public acceptance of offshore wind power: does perceived fairness of process matter?" Journal of Environmental Planning and Management **55**(10): 1387-1402.

This paper analyses the findings of recent mail surveys of residents living near two proposed offshore wind power projects - Cape Wind off Massachusetts and Bluewater Wind off Delaware. In 2009, 57% supported Cape Wind, while 80% supported Bluewater Wind. To measure the relationship between perceptions of public process and substantive support or opposition, we assessed opinions of procedural fairness, local community voice and trust in developers. A plurality of residents in both cases is relatively satisfied with the process, while statistical modelling suggests that satisfaction with the process and outcome may be mutually reinforcing or jointly determined. © 2012 Copyright Taylor and Francis Group, LLC.

Fiumicelli, D. (2011). "Wind farm noise dose response." Acoustics Bulletin **36**(6): 26-34.

Researchers from Sweden conducted a study to investigate wind farm noise dose response. The study consisted of multiple phases, including cross-sectional social surveys to derive a dose-response relationship. Subjective responses were obtained from 1,288 respondents across the different phases of the study. The first phase was carried out in an area of flat terrain in a quiet rural area, whereas the second phase was carried out in areas with different types of terrain and different degrees of urbanization and higher ambient noise levels. The investigations found a greater probability of the perception of wind turbine noise in quieter rural areas as compared with noisier suburban locations and a greater annoyance response rate in quieter areas as compared to noisier locations. Dose-response relationships were found in the study for perception of noise and for noise annoyance in relation to turbine A-weighted sound levels derived in accordance with the Swedish Environmental Protection Agency Guidelines.

Fiumicelli, D. (2012). Prediction of wind farm noise propagation with relation to the subjective dose response C3 - Proceedings of the Institute of Acoustics. Environmental Noise Propagation 2012: Definitions, Measuring and Control Aspects, London.

In the face of the threat posed by climate change the UK Government's Renewable Energy Strategy¹ has the ambitious target of generating 15% of all the UK's energy from renewable sources by 2020. Given this short time scale and the ready availability of already tried and tested wind turbine technology, the greatest proportion of these renewable sources will have to be from wind turbines. As described in the report 'Building a Low Carbon Economy'² which highlights that wind energy capture could deliver 30% of the UK's electricity supply by 2020 and be part of a radical decarbonisation of the economy by 2030. As the UK tries to meet its climate change renewable energy targets local planning authorities are faced with increasing numbers of applications for wind farms and wind turbines. With this escalating demand there is increased potential for conflict with the amenity of occupiers of neighbouring land. Local planning authorities are tasked with a difficult balance between providing adequate protection of amenity; and facilitating renewable energy development vital to meeting future needs. At the heart of this balance is consideration of the noise impacts from wind farms and wind turbines. Any assessment of noise impact requires information on likely noise emission levels and the probable human response to these levels.

Floch, S. L. and M. J. Fortin (2015). Wind farms and landscapes: Acceptance does not always mean participation. Landscape and Sustainable Development: The French Perspective: 185-200.

Fournis, Y. and M. J. Fortin (2017). "From social 'acceptance' to social 'acceptability' of wind energy projects: towards a territorial perspective." *Journal of Environmental Planning and Management* **60**(1): 1-21.

Social acceptance is central in many debates surrounding energy projects. Wind energy, in particular, has been described as a 'learning laboratory' in terms of social acceptance of energy projects. It has given way to a socio-technical paradox: the social dimension has become a factor of equal importance to technology in the wind farms implementation. Based on a literature review concerned with the social acceptance of wind energy, the paper seeks to demonstrate both the richness and the limits of the key concepts that inform the ongoing work of scholars. By doing so, we intend to emphasise the complex processes underneath in order to then elaborate a conceptual definition of social acceptability. Various modulations and limits that characterise current thinking are thus underlined. We then propose a grid analysis relying on a territorial perspective. It is structured around three levels that connect micro-social, meso-political and macro-economic processes. © 2016 Newcastle University.

Frantál, B. (2015). "Have Local Government and Public Expectations of Wind Energy Project Benefits Been Met? Implications for Repowering Schemes." *Journal of Environmental Policy and Planning* **17**(2): 217-236.

Replacing existing wind turbines with new and higher capacity turbines ('repowering') is to become a major challenge for planners within the next decade. While the benefits of repowering are evident, it cannot be assumed that the process will proceed automatically and without problems. The acceptance of future developments will be significantly affected by whether expectations of benefits from previous projects have been met, and whether perceived advantages of existing wind farms have outweighed their disadvantages. Therefore, it is important to explore how existing wind farms and their impacts on local development and well-being are assessed. This paper presents the results of a survey with local governments and inhabitants of municipalities in the Czech Republic where wind turbines have been implemented and are in operation. The findings prove that perceived positive effects dominate over negative impacts and that a majority of local authorities and inhabitants are willing to support further development in their backyards. A disruption to local landscape was detected as the main factor behind opposition. However, the significance of visual impact proved to be outweighed by subjective appraisal of economic benefits which is spatially and socially structured. The conclusion presents some implications for designing repowering schemes based on the research. © 2014, © 2014 Taylor & Francis.

Frantál, B. and P. Kučera (2009). "Impacts of the operation of Wind turbines as perceived by residents in concerned areas." *Moravian Geographical Reports* **17**(2): 35-45.

Wind power development is a global phenomenon that is in many countries still related to considerable social controversy. In context of the Czech Republic (or Central Europe) we are still short of a more complex study, which would examine potential impacts of wind turbines on the environment and the quality of life from the perspective of local actors (i.e. the residents in the concerned areas); therefore, speculations and unreasonable concerns prevail so far in this respect. The paper presents a deeper analysis of perception and attitudes of residents living in the areas with wind parks and withal it provides a partial international comparison of opinion levels of two neighboring countries (Czech Republic and Austria).

Frantál, B. and J. Kunc (2011). "Wind turbines in tourism landscapes: Czech Experience." *Annals of Tourism Research* **38**(2): 499-519.

This study proposes to assess and empirically verify possible negative effects from the construction of wind turbines on the landscape image and tourism potential of affected areas, using the example of two comparative recreational localities in the Czech Republic: one with the construction of a wind farm planned and the other with an already existing farm. The empirical research consisted of two mutually linked parts: a questionnaire survey and focused, semi-structured interviews. Emphasis was placed on the subjective perception of the phenomenon by tourists and local business representatives from the sphere of tourism. The analysis focuses also on the social-geographical factors that shape tourists attitudes to the wind energy development dilemma. © 2010 Elsevier Ltd.

Fretzer, S. (2016). "Using the Ecopath approach for environmental impact assessment-A case study analysis." *Ecological Modelling* **331**: 160-172.

If a proposed project or plan is likely to negatively impact a Natura 2000 site, it must undergo an environmental impact assessment. Article 6.3 of the Habitats Directive (92/43/EEC) clearly specifies the assessment procedure. This case study presents the assessment of three different projects that might negatively affect a Natura 2000 site in Germany. The impacts of an industrial area, construction of a

road and a wind power generator were investigated using the Ecospace habitat capacity model. The short and long-term effects of these projects were analyzed, considering cumulative effects of habitat loss, noise and light pollution on the environment. By applying Ecospace two alternatives were explored for each proposed project, thereby identifying the strategy with least impact and also determining the environmental damage and how it can be compensated. This study demonstrates that the Ecopath approach is the number one tool for environmental management in the European Union, as it can deliver the results that are needed to meet all legal requirements and it is also able to solve 'on-going' problems, for example assessment of cumulative and in-combination effects, identification of effective mitigation measures and providing clear, objective conclusions. © 2015 Elsevier B.V.

Frey, B. J. (2012). "Wind Turbines and Proximity to Homes: The Impact of Wind Turbine Noise on Health." A review of the literature & discussion of the issues.

Friedl, C. and J. Reichl (2016). "Realizing energy infrastructure projects - A qualitative empirical analysis of local practices to address social acceptance." Energy Policy 89: 184-193.

The federal state of Upper Austria, at a crossing point for European energy grids, provides large-scale resources for storage of natural gas and is among the top infrastructures in this regard in Europe. Considering the ambitious plans for enhancements of energy infrastructures in this region, the issue of social acceptance of energy infrastructure is crucial. To foster an understanding of the challenges inherent in this issue we present an analysis concentrating on the social acceptance of energy infrastructure projects in Upper Austria. This paper addresses the issues with realizing energy infrastructure projects and analyzes the problems and benefits based on an empirical-qualitative study comprising expert interviews, discussions with stakeholders, and a round table workshop integrating the disparate viewpoints. The aim of the process was to integrate different attitudes, perspectives and positions of relevant stakeholders, members of citizens' initiatives, environmental organizations and of the national government and local authorities. The results presented are based on both the analysis of the empirical-qualitative data and the existing studies and literature on social acceptance. The qualitative research compares experiences and current practices with social acceptance issues (like frameworks, participation, communication strategies) in a set of considered energy infrastructure projects. © 2015 Elsevier Ltd.

Friedmann, H. and P. Kraemer (2016). Vibration-based condition monitoring, structural health monitoring, population monitoring-Approach to a definition of the different concepts by means of practical examples from the field of wind energy. 8th European Workshop on Structural Health Monitoring, EWSHM 2016.

Monitoring of machines and structures is more and more becoming state of the art in industrial application. Nevertheless, especially in practice, the terms condition monitoring (CM) and structural health monitoring (SHM) are often used synonymously for quite different topics. Furthermore, a new monitoring type regarding the comparative monitoring of a large number of machines or structures is also affected by the confusing perception of CM and SHM. Following the term used in biology, population monitoring (PM) or fleet monitoring is proposed to define this kind of comparative monitoring. The main purpose of this paper is to clarify the terms and to explain their differences and their commonalities by means of useful examples from monitoring projects in the wind energy sector. The umbrella term for CM, SHM and PM is monitoring, this will be exemplified by means of SCADA-data. An inner ring damage identification of a roller bearing is used to exemplify the CM. Since SHM serves to ensure the load-bearing behavior and integrity of large and civil engineering structures, this will be shown by means of the damage detection with a rotor blade of a wind turbine. The PM and thus the capability of individual machines (e.g. wind turbines) within a population (e.g. wind farm) of comparing themselves with each other by means of monitoring solutions is illustrated by the comparative monitoring of different rotor blades in various wind farms. Here the objective is optimized operation for maximum operating lifetime and also maximum electricity production.

Frolova, M., et al. (2015). The evolution of renewable landscapes in Sierra Nevada (southern Spain): From small hydro- to a wind-power landscape. Renewable Energies and European Landscapes: Lessons from Southern European Cases: 117-134.

We explore the processes through which small hydropower and later on wind-power landscapes emerged in the Sierra Nevada mountain range in Andalusia (southern Spain) and the evolution of landscape practices and landscape values related with these energies. Throughout the history of small hydro development in our study area, the attitudes to it have varied between rejection and acceptance.

At the same time, the landscape features inherent to them were sometimes perceived as negative impacts and sometimes assimilated positively as new landscape values, depending on the historical and social context. The analysis of the evolution of hydropower in mountain landscapes and the related practices provides useful lessons for understanding the influence of new forms of renewable energy, not only in terms of their landscape impact but also in terms of the role of landscape values in determining their acceptance or rejection by different stakeholders. © Springer Science+Business Media Dordrecht 2015.

Gadomska, W. and M. Antolak (2014). "Landscape-related aspects of the siting of wind farms in Poland: A case study of the great Masurian Lake District." *European Spatial Research and Policy* **21**(2): 171-192.

Gan, W. Q., et al. (2016). "Exposure to loud noise, bilateral high-frequency hearing loss and coronary heart disease." *Occupational and Environmental Medicine* **73**(1): 34-41.

Objectives: Bilateral high-frequency hearing loss is an indicator for chronic exposure to loud noise. This study aimed to examine the association between bilateral high-frequency hearing loss and the presence of coronary heart disease (CHD). Methods: This study included 5223 participants aged 20-69 years who participated in the audiometry examination of the National Health and Nutrition Examination Survey 1999-2004. Bilateral high-frequency hearing loss was defined as the average high-frequency (3, 4 and 6 kHz) hearing threshold ≥ 25 dB in both ears. CHD was defined as self-reported diagnoses by doctors or other health professionals. Results: Compared with those with normal high-frequency hearing, participants with bilateral high-frequency hearing loss were more likely to have CHD (OR 1.91; 95% CI 1.28 to 2.85) after adjustment for various covariates. This association was particularly strong for currently employed workers who were exposed to loud occupational noise (OR 4.23; 95% CI 1.32 to 13.55). For this subgroup, there was no significant association of CHD with unilateral high-frequency hearing loss, and unilateral or bilateral low-frequency hearing loss. Furthermore, there was no significant association of CHD with any types of hearing loss for participants who were not exposed to loud noise. Stratified analyses for participants exposed to loud noise showed that the observed association was particularly strong for those who were less than 50 years of age, less educated and current smokers. Conclusions: On the basis of an objective indicator for personal chronic exposure to loud noise, this study confirmed that exposure to loud occupational noise is associated with the presence of CHD.

Gibbons, S. (2015). "Gone with the wind: Valuing the visual impacts of wind turbines through house prices." *Journal of Environmental Economics and Management* **72**: 177-196.

This study provides quantitative evidence on the local benefits and costs of wind farm developments in England and Wales, focussing on their visual environmental impacts. In the tradition of studies in environmental, public and urban economics, housing sales prices are used to reveal local preferences for views of wind farm developments. Estimation is based on quasi-experimental research designs that compare price changes occurring in places where wind farms become visible, with price changes in appropriate comparison groups. These groups include places close to wind farms that became visible in the past, or where they will become operational in the future and places close to wind farms sites but where the turbines are hidden by the terrain. All these comparisons suggest that wind farm visibility reduces local house prices, and the implied visual environmental costs are substantial. © 2015 Elsevier Inc.

Gonzalez-Rodriguez, A. G. (2016). "An indicator to objectively quantify the visual impact of an offshore wind farm." *Journal of Renewable and Sustainable Energy* **8**(2).

This study describes a method to quantify the visual impact of an offshore wind farm, as seen from the coast. In brief, the method involves distinguishing between the visual impact due to the intrusion in the observer's vision field and the un-aesthetic effect of the arrangement unevenness. Both parameters, visual intrusion and unevenness, can be quantifiable; therefore, a final indicator for the visual impact of the wind farm can be calculated for a specific wind farm layout. Two approaches are presented to calculate the visual intrusion, which give rise to similar results. The method has been programmed and included in an application that has been tested with two known wind farm layouts, showing a complete coherence of the results given by the method. This method provides the designer with a tool that allows him to take into account the estimated visual impact of a wind farm under study. If an algorithm is used to look for the optimum location/layout for an offshore wind farm, its programmer can include this method in order to obtain a trade-off between maximum profitability and minimum visual impact. © 2016 AIP Publishing LLC.

Gorayeb, A., et al. (2016). "Wind-energy development causes social impacts in coastal ceará state, Brazil: The case of the Xavier community." *Journal of Coastal Research* **1**(75): 383-387.

A significant increase in wind-power generation has occurred since 2008 in coastal regions of northeastern Brazil. Many wind farms have been erected on territories claimed by traditional communities, which have suffered changes in how they obtain resources as a consequence. Here we study the Xavier community, a settlement of 20 families and 66 people, located in the Camocim municipality of Ceará state. Xavier residents subsist on extractive activities such as artisanal (non-mechanized) fishing, shellfish collection, and crop cultivation. But in 2009 one of Ceará's largest wind farms was established approximately 200 meters from the settlement. Although some may see these projects as low impact, wind farms in Ceará are being implemented in areas that are environmentally unstable, located within territories claimed by traditional communities, negatively affecting their livelihoods. This paper analyzes the social impacts caused by the establishment of the wind farm through participant observation, group workshops, and analysis of textual materials. Several problems are described, including the absence of basic infrastructure and employment; road blockages; privatization of common resources; noise from turbines; constant fear of accidents involving turbines; internal conflicts among Xavier residents caused after the implementation of the wind farm; and burial of lakes. Wind-farm construction negatively influenced this traditional community by threatening territory, cultural traditions, and food security. © Coastal Education and Research Foundation, Inc. 2016.

Goulle, J. P., et al. (2012). "[Are rare earths used in offshore windpower installations toxic?]." *Bull Acad Natl Med* **196**(7): 1457-1461.

Graham, J. B., et al. (2009). "Public perceptions of wind energy developments: Case studies from New Zealand." *Energy Policy* **37**(9): 3348-3357.

Although the public generally hold positive attitudes towards wind energy, proposals for the construction of new wind farms are often met with strong resistance. In New Zealand, where the government has recently introduced ambitious policy targets for renewable energy generation, negative perceptions of wind farms are increasingly evident and have the potential to prevent the achievement of these targets. This research sets out to examine what influences social resistance to wind farms in New Zealand. Drawing from public submissions on three wind farm proposals, a framework developed by Devine-Wright [Devine-Wright, P., 2005a. Beyond NIMBYism: towards an integrated Framework for Understanding Public Perceptions of Wind Energy. *Wind Energy* 8, 125-139.] was used as the basis for identification of factors affecting public perceptions of wind farms. The research found firstly that there was no apparent relationship between the proximity of submitters to a proposed wind farm and their likelihood of having a negative perception of the proposal. A wide range of factors written in submissions appeared to have affected the submitter's decision to support or oppose the wind farm proposal. Some of these were consistent with Devine-Wright's findings, but ten further factors were added to the framework to adequately cover the aspects raised in submissions. The findings have implications for the achievement of New Zealand's energy policy aspirations. © 2009 Elsevier Ltd. All rights reserved.

Grassi, S. and T. M. Klein (2016). "3D augmented reality for improving social acceptance and public participation in wind farms planning." *Journal of Physics: Conference Series* **749**(1).

Wind energy is one of the most important source of renewable energy characterized by a significant growth in the last decades and giving a more and more relevant contribution to the energy supply. One of the main disadvantages of a faster integration of wind energy into the energy mix is related to the visual impact of wind turbines on the landscape. In addition, the siting of new massive infrastructures has the potential to threaten a community's well-being if new projects are perceived being unfair. The public perception of the impact of wind turbines on the landscape is also crucial for their acceptance. The implementation of wind energy projects is hampered often because of a lack of planning or communication tools enabling a more transparent and efficient interaction between all stakeholders involved in the projects (i.e. developers, local communities and administrations, NGOs, etc.). Concerning the visual assessment of wind farms, a critical gap lies in effective visualization tools to improve the public perception of alternative wind turbines layouts. In this paper, we describe the advantages of a 3D dynamical and interactive visualization platform for an augmented reality to support wind energy planners in order to enhance the social acceptance of new wind energy projects. © Published under licence by IOP Publishing Ltd.

Groth, T. M. and C. Vogt (2014). "Residents' perceptions of wind turbines: An analysis of two townships in Michigan." *Energy Policy* **65**: 251-260.

Wind energy development has become a 'hot topic' across Michigan as this state seeks to achieve 10% of energy delivered to consumers from renewable sources (Huron County Planning Commission, 2005). The focus of this effort to generate renewable energy has centered around wind energy. Wind turbines have been constructed at numerous locations across the state. The lower peninsulas' eastern counties near Lake Huron and Saginaw Bay were designated by the Wind Energy Resource Zone board as one such area of strong sustained wind in the state. Turbines have been constructed in 'pockets' across this 'thumb' region, yet half a decade after the first turbines were constructed, negative perceptions are still attributed to wind turbines. This paper examines residents of wind farm locations as a whole and independently as groups (those in opposition and in support of development) to identify what, if any similarities and differences, exist between the residents' perceptions. Qualitative analysis on stated negative perceptions unveiled common issues with residents: increased price of electricity with wind energy, noise from the turbine rotation and uncertainty surrounding the long term effects of wind turbines. These areas of concern seem to persist years after construction was completed. © 2013 Elsevier Ltd.

Groth, T. M. and C. A. Vogt (2014). "Rural wind farm development: Social, environmental and economic features important to local residents." *Renewable Energy* **63**: 1-8.

The research problem was to examine residents' perceptions of personal costs and benefits in terms of social, environmental or economic features that influence support of or resistance to wind farm development in four rural communities in eastern Michigan. Data were collected from residents using a mail questionnaire, which included twenty-one Likert-style questions inquiring about perceived impact statements of wind farm development in the community. The analysis indicated that there were both differences and similarities in the perception of wind farm impacts on the rural communities. More specifically, the results of the Akaike information criterion test indicated that there was substantial support for nine of the twenty-one variables in support of wind farm development. The contribution of this study recognizes the importance of noneconomic perspectives of wind farm development where turbine construction had not yet been fully exploited. In particular, the data lend support for the use of Social Exchange Theory and further exploration of its applicability in renewable energy investigations. © 2013 Elsevier Ltd.

Guo, Y., et al. (2015). "Not in my backyard, but not far away from me: Local acceptance of wind power in China." *Energy* **82**: 722-733.

Local acceptance of wind energy technology has become an important factor to consider when designing local and national wind energy technological innovation policies. Previous studies have investigated the factors that shape the local acceptance of wind power in high-income countries. However, to the best of our knowledge, these factors had not been investigated in China. Utilizing a survey and quantitative analysis, we have identified the factors that are correlated with local acceptance of wind power in China. We conducted our study in the city of Jiuquan, Gansu Province, which currently possesses the largest installed capacity for wind power generation in China. Two factors, namely, perceived economic benefits and perceived environmental costs, influence local acceptance of wind power in China most significantly. Local acceptance of wind power in China can be described as "not in my backyard, but not far away from me". In other words, the acceptance rate is lowest when the source of wind power is located in their village or community, highest when the project is located in their county and city and decreases for projects that are constructed further away. © 2015 Elsevier Ltd.

Guski, R., et al. (2016). *The WHO evidence review on noise annoyance 2000-2014*. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

WHO Europe commissioned a systematic evidence review on the effects of environmental noise on residential long-term annoyance. The main noise sources considered are aircraft, road traffic, railway traffic, combined transportation sources, and wind turbines. Methods: Data sources and study eligibility criteria were defined, a systematic literature search was done, publication quality was assessed and selection criteria for the paper defined. In addition, study quality criteria were defined for each of the studies presented in the included papers. Results: In general, there is a consistent effect of noise on annoyance; summary correlation coefficients range between 0.442 (combined sources), and 0.278 (wind

turbines). The unadjusted OR with a 10 dB level increase, based on observed data, ranges between OR = 3.405 (aircraft), and 2.738 (road). The OR for a 10 dB level increase, based on modelled data, ranges between OR = 6.633 (combined sources), and 3.033 (road). A 5 dB level increase of wind turbine sounds is associated with an increase of 6.375 % Highly Annoyed (outdoor / home). Tentative exposure-response relations for studies published between 2000 and 2014 are presented for the three transportation noise sources, respectively. With respect to exposure-response functions for aircraft noise, we propose to distinguish between "high-rate change", and "low-rate-change" airports. © 2016, German Acoustical Society (DEGA). All rights reserved.

Hafke-Dys, H., et al. (2016). "Noise annoyance caused by amplitude modulated sounds resembling the main characteristics of temporal wind turbine noise." *Archives of Acoustics* **41**(2): 221-232.

Annoyance ratings for artificially created noises, resembling the main characteristics of temporal wind turbine noise, were studied by means of a listening experiment involving 21 participants with normal hearing. Three types of stimuli were examined: broadband noise (-4 dB/octave), noise generated by moving cars, and narrowband noise. All stimuli had the sound level fluctuations typical for wind turbine noise. The magnitude of the sound level fluctuations was measured in a quantitative way, by using the characteristics of amplitude modulated sound: modulation rate and modulation depth. Our aim was to examine how the modulation rate and the modulation depth influence the noise annoyance assessment of broadband and narrowband amplitude modulated noises. Three different modulation rates, 1, 2 and 4 Hz, and sound level fluctuations (a measure of the modulation depth), 3, 6, 9 dB, were applied to each type of stimuli (with exception of noise generated by the moving cars) and investigated. The participants in the listening experiment were presented with sound stimuli in laboratory conditions and asked to rate their annoyance on a numerical scale. The results have shown a significant difference between the investigated conditions. The effect was particularly strong between the annoyance judgments of different types of noise (narrow and broadband), and modulated versus unmodulated noises. Temporal fluctuations occurring in wind turbine noise are very pertinent to the perception of annoyance and could be responsible for its being a relatively annoying noise source. The obtained results were discussed and compared to the typical modulation rates and level changes that occur in recordings of real wind turbine noise. Copyright © 2016 by PAN- IPPT.

Hajto, M., et al. (2016). "Constraints on Development of Wind Energy in Poland due to Environmental Objectives. Is There Space in Poland for Wind Farm Siting?" *Environmental Management*: 1-14.

The objective of the study was to evaluate spatial effects of adopting environmental criteria for wind farm siting, i.e., the criteria related to the settlement system and those with regards to landscape values. The set of criteria was elaborated on the basis of literature and experience-based knowledge. Some of the criteria selected are legally binding. The analyses were carried out with the use of GIS tools. Settlement areas with 1000 and 2000 m wide buffer zones, and the areas with the highest landscape values, were assumed as particularly sensitive receptors to wind farm impacts. The results show significant constraints on wind farm siting in Poland. Although the constraints are regionally diversified, they concern 93.9 % of the total country area (1000 m buffer zone) or 99.1 % (2000 m buffer zone). Presumably even greater constraints would be revealed by an additional detailed analysis at a local level. The constraints on wind farm siting in Poland cannot be decreased, because of both social attitudes and demand for appropriate environmental standards, which should be taken into account in spatial and energy policies at all decision making level.

Hall, N. L. (2014). "Can the "Social Licence to Operate" Concept Enhance Engagement and Increase Acceptance of Renewable Energy? A Case Study of Wind Farms in Australia." *Social Epistemology* **28**(3-4): 219-238.

Social licence to operate (SLO) is the ongoing acceptance or approval for a development that is granted by the local community and other stakeholders. From the current media and political attention on Australian wind farms, it appears that many specific wind farms, or indeed the industry as a whole, may not hold an SLO with affected stakeholders. This research was undertaken to examine whether the SLO might be a useful framework to enhance engagement and increase societal understanding of wind farms. Twenty-seven interviews across nine wind farms were conducted with stakeholders representing wind companies, local government authorities, local opposition, local support and turbine hosts. The interviews revealed a complexity of concerns that informed the stakeholders' perspectives, including "game-changing" issues that may stand to significantly increase wind farm acceptance. The results are presented with practical steps towards the development of a preliminary working model of an SLO for Australian wind farms that addresses identified concerns. The emerging concept of SLO appears to

provide a useful framework for wind farm developers to incorporate an improved model of consultation that engages local communities in ways that could enhance transparency and local support, and complement formal regulatory processes. © 2014 © 2014 Taylor & Francis.

Hammami, S. M., et al. (2014). Identifying the determinants of community acceptance of renewable energy technologies: The case study of a wind energy project from tunisia C3 - IREC 2014 - 5th International Renewable Energy Congress. 2014 5th International Renewable Energy Congress, IREC 2014, Hammamet, IEEE Computer Society.

By adopting an abductive logic where we iteratively synthesize existing theory and field work based on the Sidi Daoud Wind Park case, and by apprehending renewable energy technology from a social perspective, a comprehensive model is proposed in terms of input, process and output hinging around the pivotal community acceptance construct which is believed to enrich our understanding of renewable energy project implementation and to account for differences in its outcome, i.e. in terms of success or failure. © 2014 IEEE.

Hammami, S. M., et al. (2016). "Identifying the determinants of community acceptance of renewable energy technologies: The case study of a wind energy project from Tunisia." Renewable and Sustainable Energy Reviews **54**: 151-160.

By adopting an abductive logic where we iteratively synthesize existing theory and field work, and by apprehending the Sidi Daoud wind park case from a social perspective, a comprehensive model is proposed in terms of input, process and output and hinging around the pivotal role of community acceptance construct which is believed to enrich our understanding of how local residents form their responses to the implantation of a renewable energy project and to account for differences in its outcome, i.e. in terms of success or failure. © 2015 Elsevier Ltd. All rights reserved.

Hanning, C. D. and A. Evans (2012). "Wind turbine noise." Bmj **344**: e1527.

Harrison, R. V. (2015). "On the biological plausibility of Wind Turbine Syndrome." Int J Environ Health Res **25**(5): 463-468.

An emerging environmental health issue relates to potential ill-effects of wind turbine noise. There have been numerous suggestions that the low-frequency acoustic components in wind turbine signals can cause symptoms associated with vestibular system disorders, namely vertigo, nausea, and nystagmus. This constellation of symptoms has been labeled as Wind Turbine Syndrome, and has been identified in case studies of individuals living close to wind farms. This review discusses whether it is biologically plausible for the turbine noise to stimulate the vestibular parts of the inner ear and, by extension, cause Wind Turbine Syndrome. We consider the sound levels that can activate the semicircular canals or otolith end organs in normal subjects, as well as in those with preexisting conditions known to lower vestibular threshold to sound stimulation.

Harrison, R. V. (2015). "On the biological plausibility of Wind Turbine Syndrome." International journal of environmental health research **25**(5): 463-468.

Hart, D. (2014). "Wind turbines, noise and public information." Environmental Law and Management **26**(5): 169-170.

Heidenreich, S. (2015). "Sublime technology and object of fear: offshore wind scientists assessing publics." Environment and Planning A **47**(5): 1047-1062.

The development of offshore wind energy is often connected to expectations that the public will be positive about or at least indifferent to the technology. Because turbines are placed at sea—out of sight, out of mind—they are expected to avoid the public resistance experienced with respect to onshore installations. This paper examines offshore wind scientists' constructions of the public(s) by identifying narratives in the research communities. It is based on twenty-six semistructured interviews with scientists at two national research centres on offshore wind energy and technology in Norway. It finds that, although the dominant narrative of these scientists conveys a positive public, expectations of public resistance and constructions of public sentiment as NIMBY ('not in my backyard') are present in the research environments. This continued presence of narratives of irrational public resistance in the scientists' imaginings could be understood as an act of othering the public, with the possible implication of a disembedded technology development. The paper concludes by asking whether the persistence of

constructions of resistant publics mirrors a pessimistic engineering mindset. © 2015, © The Author(s) 2015.

Höltinger, S., et al. (2016). "Austria's wind energy potential – A participatory modeling approach to assess socio-political and market acceptance." *Energy Policy* **98**: 49-61.

Techno-economic assessments confirm the potential of wind energy to contribute to a low carbon bioeconomy. The increasing diffusion of wind energy, however, has turned wind energy acceptance into a significant barrier with respect to the deployment of wind turbines. This article assesses whether, and at what cost, Austrian renewable energy targets can be met under different expansion scenarios considering the socio-political and market acceptance of wind energy. Land-use scenarios have been defined in a participatory modeling approach with stakeholders from various interest groups. We calculated the levelized cost of electricity (LCOE) for all of the potential wind turbine sites, which we used to generate wind energy supply curves. The results show that wind energy production could be expanded to 20% of the final end energy demand in three out of four scenarios. However, more restrictive criteria increase LCOE by up to 20%. In contrast to common views that see local opposition against wind projects as the main barrier for wind power expansion, our participatory modeling approach indicates that even on the level of key stakeholders, the future possible contribution of wind energy to Austrian renewable energy targets reaches from almost no further expansion to very high shares of wind energy. © 2016 Elsevier Ltd

Horbaty, R., et al. (2012). "Large-scale wind deployment, social acceptance." *Wiley Interdisciplinary Reviews: Energy and Environment* **1**(2): 194-205.

The public is typically in agreement with the renewable energy targets established in many national states and generally supports the idea of increased reliance on wind energy. Nevertheless, many specific wind power projects face significant local opposition. A key question for the wind energy sector is, therefore, how to better engage local people to foster support for specific projects. IEA Wind Task 28 on Social Acceptance of Wind Energy Projects aims to facilitate wind energy development by reviewing current practices, emerging ideas, and exchanging successful practices among the participating countries. It also aims to disseminate the insights of leading research to a nontechnical audience, including project developers, local planning officials, and the general public. The interdisciplinary approach adopted by Task 28 enables an in-depth understanding of the nature of opposition to wind projects and a critical assessment of emerging strategies for social acceptance. Task 28 has analyzed a range of key issues related to social acceptance of wind energy, including the impacts on landscapes and ecosystems, on standard of living and well-being, the implementation of energy policy and spatial planning, the distribution of costs and benefits, and procedural justice. It is clear that although wind energy has many benefits; however, specific projects do impact local communities. As such the concerns of the affected people have to be taken seriously. Moreover, as opposition is rarely without foundation, it is in the interests of developers and advocates to engage local people and to improve projects for the benefit of all. © 2012 John Wiley & Sons, Ltd.

Hosking, J., et al. (2015). "Low-income resident' s preferences for the location of wind turbine farms in the Eastern Cape Province, South Africa." *Journal of Energy in Southern Africa* **26**(3): 10-18.

There is a general consensus that South Africa should be generating more power through harnessing renewable energy resources, such as wind power. However, there is no consensus with regard to the location of such generating projects. This paper describes a wind farm project proposed for development in the Kouga local municipality, reports low-income local residents' preferences on its nature and applies choice modelling to analyse these preferences. A questionnaire was presented to each respondent, the discrete choice experiment component of the questionnaire included two different onshore wind energy development scenarios and a status quo option. The scenarios differed by the combination of four elements: The distance of the wind turbines from residential areas, job creation, the number of turbines and a subsidy allocated to each household.

Howe, B., et al. (2011). "Addressing low frequency sound and infrasound from wind turbines." *Canadian Acoustics - Acoustique Canadienne* **39**(3): 86-87.

The article addresses the low frequency sound and infrasound from wind turbines. Modern wind turbines produce broadband noise, with the dominant sound source related to turbulence at the trailing edge of the blades. In relation to human perception of the sound, the dominant frequency range is not the low frequency or infrasonic ranges, but low frequency sound will routinely be an audible component

of the acoustic impact. Publications by medical professionals indicate that, at the typical setback distances in Ontario, the overall magnitude of the sound pressure levels produced by wind turbine generators does not represent a direct health risk. This includes noise at low and infrasound frequencies. The relationship between the sound level and the prevalence of annoyance is complicated, and is often influenced by other non-acoustic factors. This situation does not relate exclusively to the low frequency component of the audible noise impact of wind turbines.

Hume, K. I., et al. (2012). "Effects of environmental noise on sleep." *Noise Health* **14**(61): 297-302.

This paper summarizes the findings from the past 3 year's research on the effects of environmental noise on sleep and identifies key future research goals. The past 3 years have seen continued interest in both short term effects of noise on sleep (arousals, awakenings), as well as epidemiological studies focusing on long term health impacts of nocturnal noise exposure. This research corroborated findings that noise events induce arousals at relatively low exposure levels, and independent of the noise source (air, road, and rail traffic, neighbors, church bells) and the environment (home, laboratory, hospital). New epidemiological studies support already existing evidence that night-time noise is likely associated with cardiovascular disease and stroke in the elderly. These studies collectively also suggest that nocturnal noise exposure may be more relevant for the genesis of cardiovascular disease than daytime noise exposure. Relative to noise policy, new effect-oriented noise protection concepts, and rating methods based on limiting awakening reactions were introduced. The publications of WHO's "Night Noise Guidelines for Europe" and "Burden of Disease from Environmental Noise" both stress the importance of nocturnal noise exposure for health and well-being. However, studies demonstrating a causal pathway that directly link noise (at ecological levels) and disturbed sleep with cardiovascular disease and/or other long term health outcomes are still missing. These studies, as well as the quantification of the impact of emerging noise sources (e.g., high speed rail, wind turbines) have been identified as the most relevant issues that should be addressed in the field on the effects of noise on sleep in the near future.

Iannace, G. (2016). "Effects of noise from wind turbines inside home." *Wind Engineering* **40**(1): 25-30.

The inland areas of southern Italy were built with many wind farms which are often situated close to houses. This work reports the results of acoustic measurements made in a room inside a house located near a wind farm. The acoustic measurements were carried out during the autumn season; the values of L_{eqA} and L_{95} have been measured for different wind speeds. © The Author(s) 2016.

Ioannidou, C., et al. (2016). "Effect of modulation depth, frequency, and intermittence on wind turbine noise annoyance." *J Acoust Soc Am* **139**(3): 1241-1251.

Amplitude modulation (AM) may be an important factor for the perceived annoyance of wind turbine noise (WTN). Two AM types, typically referred to as "normal AM" (NAM) and "other AM" (OAM), characterize WTN AM, OAM corresponding to having intermittent periods with larger AM depth in lower frequency regions than NAM. The extent to which AM depth, frequency, and type affect WTN annoyance remains uncertain. Moreover, the temporal variations of WTN AM have often not been considered. Here, realistic stimuli accounting for such temporal variations were synthesized such that AM depth, frequency, and type, while determined from real on-site recordings, could be varied systematically. Listening tests with both original and synthesized stimuli showed that a reduction in mean AM depth across the spectrum led to a significant decrease in annoyance. When the spectrotemporal characteristics of the original far-field stimuli and the temporal AM variations were taken into account, the effect of AM frequency remained limited and the presence of intermittent OAM periods did not affect annoyance. These findings suggest that, at a given overall level, the AM depth of NAM periods is the most crucial AM parameter for WTN annoyance.

Jalali, L., et al. (2016). "Changes in quality of life and perceptions of general health before and after operation of wind turbines." *Environmental Pollution* **216**: 608-615.

Ontario is Canada's provincial leader in wind energy, with over 4000 MW of installed capacity supplying approximately five percent of the province's electricity demand. Wind energy is now one of the fastest-growing sources of renewable power in Canada and many other countries. However, its possible negative impact on population health, as a new source of environmental noise, has raised concerns for people living in proximity to wind turbines (WTs). The aims of this study were to assess the effect of individual differences and annoyance on the self-reported general health and health-related quality of life (QOL) of nearby residents, using a pre- and post-exposure design. Prospective cohort data were

collected before and after WT operations, from the individuals ($n = 43$) in Ontario, Canada. General health and QOL metrics were measured using standard scales, such as SF12, life satisfaction scales developed by Diener (SWLS) and the Canadian Community Health Survey (CCHS-SWL). The mean values for the Mental Component Score of SF12 ($p = 0.002$), SWLS ($p < 0.001$), and CCHS-SWL ($p = 0.044$) significantly worsened after WT operation for those participants who had a negative attitude to WTs, who voiced concerns about property devaluation, and/or who reported being visually or noise annoyed.

Jalali, L., et al. (2016). "Before-after field study of effects of wind turbine noise on polysomnographic sleep parameters." *Noise Health* **18**(83): 194-205.

Wind is considered one of the most advantageous alternatives to fossil energy because of its low operating cost and extensive availability. However, alleged health-related effects of exposure to wind turbine (WT) noise have attracted much public attention and various symptoms, such as sleep disturbance, have been reported by residents living close to wind developments. Prospective cohort study with synchronous measurement of noise and sleep physiologic signals was conducted to explore the possibility of sleep disturbance in people hosting new industrial WTs in Ontario, Canada, using a pre and post-exposure design. Objective and subjective sleep data were collected through polysomnography (PSG), the gold standard diagnostic test, and sleep diary. Sixteen participants were studied before and after WT installation during two consecutive nights in their own bedrooms. Both audible and infrasound noises were also concurrently measured inside the bedroom of each participant. Different noise exposure parameters were calculated (LA_{eq} , LZ_{eq}) and analyzed in relation to whole-night sleep parameters. Results obtained from PSG show that sleep parameters were not significantly changed after exposure. However, reported sleep qualities were significantly ($P=0.008$) worsened after exposure. Average noise levels during the exposure period were low to moderate and the mean of inside noise levels did not significantly change after exposure. The result of this study based on advanced sleep recording methodology together with extensive noise measurements in an ecologically valid setting cautiously suggests that there are no major changes in the sleep of participants who host new industrial WTs in their community. Further studies with a larger sample size and including comprehensive single-event analyses are warranted.

Jalali, L., et al. (2016). "The impact of psychological factors on self-reported sleep disturbance among people living in the vicinity of wind turbines." *Environ Res* **148**: 401-410.

Canada's wind energy capacity has grown from approximately 137MW (MW) in 2000 to over 9700MW in 2014, and this progressive development has made Canada the fifth-largest market in the world for the installation of new wind turbines (WTs). Although wind energy is now one of the fastest growing sources of power in Canada and many other countries, the growth in both number and size of WTs has raised questions regarding potential health impacts on individuals who live close to such turbines. This study is the first published research using a prospective cohort design, with noise and sleep measurements obtained before and after installation of WTs to investigate effect of such turbines on self-reported sleep disturbances of nearby residents. Subjective assessment of sleep disturbance was conducted in Ontario, Canada through standard sleep and sleepiness scales, including the Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), and Epworth daytime Sleepiness Scale (ESS). Both audible and infra-sound noises were also measured inside the bedroom. Descriptive and comparison analyses were performed to investigate the effect of WT exposure on sleep data. Results of the analysis show that participants reported poorer sleep quality if they had a negative attitude to WTs, if they had concerns related to property devaluation, and if they could see turbines from their properties. This study provides evidence for the role of individual differences and psychological factors in reports of sleep disturbance by people living in the vicinity of WTs. Crown Copyright © 2016. Published by Elsevier Inc. All rights reserved.

Jalali, L., et al. (2016). "The impact of psychological factors on self-reported sleep disturbance among people living in the vicinity of wind turbines." *Environmental Research* **148**: 401-410.

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self-reported sleep disturbances of nearby residents. Subjective assessment of sleep disturbance was conducted in Ontario, Canada through standard sleep and sleepiness scales, including the Pittsburgh Sleep Quality Index (PSQI), Insomnia Severity Index (ISI), and Epworth daytime Sleepiness Scale (ESS). Both audible and infra-sound noises were also measured inside the bedroom. Descriptive and comparison analyses were performed to investigate the effect of WT exposure on sleep data. Results of the analysis show that participants reported poorer sleep quality if they had a negative attitude to WTs, if they had concerns related to property devaluation, and if they could see turbines from their properties. This study provides evidence for the role of individual differences and psychological factors in reports of sleep disturbance by people living in the vicinity of WTs. © 2016.

Jami, A. A. and P. R. Walsh (2016). "Wind power deployment: The role of public participation in the decision-making process in Ontario, Canada." *Sustainability (Switzerland)* **8**(8).

A wider use of renewable energy is emerging as a viable solution to meet the increasing demand for global energy while contributing to the reduction of greenhouse gas emissions. However, current literature on renewable energy, particularly on wind power, highlights the social barriers and public opposition to renewable energy investment. One solution to overcome the public opposition, which is recommended by scholars, is to deploy a collaborative approach. Relatively little research has specifically focused on the role of effective communication and the use of a knowledge-broker in collaborative decision-making. This study attempts to fill this gap through the proposition of a participatory framework that highlights the role of the knowledge-broker in a wind project decision-making process. In this paper, five illustrative wind projects in Ontario are used to highlight the current situation with public participation and to address how the proposed framework could have improved the process. Based on the recommended collaborative framework, perception must shift from the dominant view of the public as "a risk to be managed" towards "a resource that can be tapped". The developers need to improve sharing what they know and foster co-learning around questions and concerns. © 2016 by the authors; licensee MDPI, Basel, Switzerland.

Janssen, S. A., et al. (2009). *Exposure-response relationships for annoyance by wind turbine noise: A comparison with other stationary sources*. 8th European Conference on Noise Control 2009, EURONOISE 2009 - Proceedings of the Institute of Acoustics, Edinburgh.

There are indications that, given a certain level of noise exposure, the expected annoyance by wind turbine noise is higher than that by noise from other sources such as industrial noise or transportation noise. The aim of the present study was to establish the exposure-response relationship between wind turbine noise exposure and the expected percentage annoyed residents on the basis of available data. Data from two surveys in Sweden (N=341, N=754) and one survey in the Netherlands (N=725) were combined to achieve relationships between Lden and annoyance indoors as well as annoyance outdoors at the dwelling. In addition, the influence of several individual and situational factors was assessed. In particular, annoyance was lower in residents who received economical benefit from wind turbines, and higher in residents for whom the wind turbine was visible from the dwelling. Age and noise sensitivity had similar effects on annoyance to those found in research on annoyance by other sources. The exposure-response relationship for wind turbine noise is compared to previously established relationships for industrial noise.

Janssen, S. A., et al. (2011). "A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources." *J Acoust Soc Am* **130**(6): 3746-3753.

Surveys have shown that noise from wind turbines is perceived as annoying by a proportion of residents living in their vicinity, apparently at much lower noise levels than those inducing annoyance due to other environmental sources. The aim of the present study was to derive the exposure-response relationship between wind turbine noise exposure in L(den) and the expected percentage annoyed residents and to compare it to previously established relationships for industrial noise and transportation noise. In addition, the influence of several individual and situational factors was assessed. On the basis of available data from two surveys in Sweden (N=341, N=754) and one survey in the Netherlands (N=725), a relationship was derived for annoyance indoors and for annoyance outdoors at the dwelling. In comparison to other sources of environmental noise, annoyance due to wind turbine noise was found at relatively low noise exposure levels. Furthermore, annoyance was lower among residents who received economical benefit from wind turbines and higher among residents for whom the wind turbine was visible from the dwelling. Age and noise sensitivity had similar effects on

annoyance to those found in research on annoyance by other sources. Copyright 2011 Acoustical Society of America

Jeffery, R. D., et al. (2013). "Adverse health effects of industrial wind turbines." *Can Fam Physician* **59**(9): 921.

Jeffery, R. D., et al. (2013). "Adverse health effects of industrial wind turbines." *Can Fam Physician* **59**(5): 473-475.

Jeffery, R. D., et al. (2014). "Industrial wind turbines and adverse health effects." *CAN J RURAL MED* **19**(1): 21-26.

INTRODUCTION: Some people living in the environs of industrial wind turbines (IWTs) report experiencing adverse health and socioeconomic effects. This review considers the hypothesis that annoyance from audible IWTs is the cause of these adverse health effects.

METHODS: We searched PubMed and Google Scholar for articles published since 2000 that included the terms "wind turbine health," "wind turbine infrasound," "wind turbine annoyance," "noise annoyance" or "low frequency noise" in the title or abstract.

RESULTS: Industrial wind turbines produce sound that is perceived to be more annoying than other sources of sound. Reported effects from exposure to IWTs are consistent with well-known stress effects from persistent unwanted sound.

CONCLUSION: If placed too close to residents, IWTs can negatively affect the physical, mental and social well-being of people. There is sufficient evidence to support the conclusion that noise from audible IWTs is a potential cause of health effects. Inaudible low-frequency noise and infrasound from IWTs cannot be ruled out as plausible causes of health effects.

Jeffery, R. D., et al. (2014). "Industrial wind turbines and adverse health effects." *Canadian journal of rural medicine : the official journal of the Society of Rural Physicians of Canada = Journal canadien de la médecine rurale : le journal officiel de la Société de médecine rurale du Canada* **19**(1): 21-26.

Some people living in the environs of industrial wind turbines (IWTs) report experiencing adverse health and socioeconomic effects. This review considers the hypothesis that annoyance from audible IWTs is the cause of these adverse health effects. We searched PubMed and Google Scholar for articles published since 2000 that included the terms "wind turbine health," "wind turbine infrasound," "wind turbine annoyance," "noise annoyance" or "low frequency noise" in the title or abstract. Industrial wind turbines produce sound that is perceived to be more annoying than other sources of sound. Reported effects from exposure to IWTs are consistent with well-known stress effects from persistent unwanted sound. If placed too close to residents, IWTs can negatively affect the physical, mental and social well-being of people. There is sufficient evidence to support the conclusion that noise from audible IWTs is a potential cause of health effects. Inaudible low-frequency noise and infrasound from IWTs cannot be ruled out as plausible causes of health effects.

Jin, J., et al. (2016). "Dispatching strategies for coordinating environmental awareness and risk perception in wind power integrated system." *Energy* **106**: 453-463.

Wind power plays a significant role in economic and environmental operation of electric power system. Meanwhile, the variability and uncertainty characteristics of wind power generation bring technical and economical challenges for power system operation. In order to harmonize the relationship between environmental protection and risk management in power dispatching, this paper presents a stochastic dynamic economic emission dispatch model combining risk perception with environmental awareness of decision-makers by following the principle of chance-constrained programming. In this power dispatching model, the description of wind power uncertainty is derived from the probability statistic character of wind speed. Constraints-handling techniques as a heuristic strategy are embedded into non-dominated sorting genetic algorithm-II. In addition, more information is digested from the Pareto optimum solution set by cluster analysis and fuzzy set theory. The simulation results eventually demonstrate that the increase of the share of wind power output will bring higher risk, though it is beneficial for economic cost and environmental protection. Since different risk perception and environmental awareness can possibly lead to diverse non-dominated solutions, decision-makers may choose an appropriate dispatching strategy according to their specific risk perception and environmental awareness. © 2016 Elsevier Ltd.

Jones, C. R. and J. R. Eiser (2009). "Identifying predictors of attitudes towards local onshore wind development with reference to an English case study." *Energy Policy* **37**(11): 4604-4614.

The threats posed by climate change are placing governments under increasing pressure to meet electricity demand from low-carbon sources. In many countries, including the UK, legislation is in place to ensure the continued expansion of renewable energy capacity. Onshore wind turbines are expected to play a key role in achieving these aims. However, despite high levels of public support for onshore wind development in principle, specific projects often experience local opposition. Traditionally this difference in general and specific attitudes has been attributed to NIMBYism (not in my back yard), but evidence is increasingly calling this assumption into question. This study used multiple regression analysis to identify what factors might predict attitudes towards mooted wind development in Sheffield, England. We report on the attitudes of two groups; one group (target) living close to four sites earmarked for development and an unaffected comparison group (comparison). We found little evidence of NIMBYism amongst members of the target group; instead, differences between general and specific attitudes appeared attributable to uncertainty regarding the proposals. The results are discussed with respect to literature highlighting the importance of early, continued and responsive community involvement in combating local opposition and facilitating the deployment of onshore wind turbines. © 2009 Elsevier Ltd. All rights reserved.

Jones, N. (2016). "Wind Energy and Adverse Visual-Impact Litigation: A Balance of Global and Local Interests?" Climate Law 6(3-4): 336-352.

Wind energy is one of the world's fastest growing forms of energy. It has many advantages over traditional forms of energy. However, visual impact is a disadvantage. Although planning applications for wind-farm developments are on the rise worldwide, the visual impact of potential developments repeatedly provokes opposition to new wind-farm projects. Litigation aimed at enjoining the construction of wind-energy facilities can slow wind-energy development and increase its cost. This article takes a comparative approach to such visual-impact litigation, looking at cases from Australia, New Zealand, and England in order to understand why planning cases are much more likely to succeed in some jurisdictions than others. I argue that in some jurisdictions decision-makers and courts are impliedly prioritizing the global, national, and local interests in favour of wind-farm development over the national and local interests in favour of landscape and visual-amenity protection. © 2016 by Koninklijke Brill NV, Leiden, The Netherlands.

Junek, P., et al. (2011). "Effects of low frequency noise from open air music festivals on unconcerned people in the surrounding areas." Hygiene 56(1): 11-17.

Low frequency noise in the frequency range below 200 Hz has a very low attenuation through the open air, walls, windows and other barriers. It propagates over very large distances and can cause standing waves and resonances in dwellings. Therefore, the acoustic fields can be non homogenous in the embosomed areas. Some of the sources of low frequency noise are musical instruments. Presently, open air festivals have become a part of our everyday life, and sleep disturbance is commonly reported by people living in surrounding areas. The authors of the paper relate complaints of citizens from the surroundings of the open air festivals locations with low frequency noise in the music, based on series of measurements taken in the years 2008 and 2009. They point out the problems with measurements of the A-weighted sound level noise in which the low frequencies are present. They propose to use the difference between C- and A-weightings to indicate presence of the low frequency noise in the music. Examples of the outdoor and indoor noise measurements taken during the open air festivals are presented with categorization based on the types of music. Biological aspects of the influence of music on humans are also presented. It seems that loud music with low frequency noise can influence several systems in the human body. Special attention is paid to brain waves. Sleep disturbance of people living in distant dwellings is also worth concern. The aim of the presented work is to point out some negative effects of electronically amplified music at open air festivals on people living in the surrounding areas, and demonstrate the unsuitability of contemporary common measurement methods used in environmental noise investigation and health risk assessment.

Jung, S. S., et al. (2009). "Spectrum of infrasound and low-frequency noise in passenger cars." Journal of the Korean Physical Society 55(6): 2405-2410.

The interior sound pressure spectrum of modern passenger cars running at various speeds on various road conditions was analyzed in terms of a 1/3 octave band over a frequency range of 1 to 250 Hz. The car speed varied from standing idle to a motorway speed of 110 km/h on a flat asphalt road and a cement road and in a tunnel. The 1/3 octave spectrum consisted of a nearly flat sound pressure level in the infrasound region up to 10 Hz, followed by a gradual decrease with frequency. The spectrum

contained several humps, which corresponded to the resonance frequencies of engine firing and rambling noise. The spectrum profile suggests that much of the noise energy is in the infrasound region and increases with car speed. The levels of infrasound and audible sound pressures in modern Hyundai cars were shown to be significantly lower than those in the equivalent cars of 1970 models due to the incorporation of new materials with improved structural design.

Kageyama, T. (2016). "Adverse effects of community noise as a public health issue." Sleep and Biological Rhythms **14**(3): 223-229.

Too much noise disturbs sleep, as well known. The number of persons affected by community noise is estimated to be huge. This paper summarizes the recommendation by WHO (1999) and the following international documents, and introduce new data and debate. First, we should choose noise descriptors to study and to regulate noise-induced sleeplessness taking account of (1) whether we want to focus on continuous noise or intermittent noise, and (2) whether we want to focus on noise prediction or ecological measurement. LAeq (A-weighted sound equivalent level) at sleep period well predicts sleep disturbance in general. Since intermittent noise is more likely to disturb sleep than continuous noise, even if their LAeq is the same, LAmx and LAE are also used. Second, we should determine sleep descriptors such as EEG, actigraphy, and questionnaires. The descriptors should be chosen, in consideration of burdens to subjects and time-scale that should be matched with noise assessment. Based on the dose-response relationship between community noise and sleep disturbance, WHO (1999) recommended that indoor sound level should be LAeq of 35 dB or below for the general population from the aspect of health sciences. WHO Regional Office for Europe (2004), however, proposed much more strict guidelines, taking the recent studies on community noise and cardiovascular diseases in the general population. Most of the data were, however, cross-sectionally obtained, and causality cannot be determined. As a result, intensive debate emerged whether or not the reported effects are meaningful and all the effects are impermissible, reflecting the difference between European view of health and US pragmatic position. On the other hand, effects of ultra-low-frequency sound from wind turbine plants on sleep and health seem negligible, although audible noise from wind turbine can disturb sleep among residents. Individual difference in sensitivity to noise and effects of daytime noise on night/shift-workers should be further investigated. If they can be clarified, this should be systematically reflected to the exposure assessment.

Kageyama, T., et al. (2016). "Exposure-response relationship of wind turbine noise with self-reported symptoms of sleep and health problems: A nationwide socioacoustic survey in Japan." Noise Health **18**(81): 53-61.

The association of wind turbine noise (WTN) with sleep and physical/mental health has not been fully investigated. To investigate the relationship of WTN with the prevalence of self-reported symptoms of sleep and health problems, a socioacoustic survey of 1079 adult residents was conducted throughout Japan (2010-2012): 747 in 34 areas surrounding wind turbine plants and 332 in 16 control areas. During face-to-face interviews, the respondents were not informed of the purpose of the survey. Questions on symptoms such as sleeplessness and physical/mental complaints were asked without specifying reasons. Insomnia was defined as having one or any combination of the following that occurs three or more times a week and bothers a respondent: Difficulty initiating sleep, difficulty maintaining sleep, premature morning awakening, and feeling of light overnight sleep. Poor health was defined as having high scores for health complaints, as determined using the Total Health Index, exceeding the criteria proposed by the authors of the index. The noise descriptor for WTN was LAeq,n outdoor, estimated from the results of actual measurement at some locations in each site. Multiple logistic analysis was applied to the LAeq,n and insomnia or poor health. The odds ratio (OR) of insomnia was significantly higher when the noise exposure level exceeded 40 dB, whereas the self-reported sensitivity to noise and visual annoyance with wind turbines were also independently associated with insomnia. OR of poor health was not significant for noise exposure, but significant for noise sensitivity and visual annoyance. The above two moderators appear to indicate the features of respondents who are sensitive to stimuli or changes in their homeostasis.

Kaldellis, J. K., et al. (2012). "Renewable energy applications in Greece-What is the public attitude?" Energy Policy **42**: 37-48.

Large-scale integration of Renewable Energy Sources (RES) applications is thought to be imperative for Greece in view of meeting the targets of 2020, which dictate that 20% of the national gross energy consumption and 40% of the national gross electricity consumption should be covered by RES. However, availability of suitable sites for the installation of such applications is questioned, since apart

from the fact that many locations of high RES potential and adequate infrastructure have already been allocated, the society opposition often sets additional barriers. The present study focuses on the assessment of the levels of social acceptability for selected RES technologies (wind, small hydro and photovoltaics) in a representative region of Southern Greece. The specific area is of major interest since, apart from the operating and scheduled installations of RES applications in the next years, the local population is also familiar with the long-term operation of a lignite-based power station (850. MW). One three-part questionnaire has been deployed for conducting the survey based on a representative sample of local inhabitants. According to the results obtained, high levels of acceptability of renewable energy applications have been encountered although the need for additional public information regarding RES exploitation has also been designated. © 2011 Elsevier Ltd.

Kaliski, K. and G. Neeraj (2013). Prevalence of complaints related to wind turbines in northern New England C3 - Proceedings of Meetings on Acoustics. 21st International Congress on Acoustics, ICA 2013 - 165th Meeting of the Acoustical Society of America, Montreal, QC.

As of the end of December 2012, there were over a dozen large operating wind projects with a total capacity exceeding 600 MW in northern New England. This paper evaluates the prevalence of noise complaints to regulatory authorities from those wind projects. A comparison of the distance of complainants and non-complainants from wind farms is made with the goal of assessing the prevalence of complaints at various distances from the wind projects. © 2013 Acoustical Society of America.

Karydis, M. (2013). "Public attitudes and environmental impacts of wind farms: A review." Global Nest Journal **15**(4): 585-604.

The promotion of renewable sources for electricity production, independent of carbon fuels and nuclear power, is a priority in the energy policy of many countries all over the world. The European Union has launched an ambitious program to increase the contribution of energy production from wind turbines; the aim set for the year 2020 is that wind power should account for 31% of EU's current target regarding 20% reductions of carbon dioxide. This policy is favored by the fact that wind energy production cost is nowadays competitive in many cases to the cost of electricity produced from conventional non-renewable sources. However, there is a conflict concerning public attitudes: although the public in general is in favor of renewable energy sources including wind, there is usually very strong opposition by local people living in neighboring areas of wind farm developments that is attitudes toward wind power are to a large extent different from attitudes toward wind farms. It is also interesting that negative public opinion is rather high during the planning stage and significantly lower during the implementation stage. In addition, there are impacts on landscape aesthetic, human health as well as ecological impact on the flora and fauna, although compared to environmental impact from conventional energy sources, the environmental impact caused by wind turbines is relatively minor. Recent developments of offshore wind farms seemed to avoid people's negative attitudes and soften public resistance and hostility against wind power energy but these expectations were rather optimistic. Opposition due to seascape aesthetic spoiling is as strong even for the marine environment. The impact on marine life and particularly on sea mammals due to noise and vibrations need to be further investigated. Existing activities such as navigation, fishing and recreational activities should not be hindered during site selection and planning. In the present work public attitudes and impacts on human health as well as impacts on landscape and ecosystem level, both terrestrial and marine, are reviewed and discussed. © 2013 Global NEST Printed in Greece. All rights reserved.

Kasprzak, C. (2010). "The influence of infrasounds on the electrocardiograph patterns in humans." Acta Physica Polonica A **118**(1): 87-90.

This study investigates how infrasound exposure should influence the electrocardiograph (ECG) patterns and the functioning of the cardiovascular system. Infrasound waves are widespread and common and now perceptible in the working environment (particularly in industry) as well as in the recreation grounds (natural sources of infrasounds). the main sources of infrasounds include heavy machines, transport and materials handling installations, as well as natural phenomena, such as blowing winds, storms or flowing waters. Research work has now established that low-frequency noise affects the morphology of the electric biopotentials of human brain and influence the blood pressure, the level of electrodermal activity and visual-motional coordination in humans. the effects of infrasounds on fluctuations of the ECG patterns have received little attention so far. This study summarises the research data to determine how low-frequency noise with frequency $f = 7$ Hz and the acoustic pressure level SPL = 120 dB (HP) should influence the ECG patterns. Experiments were performed on a group of 33

participants. Thus obtained experimental data indicate that infrasound exposure leads to major changes in the functioning of human heart.

Keith, S. E., et al. (2016). "Wind turbine sound pressure level calculations at dwellings." *J Acoust Soc Am* **139**(3): 1436-1442.

This paper provides calculations of outdoor sound pressure levels (SPLs) at dwellings for 10 wind turbine models, to support Health Canada's Community Noise and Health Study. Manufacturer supplied and measured wind turbine sound power levels were used to calculate outdoor SPL at 1238 dwellings using ISO [(1996). ISO 9613-2-Acoustics] and a Swedish noise propagation method. Both methods yielded statistically equivalent results. The A- and C-weighted results were highly correlated over the 1238 dwellings (Pearson's linear correlation coefficient $r > 0.8$). Calculated wind turbine SPLs were compared to ambient SPLs from other sources, estimated using guidance documents from the United States and Alberta, Canada.

Keith, S. E., et al. (2016). "Wind turbine sound pressure level calculations at dwellings." *Journal of the Acoustical Society of America* **139**(3): 1436-1442.

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Keith, S. E., et al. (2016). "Wind turbine sound pressure level calculations at dwellings." *The Journal of the Acoustical Society of America* **139**(3): 1436-1442.

Kelley, N. D., et al. (1985). *Acoustic noise associated with the MOD-1 wind turbine: its source, impact, and control*. US Government Printing Office.

Kermagoret, C., et al. (2016). "Stakeholder Perceptions of Offshore Wind Power: A Fuzzy Cognitive Mapping Approach." *Society and Natural Resources* **29**(8): 916-931.

ABSTRACT: Using the method of fuzzy cognitive mapping, this study explores stakeholder attitudes toward offshore wind energy. The survey was conducted with local communities of the Bay of Saint-Brieuc, where an offshore wind farm is under development. It was used to record the stakeholder perceptions of social, ecological, and economic impacts and the expression of expected compensation for negative impacts. Distribution and interaction among the data were analyzed through multiple correspondence analysis. Our study illustrates a gap between positive impacts associated with sustainable development perceived at the national level and more negative impacts perceived by local communities. The expression of expected compensation is dependent on the perceived impacts. This study highlights the place attachment of local stakeholders and thus suggests developing offshore wind farms with respect to territorial integrity and its heritage dimension in order to improve social acceptability. © 2016, Copyright © Taylor & Francis Group, LLC.

Khan, S., et al. (2015). *Facts and popular perceptions on saving energy and the environment*. 2015 International Conference on Green Energy and Technology, ICGET 2015.

Although today's major concerns are moving to renewable energy and the saving of energy, there are deeper energy-related issues which are less discussed and explored. To what extent can renewable energy take over from conventional sources? How much into the future should we be concerned about? Electricity generation for stationary applications can be from coal, nuclear power, solar power and wind turbines, whereas transportation relies mostly on increasingly scarce oil. Coal and nuclear fuel will be nowhere close to depletion over the next 100 years. Both governments and commercial organizations mostly benefit from increased energy consumption, and cannot be fully relied upon to pursue saving energy and the environment. It is private citizens who are most concerned about saving energy, being concerned about availability in their own lifetimes and that of their children. However, the general public is less aware of the deeper issues involved. The issues of energy and the environment are interdependent on each other, and determine the quality of life for ourselves and our future

generations. As the attitude of people to saving energy determines availability (or depletion) for future generations, this paper explores facts vs. public perceptions on energy. A preliminary survey was conducted, which found that there are genuine concerns about saving energy and the environment. Areas where there were misconceptions were identified. Although the sample size was small (<100), the survey paved the way for a broader survey with a larger sample size. © 2015 IEEE.

Khorsand, I., et al. (2015). "Wind energy in the city: An interurban comparison of social acceptance of wind energy projects." *Energy Research and Social Science* 8: 66-77.

A transition towards low-carbon energy sources, such as wind, requires higher levels of public interaction; as such, the ultimate contribution of wind energy relies as much on technological advancements and policies as on societal sentiments. This study evaluates the influence of region, community involvement, and several IEA-recommended practices on social acceptance of wind energy projects among residents (n = 350) surveyed from cities in four OECD and three non-OECD countries. The results indicate interurban variations among the generally high levels of acceptance reported, especially among residents of cities in developing countries with lower domestic CO₂ emissions. The level of community involvement in a hypothetical wind energy project had a positive effect on acceptance, and respondents from cities in countries with the highest installed wind capacity reported the greatest sensitivity towards involvement. Moreover, the results revealed that although the IEA-recommended practices collectively predicted acceptance across all cities, fair distribution of earnings and costs was the only significant individual predictor. These economic considerations, combined with increased community involvement, appear to be paramount to facilitating future development of wind energy. Through its broad geographical coverage, this research provides valuable groundwork for future cross-cultural studies on social acceptance of wind energy. © 2015 Elsevier Ltd.

Kienast, F., et al. (2017). "Conflicts between decentralized renewable electricity production and landscape services – A spatially-explicit quantitative assessment for Switzerland." *Renewable and Sustainable Energy Reviews* 67: 397-407.

The production of decentralized renewable electricity often collides with provisioning, regulating and cultural services of the landscape. In this paper we operationalize the landscape service approach and generate conflict maps between three renewable energies (wind; PV; forest biomass) and six competing landscape services (nutrition and materials; aesthetics; physical and experiential interactions; heritage and symbolic content; water and liquid flows; lifecycle maintenance, habitat and gene pool protection). Media content analysis and expert interviews were used to ground-truth the national conflict maps in several Swiss regions and to understand to what degree the national conflict assessments match the regional and local perceptions of these conflicts. In Switzerland (approximately 40,000 km²) biomass from forests is by far the least conflicting renewable energy, followed by PV on roofs. For the latter 68% of the technically feasible energy potential can be generated with low conflicts, and more is expected with new materials. Wind has a high conflict potential: only 12% of the technically feasible energy potential is low conflict. PV on open land, marginal land and shrubland, is – at the moment – not currently feasible in Switzerland. The accuracy of our conflict assessment is sufficiently high to estimate the proportion that socially sustainable energy could cover of the overall energy gap of 22–25 TWh/yr caused by the phase-out of Swiss nuclear plants by 2050. Low-conflict solar energy from rooftops could contribute approximately 30% of the required 22–25 TWh/yr. Intensified wood production and wind energy could add another 40%. The gap of approximately 30% must come from undisputed energy sources such as biogas from recycled organic material, from centralized renewable energies such as geothermal or large hydropower, or from new or technologically improved renewable energies. The presented decision support tools are a timely contribution to the designation of legally binding zones for renewable energy production. © 2016 Elsevier Ltd

Klaeboe, R. and H. B. Sundfor (2016). "Windmill Noise Annoyance, Visual Aesthetics, and Attitudes towards Renewable Energy Sources." *Int J Environ Res Public Health* 13(8).

A small focused socio-acoustic after-study of annoyance from a windmill park was undertaken after local health officials demanded a health impact study to look into neighborhood complaints. The windmill park consists of 31 turbines and is located in the South of Norway where it affects 179 dwellings. Simple exposure-effect relationships indicate stronger reactions to windmills and wind turbine noise than shown internationally, with the caveat that the sample size is small (n = 90) and responses are colored by the existing local conflict. Pulsating swishing sounds and turbine engine hum are the main causes of noise annoyance. About 60 per cent of those who participated in the survey were

of the opinion that windmills degrade the landscape aesthetically, and were far from convinced that land-based windmills are desirable as a renewable energy source (hydropower is an important alternative source of renewables in Norway). Attitudes play an important role in addition to visual aesthetics in determining the acceptance of windmills and the resulting noise annoyance. To compare results from different wind turbine noise studies it seems necessary to assess the impact of important modifying factors.

Klæboe, R. and H. B. Sundfør (2016). Windmill noise annoyance, visual aesthetics, and attitudes towards renewable energy sources. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

A small focused socio-acoustic after-study was undertaken in the autumn of 2015 after local health officials demanded a health impact study to look into neighbor noise complaints. The Lista Windmill Park consists of 31 turbines and is located in the South of Norway affecting 179 properties. Simple exposure effect-relationships indicate stronger reactions to windmills and windmill noise than shown internationally, with the caveat that the sample size is small (n=90) and responses are colored by a conflict situation. Pulsating swishing sounds and turbine engine hum are the main causes of noise annoyance. About 60 per cent of those who participated in the survey were of the opinion that windmills degraded the landscape aesthetically, and are not convinced that land-based windmills are desirable as a renewable energy source in Norway. The results suggest that attitudes play an important role in addition to visual aesthetics in determining the acceptance of windmills and resulting noise annoyance. © 2016, German Acoustical Society (DEGA). All rights reserved.

Klæboe, R. and H. B. Sundfør (2016). "Windmill noise annoyance, visual aesthetics, and attitudes towards renewable energy sources." International Journal of Environmental Research and Public Health **13**(8).

A small focused socio-acoustic after-study of annoyance from a windmill park was undertaken after local health officials demanded a health impact study to look into neighborhood complaints. The windmill park consists of 31 turbines and is located in the South of Norway where it affects 179 dwellings. Simple exposure-effect relationships indicate stronger reactions to windmills and wind turbine noise than shown internationally, with the caveat that the sample size is small (n = 90) and responses are colored by the existing local conflict. Pulsating swishing sounds and turbine engine hum are the main causes of noise annoyance. About 60 per cent of those who participated in the survey were of the opinion that windmills degrade the landscape aesthetically, and were far from convinced that land-based windmills are desirable as a renewable energy source (hydropower is an important alternative source of renewables in Norway). Attitudes play an important role in addition to visual aesthetics in determining the acceptance of windmills and the resulting noise annoyance. To compare results from different wind turbine noise studies it seems necessary to assess the impact of important modifying factors. © 2016 by the authors; licensee MDPI, Basel, Switzerland.

Knopper, L. D. and C. A. Ollson (2011). "Health effects and wind turbines: a review of the literature." Environ Health **10**: 78.

BACKGROUND: Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential complaints from, or potential effects to, people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet. METHODS: The purpose of this paper is to review the peer-reviewed scientific literature, government agency reports, and the most prominent information found in the popular literature. Combinations of key words were entered into the Thomson Reuters Web of KnowledgeSM and the internet search engine Google. The review was conducted in the spirit of the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions. RESULTS: Conclusions of the peer reviewed literature differ in some ways from those in the popular literature. In peer reviewed studies, wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise. To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population. In the popular literature, self-reported health outcomes are related

to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured. CONCLUSIONS: What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. The difference between both types is the reason for annoyance. While it is acknowledged that noise from wind turbines can be annoying to some and associated with some reported health effects (e.g., sleep disturbance), especially when found at sound pressure levels greater than 40 db(A), given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from wind turbines themselves. In other words, it appears that it is the change in the environment that is associated with reported health effects and not a turbine-specific variable like audible noise or infrasound. Regardless of its cause, a certain level of annoyance in a population can be expected (as with any number of projects that change the local environment) and the acceptable level is a policy decision to be made by elected officials and their government representatives where the benefits of wind power are weighted against their cons. Assessing the effects of wind turbines on human health is an emerging field and conducting further research into the effects of wind turbines (and environmental changes) on human health, emotional and physical, is warranted.

Knopper, L. D., et al. (2014). "Wind turbines and human health." *Front. public health* 2: 63.

The association between wind turbines and health effects is highly debated. Some argue that reported health effects are related to wind turbine operation [electromagnetic fields (EMF), shadow flicker, audible noise, low-frequency noise, infrasound]. Others suggest that when turbines are sited correctly, effects are more likely attributable to a number of subjective variables that result in an annoyed stressed state. In this review, we provide a bibliographic-like summary and analysis of the science around this issue specifically in terms of noise (including audible, low-frequency noise, and infrasound), EMF, and shadow flicker. Now there are roughly 60 scientific peer-reviewed articles on this issue. The available scientific evidence suggests that EMF, shadow flicker, low-frequency noise, and infrasound from wind turbines are not likely to affect human health; some studies have found that audible noise from wind turbines can be annoying to some. Annoyance may be associated with some self-reported health effects (e.g., sleep disturbance) especially at sound pressure levels >40dB(A). Because environmental noise above certain levels is a recognized factor in a number of health issues, siting restrictions have been implemented in many jurisdictions to limit noise exposure. These setbacks should help alleviate annoyance from noise. Subjective variables (attitudes and expectations) are also linked to annoyance and have the potential to facilitate other health complaints via the nocebo effect. Therefore, it is possible that a segment of the population may remain annoyed (or report other health impacts) even when noise limits are enforced. Based on the findings and scientific merit of the available studies, the weight of evidence suggests that when sited properly, wind turbines are not related to adverse health. Stemming from this review, we provide a number of recommended best practices for wind turbine development in the context of human health.

Kokologos, D., et al. (2014). "Visual impact assessment method for wind parks: A case study in Crete." *Land Use Policy* 39: 110-120.

The number of large scale wind parks (WPs), has gradually increased over recent years as a result of the support by national and European policies. Even though it is a more environmentally friendly electricity generation option than conventional power stations, large WPs pose questions concerning their visual impact in the areas they are located. Particularly when there are no clearly defined siting criteria, land use conflicts are more intense, leading to the inhibition, and delaying, of wind park projects. In this paper, a methodology for the assessment of wind parks' aesthetic integration, and for the support of public decision-making processes, was developed. The main asset of the proposed methodology is the combined use of quantitative indicators and dynamic 3D computer simulation. The visual impact of a WP installation is determined, through the comparative consideration of the quantitative and qualitative results. The proposed methodology simulates the changes after the WP installation realistically and calculates the grade of the visual impact, and was applied to a WP in the prefecture of Chania, Crete. © 2014 Elsevier Ltd.

Kontogianni, A., et al. (2014). "Planning globally, protesting locally: Patterns in community perceptions towards the installation of wind farms." *Renewable Energy* 66: 170-177.

The evidence is compelling that extended use and production of energy are globally responsible for the serious deterioration of physical environment and climate change. The further penetration of renewable energy sources (RES) emerges as a crucial factor contributing to the mitigation of global warming. Within this framework wind energy is expected to have a leading role for Greece's compliance with the EU environmental targets of 2020. However, the installation of wind parks in specific regions with high wind potential is seriously constrained by the reaction of local communities. Using a survey the present research dissects public acceptance for existing and proposed wind farms in the region of Southern Evia, Greece. Results indicate an overall support for wind energy and confirm the growing inconvenience with NIMBYism, especially in areas with existing wind parks in operation, as a theoretical framework explaining resistance to planned wind energy investments. By contrasting self-reported ex ante- and ex post-perceptions of impacts and benefits we highlight the role of experience in community acceptance of wind energy installations. Our statistical models prescribe the profile of those most probably in favour of existing installations, new installations in other parts of Evia or new installations elsewhere in Greece. Finally, we introduce the 'Not-In-My-Front-Yard' (NIMFY) syndrome suggesting that the impact of visibility on public acceptance is far from being a simple concept as it is linked to both a physical landscape context and socio-economic parameters. © 2013 Elsevier Ltd.

Krahé, D. (2012). What makes low-frequency noise annoying? C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

People suffering from low-frequency noise (LFN) are not seldom living in otherwise quite areas e.g. without traffic noise. They are annoyed at levels near or even significantly below the hearing threshold given in regulations and standards. Another specific characteristic of LFN seems to be the directly mental impact causing e.g. frustration, anxiety, nervousness and sleeplessness. An explanation could be a stimulation of physiological processes in the nervous system, where the stimulation covers the frequency range of brain waves. Investigations were done to support this assumption. Different stimuli are assessed in listening test and processed by an auditory model. In both cases, stimuli with a strong concentration on the low-frequency range are found out as more critical. The auditory model shows distinctive time patterns of the spikes on the nerve fibers in this situation. Measurements done at and in the home of complainants revealed LFN of this critical character often. A recent investigation was recording EEGs from complainants under laboratory condition with different kind of stimuli. It is in the discussion, in which way the EEGs reflect the directly mental impact of LFN.

Krekel, C. and A. Zerrahn (2017). "Does the presence of wind turbines have negative externalities for people in their surroundings? Evidence from well-being data." Journal of Environmental Economics and Management **82**: 221-238.

Throughout the world, governments foster the deployment of wind power to mitigate negative externalities of conventional electricity generation, notably CO₂ emissions. Wind turbines, however, are not free of externalities themselves, particularly interference with landscape aesthetics. We quantify these negative externalities using the life satisfaction approach. To this end, we combine household data from the German Socio-Economic Panel Study (SOEP) with a novel panel dataset on over 20,000 installations. Based on geographical coordinates and construction dates, we establish causality in a difference-in-differences design. Matching techniques drawing on exogenous weather data and geographical locations of residence ensure common trend behaviour. We show that the construction of wind turbines close to households exerts significant negative external effects on residential well-being, although they seem both spatially and temporally limited, being restricted to about 4000 m around households and decaying after five years at the latest. Robustness checks, including view shed analyses based on digital terrain models and placebo regressions, confirm our results. © 2016 Elsevier Inc.

Krogh, C. M. E., et al. (2012). Wind turbine noise perception, pathways and effects: A case study C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

In Ontario Canada wind turbines are being sited close to humans. Wind turbine noise is perceived to be more annoying than other equally loud sources of sound. This annoyance can contribute to stress related health impacts. An Ontario government commissioned report concludes a nontrivial percentage of exposed persons will be impacted. Our research documents some Ontarians living in the environs of wind turbines report experiencing physiological and psychological symptoms, reduced quality of life, degraded living conditions, and adverse social economic impacts including a loss of social justice. In

some cases the effects resulted in families abandoning their homes. Others have negotiated financial agreements with wind energy developers. An Ontario Environmental Tribunal considered a wide body of evidence including expert witness testimony and found that wind turbines can harm humans if placed too close to residents. Peer reviewed literature, case reports, freedom of information documents and expert testimony will be presented which support the conclusion that noise perception via the indirect pathway can result in serious negative effects.

Krogh, C. M. E., et al. (2012). Annoyance can represent a serious degradation of health: Wind turbine noise a case study C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012.

41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

Annoyance is often discounted as a health concern. Wind turbine noise is perceived to be more annoying than other equally loud sources of sound. The Ontario government commissioned a report which concludes a non-trivial percentage those exposed to wind turbine sound will be highly annoyed which can be expected to contribute to stress related health impacts. Our research in Ontario, Canada documents some individuals living in the environs of wind turbines report experiencing physiological and psychological symptoms, reduced quality of life, degraded living conditions, and adverse social and economic impacts. Some families have abandoned their homes or negotiated financial agreements with wind energy developers. An Ontario Environmental Review Tribunal considered a wide body of evidence including expert testimony and found wind turbines can harm humans if placed too close to residents. Evidence including peer reviewed literature, case reports, freedom of information documents and expert testimony are presented which support the conclusion that annoyance can represent a serious degradation of health.

Kurpas, D., et al. (2013). "Health impact of wind farms." Ann Agric Environ Med **20**(3): 595-604.

INTRODUCTION AND OBJECTIVE: Wind power is employed worldwide as an alternative source of energy. At the same time, however, the health effects of wind turbines have become a matter of discussion. The purpose of this study is a critical review of available reports providing arguments both for and against the construction of wind farms. The authors also attempt to propose recommendations in accordance with the Evidence-Based Medicine (EBM) guidelines. In the case of exposure to wind farms, a randomized controlled trial (RCT) is impossible. To obtain the highest-level recommendations, analysis of case-control studies or cohort studies with control groups should be performed. Preferably, it should include geostatistical analysis conducted with the use of variograms and the kriging technique. Combinations of key words were entered into the Thomson Reuters Web of Knowledge (SM) and the Internet search engine Google. SHORT DESCRIPTION OF STATE OF THE ART: The nuisance caused by wind turbines is stereotypically linked with the noise that they produce. Nevertheless, the visual aspect of wind farms, opinions about them, and sensitivity to sound seem to be of the greater importance. To date, the direct correlations between the vicinity of modern wind farms, the noise that wind turbines make, and possible consequences to health have not been described in peer reviewed articles. Health effects are more probably associated with some environmental factors leading to annoyance or frustration. All types of studies share the same conclusion: wind turbines can provoke annoyance. As with any project involving changes in the local environment, a certain level of irritation among the population can be expected. There are elected officials and government representatives who should decide what level of social annoyance is acceptable, and whether wind power advantages outweigh its potential drawbacks. The influence of wind turbines on human emotional and physical health is a relatively new field of research. Further analyses of these issues are justified, especially because none of the studies published in peer-reviewed journals so far meet the criteria for cohort or case-control studies.

SUMMARY: Due to methodology, currently available research results do not allow for higher than C-level recommendations. In the case of wind farms, the ideal types of research would be: a retrospective observation of a particular group of residents before and after the wind farm construction, case-control studies or cohort studies with control groups matched in respect of socioeconomic factors, predisposition for chronic diseases, exposure to environmental risk factors, and only one variable which would differentiate cases from controls--the distance between place of residence and a wind farm.

Labussi re, O. and A. Nada i (2015). Wind power landscapes in France: Landscape and energy decentralization. Renewable Energies and European Landscapes: Lessons from Southern European Cases: 81-94.

In 2000, at the dawn of the adoption of the EU Directive on renewable energy, a green-red alliance opened a political window for the emergence of a genuine wind power policy in France. Yet today, after

more than 10 years of one of the highest feed-in tariffs in the world, the installed capacity in France is still low. Wind power, if it is to be developed at any significant level, has to fight against the centralization of both French energy policy and landscape protection. In this context, the landscape processes, which take place when wind power is either planned or sited at the local level through open governance, are places and occasions for institutional and social innovation that contribute to building decentralization. This chapter examines the ways in which wind power development has raised tensions over the centralization of both energy and landscape policy in France. © Springer Science+Business Media Dordrecht 2015.

Ladenburg, J. (2009). "Visual impact assessment of offshore wind farms and prior experience." *Applied Energy* 86(3): 380-387.

Energy planners have shifted their attention towards offshore wind power generation and the decision is supported by the public in general, which in the literature has a positive attitude towards offshore wind generation. However, globally only a few offshore wind farms are operating. As more wind farms start operating and more people become experienced with especially the visual impacts from offshore wind farms, the public positive attitude could change if the experienced impacts are different from the initially perceived visual interference. Using a binary logit model, the present paper investigates the relation between different levels of prior experience with visual disamenities from offshore wind farms and perception of visual impacts from offshore wind farms. The differences in prior experience are systematically controlled for sampling respondents living in the areas close to the large scale offshore wind farms Nysted and Horns Rev and by sampling the a group of respondents representing the Danish population, which has little experience with offshore wind farms. Compared to previous results in the literature, the present paper finds that perception of wind power generation is influenced by prior experience. More specifically, the results show that people with experience from offshore wind farms located far from the coast have a significant more positive perception of the visual impacts from offshore wind farms than people with experience from wind farms located closer to the coast. These results are noteworthy on two levels. First of all, the results show that perceptions of offshore wind generation are systematically significantly influenced by prior experience with offshore wind farms. Secondly, and in a policy context, the results indicate that the future acceptance of future offshore wind farms is not independent of the location of existing and new offshore wind farms. This poses for caution in relation to locating offshore wind farms too close to the coast. © 2008 Elsevier Ltd. All rights reserved.

Ladenburg, J. and J. O. Dahlgaard (2012). "Attitudes, threshold levels and cumulative effects of the daily wind-turbine encounters." *Applied Energy* 98: 40-46.

An imperative factor in the identification of suitable wind-turbine locations and the subsequent development thereof is the general acceptance of the proposed wind turbines. In this perspective, the existing number of turbines is expected to be a driver of attitude. However, to date only a few studies have assessed the influence of the turbine density in the residential area has on attitude. The present paper sheds light on this issue and finds that attitude towards existing turbines is negatively related with the number of turbines encountered on a daily basis. If the respondents see more than five on-land turbines, they are less positive. However, conditional of seeing more than five turbines a day, opposition does not increase with increasing turbine encounters. These results suggest that the general long-run threshold for opposition towards wind turbines is five turbine encounters per day. © 2012 Elsevier Ltd.

Ladenburg, J. and B. Möller (2011). "Attitude and acceptance of offshore wind farms - The influence of travel time and wind farm attributes." *Renewable and Sustainable Energy Reviews* 15(9): 4223-4235.

Generally people are more positive towards offshore wind farms compared to on-land wind farms. However, the attitudes are commonly assumed to be independent of experience with wind farms. Important relations between attitude and experience might therefore be disregarded. The present paper gives a novel contribution to this field. First of all, we give a thorough review of the studies that have analysed the relation between experience with wind turbines and attitude. In addition, we supplement the review by analysing the effect of travel distance to the nearest offshore wind farm and the wind farms attributes on attitude towards offshore wind farms. The results point towards that the travel time and the attributes of the nearest offshore wind farm influence the attitude significantly. Travel time has mixed effects on the attitude, whilst offshore wind farms with many turbines generate more positive attitudes compared to wind farms with fewer turbines. © 2011 Elsevier Ltd. All rights reserved.

Ladenburg Jacob, J. (2010). "Attitudes towards offshore wind farms-The role of beach visits on attitude and demographic and attitude relations." *Energy Policy* **38**(3): 1297-1304.

Presently, less than a handful of papers have analysed the attitude towards offshore wind farms in a population living in an area with offshore wind farms. This leaves the experience-based attitude and demographic relations analysis relatively unexplored. The present studies aims at covering some of that seemingly uncharted territory by analysing attitudes from a sample of more than 1000 respondents. Applying an Ordered Probit Model, the results show general positive attitudes towards offshore wind farms and that the attitude formation seems to be a function of the gender, income, level of education, visit frequency and type of visit to the beach and the view to on-land turbines from the residence. Interestingly and perhaps the most interesting results, the observed relations between demographics and attitude are found to be dependent on the type and frequency of usage of the beach among the respondents. Attitudes towards offshore wind farms and demographic associations are thus found to be more evident in the case that respondents do use not the beach for walking on a relatively frequent basis but much weaker if the respondent use the beach on a frequent basis. However, these results are sensitive to the type of beach usage. This suggests that attitude formation towards offshore wind farms appear to be dependent on a combination of the type and frequency of use of the beach. To the author's knowledge these findings are novel, as such relation has not yet been identified in the literature. As such, the results shed light on a new angle in both the literature focusing on the opposition formation towards wind power projects in general and offshore wind farms in particular. © 2009 Elsevier Ltd.

Langbroek, M. and F. Vanclay (2012). "Learning from the social impacts associated with initiating a windfarm near the former island of Urk, The Netherlands." *Impact Assessment and Project Appraisal* **30**(3): 167-178.

The social impacts of the planned windfarm 'Windpark Noordoostpolder' on the village of Urk are considered. Generating 190 megawatts (MW) when operational, the windfarm will be the largest in the Netherlands. Urk residents will experience a variety of negative impacts including a reduction in the aesthetic quality of their landscape, and their community identification and place attachment will be affected. The windfarm will also reduce leisure and recreation opportunities. While construction of the windfarm will arguably increase options for economic prosperity and employment, these benefits will flow to temporary construction workers who will likely come from elsewhere, and who will themselves be a cause of negative social impact and potential harm to the Urk community given its particular social characteristics as a fishing village and conservative religious community. Now part of the mainland, Urk is a former island and retains a strong independent identity and a sense of islandness. The windfarm project has generated strong feelings and has mobilized community action against the project. With their appeal rejected, the Urk community feels betrayed and considers that their concerns have not been taken seriously. © 2012 Copyright IAIA.

Langer, K., et al. (2016). "A qualitative analysis to understand the acceptance of wind energy in Bavaria." *Renewable and Sustainable Energy Reviews* **64**: 248-259.

Acceptance plays an important role in the successful adoption of wind energy technology. This article identifies factors influencing the acceptance of wind energy and selects those factors which have the highest relevance for wind energy acceptance in Bavaria. We decided to analyze the Federal State of Bavaria in Germany as its current policy governance decelerates the building-up of wind turbines in this federal state. Using a qualitative approach, the results indicate that the perception of political processes, such as the recent enacting of the 10-H regulation in Bavaria, influences the acceptance towards wind energy, as trust and transparency in political processes are essential. In addition, the paper reveals the importance of the distributive justice, focusing in particular on the subitem envy, which can be considered on a neighboring or regional level. Additionally it reveals additional factors which are relevant for wind energy acceptance in the specific case of the analyzed federal state. © 2016 Elsevier Ltd.

Large, S. and M. Stigwood (2014). *The noise characteristics of 'compliant' wind farms that adversely affect its neighbours*. INTERNOISE 2014 - 43rd International Congress on Noise Control Engineering; Improving the World Through Noise Control.

In the UK many wind farms cause complaints of noise despite complying with control limits. Problems relate to reliance on the LA90 index, failure to consider or apply ratings on the context of the sound characteristics and actual human responses due to complex characteristics. In general in the UK low frequency and very low frequency sound effects are either ignored or denied. The complex

interrelationship of features within this noise and difficulties in quantifying and qualifying noise impact and inappropriate comparison with other sources of noise renders the effects difficult to investigate or quantify with contradictory outcomes possible using the same data sets. Claim and counterclaim of health and adverse effects complicate the analysis. This paper explores some of the interrelating characteristics of wind farm noise measured and observed in the field that appear to influence complaints made by communities. Cumulative effects occurring in environments normally dominated by natural sounds and both audible and inaudible elements remain alien sounds which are not habituated to. It appears that sensitisation arises. The physical reason for the failure to appropriately identify modulating noise effects and in particular low frequency modulating noise problems are explored.

Larsson, C. and O. Ohlund (2014). "Amplitude modulation of sound from wind turbines under various meteorological conditions." *J Acoust Soc Am* **135**(1): 67-73.

Wind turbine (WT) sound annoys some people even though the sound levels are relatively low. This could be because of the amplitude modulated "swishing" characteristic of the turbine sound, which is not taken into account by standard procedures for measuring average sound levels. Studies of sound immission from WTs were conducted continually between 19 August 2011 and 19 August 2012 at two sites in Sweden. A method for quantifying the degree and strength of amplitude modulation (AM) is introduced here. The method reveals that AM at the immission points occur under specific meteorological conditions. For WT sound immission, the wind direction and sound speed gradient are crucial for the occurrence of AM. Interference between two or more WTs could probably enhance AM. The mechanisms by which WT sound is amplitude modulated are not fully understood.

Le Floch, S. (2011). "Neighbour, citizen and local inhabitant: Three characters engaged in wind turbine turbulence." *Natures Sciences Societes* **19**(4): 344-354.

Participation has become a consensual objective. It has been inscribed in different international and national regulatory texts-Rio Summit, Aarhus Convention, French 1995 Environmental Law-and generates a mass of academic work. Nonetheless, existing scientific literature deals little with the categories of "public" involved in the different modes of participation. This paper is based upon the assertion that improved participation requires greater in-depth definition of the targeted public. On the basis of empirical work dealing with social contestation about windfarms, the paper examines the different participating characters and their related spaces as perceived by public and private actors engaged in the development of wind energy production: the diversely defined neighbour-the neighbour as owner, the "oversensitive" neighbour; the (rarely mentioned) citizen; and the emerging local inhabitant. The promises and dangers of this emerging character are discussed: could there be a place in participation for the local inhabitant as a geographical human being-one whose experience of the environment matters, conceived as including both socio-political and sensitive dimensions-, in the current context where primacy is given to private spaces and where a new model of citizenship is created, based no longer on associative forms of interaction but on the right to be left alone and on the right to exclude (Mitchell, 2005)? © 2012 NSS-Dialogues, EDP Sciences.

Lee, S., et al. (2011). "Annoyance caused by amplitude modulation of wind turbine noise." *Noise Control Engineering Journal* **59**(1): 38-46.

A listening test has been performed to investigate the relationship between human annoyance and the amplitude modulation of wind turbine noise. To obtain sound samples for the listening test, sound from a 1.5 MW wind turbine in Korea was recorded. The strength of the amplitude modulation of the sound samples was defined in terms of the modulation depth spectrum, which was approximated by assuming that the sound samples are sinusoidally amplitude-modulated. The stimuli for the listening tests were created by reducing the modulation depth spectrum of the sound samples. A total of 30 participants were involved in the listening tests. The results of the listening tests indicate that the equivalent sound level and the amplitude modulation of wind turbine noise both significantly contribute to noise annoyance. © 2011 Institute of Noise Control Engineering.

Lee, S., et al. (2013). "Numerical modeling of wind turbine aerodynamic noise in the time domain." *J Acoust Soc Am* **133**(2): EL94-100.

Aerodynamic noise from a wind turbine is numerically modeled in the time domain. An analytic trailing edge noise model is used to determine the unsteady pressure on the blade surface. The far-field noise due to the unsteady pressure is calculated using the acoustic analogy theory. By using a strip theory approach, the two-dimensional noise model is applied to rotating wind turbine blades. The numerical

results indicate that, although the operating and atmospheric conditions are identical, the acoustical characteristics of wind turbine noise can be quite different with respect to the distance and direction from the wind turbine.

Leibenath, M. and A. Otto (2013). "Local debates about 'landscape' as viewed by German regional planners: Results of a representative survey in a discourse-analytical framework." *Land Use Policy* **32**: 366-374.

The word 'landscape' has attracted increasing attention from both researchers and practitioners in recent years. Although much has been written about the meanings of 'landscape', little is yet known about local landscape discourses in Germany. The article gives an overview of local debates in which 'landscape' plays a role and introduces a framework for studying the discursive constitution of landscapes. The empirical part is based on a comprehensive telephone survey among representatives of regional planning agencies. Among the key findings is that wind energy and regional development seem to be the most frequent subjects of landscape-related debates at the local level - particularly in the southern states of Bavaria and Baden-Wuerttemberg, where comparably few renewable energy facilities have so far been installed. The article concludes with an outlook on how the survey might be used in further discourse analytical studies. © 2012 Elsevier Ltd.

Lenchine, V. V. (2009). "Amendment for wind farms environmental noise guidelines." *Acoustics Australia* **37**(1): 24-25.

The South Australian Environment Protection Authority (SA EPA) is aimed to help developers, planning and governmental authorities, and the general community for evaluating the noise impact from wind farms. The State Strategic Plan is promoting the use of renewable energy sources and development of regulations and guidelines to prevent excessive noise. The government is also working to issue or update regulation related to wind farm noise and various working groups have presented a draft Australia standard and updated New Zealand Standard for this purpose. Calculation of the wind farm noise can be performed by correction for the reference point sound pressure level (SPL) method. Noise modeling software can also be used to predict wind farm noise using different algorithms. Some experts say that the ISO-9613-2 procedure can provide accurate results for predicting noise impact from the wind farms.

Lenchine, V. V. (2012). Variations in sound pressure levels under random change of atmospheric conditions C3 - Australian Acoustical Society Conference 2012, Acoustics 2012: Acoustics, Development, and the Environment. Conference on Australian Acoustical Society 2012: Acoustics, Development, and the Environment, Acoustics 2012, Fremantle, WA.

Variations in sound power of many environmental noise sources have certain limits. Changes in the environmental conditions also evoke deviations in the measured sound pressure levels within certain boundaries. A span of the possible changes in the noise levels associated with a particular noise source is normally less for consequent time intervals. Its limits can be established from feasible changes of atmospheric conditions and sound power of the source. Measured sound pressure levels (SPLs) of a noise source represent a sequence of probable magnitudes that vary within certain limits. In some cases, variations of the SPLs can be treated as a Markov chain and respectively be explored using statistical methods. It is shown that under certain assumptions the random noise contribution variations tend to be periodic. Conclusions about character of signal from source of interest can be obtained from measurements when the source controls the total noise. Information about the SPLs variations can be utilised for data analysis aiming to calculate noise contribution from a particular noise source. Analysis of data pertained to monitoring of wind farm noise is considered as a case study. The suggested technique can be engaged to extract wind farm noise from SPL logging data without employment of special instruments or excessively complex procedures. If necessary, it can be adopted for other applications.

Leventhall, G. (2013). Infrasound and the ear. Proceedings 5th International.

Leventhall, G. and D. Bowdler (2011). Wind Turbine Noise: how it is produced, propagated measured and received, Multi-Science Publishing, Brentwood, UK.

Licitra, G., et al. (2015). Sensitivity analysis of modelling parameters in wind turbine noise assessment procedure. 22nd International Congress on Sound and Vibration, ICSV 2015.

In 2013 the Italian Institute for Environmental Protection and Research (ISPRA), in cooperation with the Environmental Protection Agency of Tuscany Region (ARPAT), published a new methodology for the assessment of noise impact of wind farms. The procedure estimates the emissive and the residual components of noise, also when the residual noise is mainly generated by wind, measured through measurement campaigns of noise and weather parameters at the receiver for at least 3 weeks. Through iterative steps, the method returns the evaluation of noise impact produced by wind farms, without stopping the farm for measuring the residual noise. The method has been successfully tested through specific measurement campaigns in some Italian sites with different orography conditions, but a proper uncertainty analysis has not been performed yet. Some specific numerical values to be assigned to the parameters for the calculation of noise propagation are involved in the procedure. The paper presents the sensitivity analysis of a key parameter, N_{eq} , aiming to establish the influence that a variation of a specific input of the procedure has on the final results. This analysis will allow a better understanding of which procedure parameters require more accuracy and will help reducing the uncertainties of the noise impact prediction.

Lindén, A., et al. (2015). "Community attachment and municipal economy: Public attitudes towards wind power in a local context." *Environmental Science and Policy* **54**: 10-14.

This study examines public attitudes towards wind power through two hypotheses. The community attachment hypothesis states that people living in small municipalities are more likely to display NIMBYism (Not-In-My-BackYard) or have a more negative attitude. According to the economic trouble hypothesis people living in municipalities with weak economy are less likely to display NIMBYism or have a more positive attitude. Using a combination of survey data from Finland ($n = 3459$) and municipality-level statistics we find some support for both hypotheses. Compared to females, males display less NIMBYism and have more negative general attitude towards wind power. While older respondents also display less NIMBYism, they have a more positive general attitude towards wind power. Our results suggest two things. First, it seems that the average attitude and NIMBYism are both valuable aspects of public opinion, providing separate information, and potentially supporting different hypotheses. Whenever possible, they should be investigated in parallel. Secondly, future research should place more emphasis on community-level indicators in order to capture the impact of local context on attitudes towards environmental issues.

Lindén, A., et al. (2015). "Community attachment and municipal economy: Public attitudes towards wind power in a local context." *Environmental Science and Policy* **54**: 10-14.

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Liu, C. S., et al. (2016). "Occupational noise frequencies and the incidence of hypertension in a retrospective cohort study." *American Journal of Epidemiology* **184**(2): 120-128.

Occupational noise exposure is associated with cardiovascular disease, but little is known about the contributions of noise frequency components. This retrospective study investigated the relationship between exposure to different noise frequencies and the incidence of hypertension. A cohort of 1,002 volunteers from 4 machinery and equipment manufacturing companies in Taichung, Taiwan, was followed from 1973 to 2012. Personal noise measurements and environmental octave-band analyses were performed to divide subjects into different exposure groups. Cox regression models were used to estimate the relative risk of hypertension. Participants exposed to ≥ 80 A-weighted decibels (dBA) over 8 years had a higher relative risk of hypertension (relative risk = 1.38, 95% confidence interval: 1.02, 1.85) compared with those exposed to < 75 dBA. Significant exposure-response patterns were observed

between incident hypertension and stratum of noise exposure at frequencies of 250 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz. The strongest effect was found at 4 kHz; a 20-dBA increase in noise exposure at 4 kHz was associated with a 34% higher risk of hypertension (relative risk = 1.34, 95% confidence interval: 1.01, 1.77). Occupational noise exposure may be associated with an increased risk of hypertension, and the 4 kHz component of occupational noise exposure may have the strongest relationship with hypertension.

Liu, D., et al. (2016). "Resident acceptance of wind farms - An emerging tourism market in China." Journal of Hospitality and Tourism Management **27**: 1-3.

The concept of analyzing images captured by tourists before, during, and after a tourism experience is not something new to the field of tourism. Now for over forty years, the power of images captured prior to, as well as formulated during and post-event, have been associated with an individual's destination selection process (Gartner, 1994). This study conducted in China reviewed tourist blog posts which included photos posted to Baidu.com. The content analysis of the posted photographs and corresponding statements yielded four type of tourists: educational tourists, holiday tourist, romantic tourist, and nature tourist. Given the presence of these preliminary findings it appears that governmental tourism marketing activities should include wind farming as part of their national campaign. © 2015 The Authors.

Liu, D., et al. (2016). "Chinese domestic tourist perceptions of wind farms experiences." Journal of Sustainable Tourism **24**(11): 1569-1583.

Wind farm complexes have grown in popularity as a form of energy tourism, but to date there is a paucity of research that addresses tourist perceptions of wind farms as a form of special interest tourism (i.e. energy tourism). The scope of this study concentrated on determining and statistically profiling domestic tourists' perceptions of wind farm complexes for energy tourism purposes. As such, this study applies grounded theory as a means of interpreting domestic tourist perceptions of their lived wind farm experiences. By means of a qualitative research design, the researchers discovered that domestic Chinese tourists found their wind farm experiences were typified by interests in sustainability energy, exposure to differing local cultures, the science surrounding wind turbine technology and personal enrichment associated with the sharing of wind farm experiences with family and friends. The primary implication of this study calls for the deployment of collaborative interagency policies which promote wind farming as part of the government's overall sustainable energy platform while also supporting energy tourism as a means of personal enrichment and a form of economic development. © 2016 Informa UK Limited, trading as Taylor & Francis Group.

Liu, P. and C. Y. Barlow (2016). The environmental impact of wind turbine blades. IOP Conference Series: Materials Science and Engineering.

The first generation of wind turbine (WT) blades are now reaching their end of life, signalling the beginning of a large problem for the future. Currently most waste is sent to landfill, which is not an environmentally desirable solution. Awareness of this issue is rising, but no studies have fully assessed the eco impact of WT blades. The present study aims to provide a macroscopic quantitative assessment of the lifetime environmental impact of WT blades. The first stage has been to analyse global data to calculate the amount of WT blade materials consumed in the past. The life cycle environmental impact of a single WT blade has then been estimated using eco data for raw materials, manufacturing processes, transportation, and operation and maintenance processes. For a typical 45.2 meter 1.5 MW blade this is 795 GJ (CO2 footprint 42.1 tonnes), dominated by manufacturing processes and raw materials (96% of the total). Based on the 2014 installed capacity, the total mass of WTB is 78 kt, their energy consumption is 82 TJ and the carbon dioxide footprint is 4.35 Mt. These figures will provide a basis for suggesting possible solutions to reduce WTB environmental impact. © Published under licence by IOP Publishing Ltd.

Lombard, A. and S. Ferreira (2014). "Residents' attitudes to proposed wind farms in the West Coast region of South Africa: A social perspective from the South." Energy Policy **66**: 390-399.

The West Coast Region (WCR) of the Western Cape Province in South Africa is earmarked for 13 onshore wind farm projects totaling approximately 700 wind turbines. The developed world debate about the social acceptance of wind farm projects has impeded and illuminated a number of these developments. This paper is aimed at understanding people's reaction to proposed wind farm projects in the WCR - a region of a developing country - and to investigate whether the reasoning behind

opposition to or acceptance of wind farm projects is similar to the discourse on the topic by scholars in the developed world. Quantitative and qualitative methods were used to collect primary data by semi-structured interviews and a questionnaire survey. A spatial dimension was added through a map-based approach. Reactions by WCR residents to the wind farm projects were mainly positive, although some opposition was detected. International scholarship holds that place attachment serves as a reason for opposition to wind farm projects. Although most of the WCR residents had strong place attachments to their region, most of the respondents also supported the proposed wind farm projects. © 2013 Elsevier Ltd.

Madsen, H. A. (2010). "Low frequency noise from wind turbines mechanisms of generation and its modelling." *Journal of Low Frequency Noise Vibration and Active Control* **29**(4): 239-251.

The objective of the present paper is to present an overview of LFN characteristics of modern MW turbines based on numerical simulations. Typical sizes of modern turbines are from 1-3 MW nominal generator power and a rotor diameter ranging from 80-100 m but larger prototypes up to 5 MW and with a rotor diameter of 126 m have now been installed. The numerical investigations comprise the common upwind rotor concept but also the turbines with a downwind rotor are considered. The reason to include the downwind rotor concept is that this turbine design has some advantages which could lead to future competitive designs compared with the upwind threebladed rotor. The simulation package comprises an aeroelastic time simulation code HAWC2 and an acoustic low frequency noise (LFN) prediction model. Computed time traces of rotor thrust and rotor torque from the aeroelastic model are input to the acoustic model which computes the sound pressure level (SPL) at a specified distance from the turbine. The influences on LFN on a number of turbine design parameters are investigated and the position of the rotor relative to the tower (upwind or downwind rotor) is found to be the most important design parameter. For an upwind rotor the LFN levels are so low that it should not cause annoyance of neighbouring people. Important turbine design parameters with strong influence on LFN are the blade tip speed and the distance between rotor and tower.

Maehr, A. M., et al. (2015). "Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape." *Landscape and Urban Planning* **142**: 71-79.

Social acceptance for wind turbines is variable, providing a challenge to the implementation of this energy source. Psychological research could contribute to the science of climate change. Here we focus on the emotional responses to the visual impact of wind turbines on the landscape, a factor which dominates attitudes towards this technology. Participants in the laboratory viewed images of turbines and other constructions (churches, pylons and power-plants) against rural scenes, and provided psychophysiological and self-report measures of their emotional reactions. We hypothesised that the emotional response to wind turbines would be more negative and intense than to control objects, and that this difference would be accentuated for turbine opponents. As predicted, the psychophysiological response to turbines was stronger than the response to churches, but did not differ from that of other industrial constructions. In contrast with predictions, turbines were rated as less aversive and more calming compared with other industrial constructions, and equivalent to churches. Supporters and non-supporters did not differ significantly from each other. We discuss how a methodology using photo manipulations and emotional self-assessments can help estimate the emotional reaction to the visual impact on the landscape at the planning stage for new wind turbine applications. © 2015 Elsevier B.V.

Maffei, L., et al. (2013). "The effects of vision-related aspects on noise perception of wind turbines in quiet areas." *Int J Environ Res Public Health* **10**(5): 1681-1697.

Preserving the soundscape and geographic extension of quiet areas is a great challenge against the wide-spreading of environmental noise. The E.U. Environmental Noise Directive underlines the need to preserve quiet areas as a new aim for the management of noise in European countries. At the same time, due to their low population density, rural areas characterized by suitable wind are considered appropriate locations for installing wind farms. However, despite the fact that wind farms are represented as environmentally friendly projects, these plants are often viewed as visual and audible intruders, that spoil the landscape and generate noise. Even though the correlations are still unclear, it is obvious that visual impacts of wind farms could increase due to their size and coherence with respect to the rural/quiet environment. In this paper, by using the Immersive Virtual Reality technique, some visual and acoustical aspects of the impact of a wind farm on a sample of subjects were assessed and analyzed. The subjects were immersed in a virtual scenario that represented a situation of a typical rural outdoor scenario that they experienced at different distances from the wind turbines. The influence of

the number and the colour of wind turbines on global, visual and auditory judgment were investigated. The main results showed that, regarding the number of wind turbines, the visual component has a weak effect on individual reactions, while the colour influences both visual and auditory individual reactions, although in a different way.

Maffei, L., et al. (2013). A preliminary investigation on some psychological and acoustic aspects of wind farms' noise annoyance C3 - 42nd International Congress and Exposition on Noise Control Engineering 2013, INTER-NOISE 2013: Noise Control for Quality of Life, 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, Innsbruck, OAL-Osterreichischer Arbeitsring fur Larmbekampfung.

In the last years the global installed capacity of the renewable energy grew at very rapid rates. Among renewable energy wind energy is one of the typologies with the most significant growth. However the Wind Farms (WF) entail environmental impact problems specially on people. The major reasons of complaints are the acoustic and visual impact. Recent researches have concluded that noise annoyance from WFs was higher than from several other noise sources at comparable noise levels. Even though the sound levels, as heard by resident, are generally lower than 50 dB(A), many people oppose to WF concluding that they have health problems caused directly by wind turbines. In quiet environments the wind blowing is one of the main sound for inhabitants and its semantic content still exist when we consider the wind turbine noise. Wind turbine noise coexist with wind noise and their relative masking changes according to the functioning conditions. In these conditions it is very difficult to establish if the complaints of residents are due to physical rather than psychological origin. In this paper are presented the preliminary results of an auditory test in which two groups of subjects, with chronic and no-chronic exposure to wind turbine noise, have been asked to recognize, by a YES/NO questionnaire, the noise of these plants.

Maffei, L., et al. (2015). Investigation on the perception of wind turbine noise for chronic and non-chronic subjects. 22nd International Congress on Sound and Vibration, ICSV 2015.

In spite of the important contribute to the reduction of CO2 emission of last decades, the wind farms are often considered responsible to generate other types of emissions. The most important is the noise. It is radiated by mechanical interaction of the wind turbine components and by aerodynamic interaction of the air flow over the blades. To be cost-effective, these plants should be installed in areas with specific wind conditions over long periods of the year. In most cases these areas are rural areas, where the population density is very low but where the environment value, specially the sonic one, is very relevant for residents. Previous researches have demonstrated that despite the sound levels caused by wind turbines at the receivers are generally of low magnitude, this kind of noise is considered as more annoying than the one of other noise sources (e.g. traffic noise, railway noise). Others study have underlined how both physical aspects (e.g. acoustic, visuals) and individual aspects (e.g. psychological, socio-economics, politic) can modify the perception of the wind turbines noise. In this paper are presented the results of an auditory test on the perception of wind turbines noise for two different groups of subjects. The first group, called "chronic", composed by people living by long time in the vicinity of wind turbines and the second group, called "non-chronic", composed by subjects who have never been exposed nor have experienced before the wind turbines noise. The test was presented in 4 different spatial regions (Zones) moving away from the source. The results showed a significant difference between the groups, with the chronic group who reported a wind turbine noise recognition rate, always higher than non chronic.

Maffei, L., et al. (2015). "Auditory recognition of familiar and unfamiliar subjects with wind turbine noise." Int J Environ Res Public Health **12**(4): 4306-4320.

Considering the wide growth of the wind turbine market over the last decade as well as their increasing power size, more and more potential conflicts have arisen in society due to the noise radiated by these plants. Our goal was to determine whether the annoyance caused by wind farms is related to aspects other than noise. To accomplish this, an auditory experiment on the recognition of wind turbine noise was conducted to people with long experience of wind turbine noise exposure and to people with no previous experience to this type of noise source. Our findings demonstrated that the trend of the auditory recognition is the same for the two examined groups, as far as the increase of the distance and the decrease of the values of sound equivalent levels and loudness are concerned. Significant differences between the two groups were observed as the distance increases. People with wind turbine noise experience showed a higher tendency to report false alarms than people without experience.

Magari, S. R., et al. (2014). "Evaluation of community response to wind turbine-related noise in western New York state." *Noise Health* **16**(71): 228-239.

As the boundaries of harvesting wind energy expand to meet the ever-increasing societal energy demands, the number and size of wind turbines being constructed rises. As part of a larger project to monitor sound in an operating wind park in western New York State, a cross-sectional survey was conducted among individuals living in and around the wind park to characterize the perception, level of annoyance, and self-reported health effects of residents. We conducted the study in a 126 MW wind park consisting of 84 turbines spanning approximately 19 square miles of farmland. Short-term outdoor and indoor sound level measurements were also performed at each dwelling in which a questionnaire was administered. To our knowledge, this study is the first to collect sound measurements at individual residences. There was no apparent exposure-response relationship between an individual's level of annoyance and the short duration sound measurements collected at the time of the survey. There was a correlation between an individual's concern regarding health effects and the prevalence of sleep disturbance and stress among the study population. The siting process is unique to each community with varying degrees of success. Additional sound level measurements inside and outside homes in larger cohorts in concert with detailed questionnaires would be useful in verifying those exposure-response relationships found in studies using calculated sound level data. Additional research should include a detailed investigation of sleep patterns and possible disturbance in those living in and near operating wind turbine projects.

Manchado, C., et al. (2015). "A review on the Spanish Method of visual impact assessment of wind farms: SPM2." *Renewable and Sustainable Energy Reviews* **49**: 756-767.

This work offers a review of the so-called Spanish Method for the visual impact assessment of wind farms. The five coefficients originally proposed in the method have been analysed and discussed from several approaches: validity, efficiency, limitations and need of actualisation, among others. As a result, we establish a set of new proposals that update or modify the definition or calculation of these coefficients, but always trying to retain their original meaning. The work is complemented by a short case study in which we compare the values of the coefficients of the original Spanish Method with those arisen from our new proposal. The difference is often relevant, both in the numerical value of the coefficients and in the improvement of their ability to describe the visual effect. Finally, the new formulation of the Spanish Method opens a possibility for the public participation in several moments of the process. © 2015 Elsevier Ltd. All rights reserved.

Marciniak, W., et al. (1999). "Echocardiographic evaluation in 485 aeronautical workers exposed to different noise environments. Aviation Space." *Medicine* **70**(3).

May, M. and R. Y. McMurtry (2015). "Wind Turbines and Adverse Health Effects: A Second Opinion." *J Occup Environ Med* **57**(10): e130-132.

McBride, D., et al. (2014). *Investigating the impacts of wind turbine noise on quality of life in the Australian context: A case study approach*. INTERNOISE 2014 - 43rd International Congress on Noise Control Engineering: Improving the World Through Noise Control.

The WHO considers noise pollution to be of sufficient threat to public health to justify the publication of guidelines on noise effects and mitigation. 'Community noise' has largely been studied in the context of transportation and general neighbourhood noise, with exposure to wind turbine noise relatively understudied for historical, methodological, and political reasons. There also appears to be a general uncoupling of wind turbine noise from the other sources, which endows upon it an exclusivity that excuses it from the methods, guidelines, and critique used for other noise sources. This study aimed to advance understanding of wind turbine noise impacts by adopting a case study approach based on detailed information from 25 individuals, Australian adults residing rurally and within 1000-3500m of three or more wind turbines. Participants were selected on the basis of health concerns evidenced through statutory declarations or submissions to hearings. The 25 respondents completed a face-to-face survey measuring health-related quality of life (HRQOL) questionnaire as developed by the World Health Organisation (WHO), the 'WHOQOL-BREF'. The results were compared to normative population data and showed clinically significant reduction in HRQOL.

McBride, D., et al. (2013). A longitudinal study of the impact of wind turbine proximity on health related quality of life C3 - 42nd International Congress and Exposition on Noise Control Engineering 2013, INTER-NOISE 2013: Noise Control for Quality of Life. 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, Innsbruck, OAL-Osterreichischer Arbeitsring fur Larmbekampfung.

Background. Wind turbine noise is known to cause annoyance and sleep disturbance, which are primary health effects. An additional risk factor is the trait of noise sensitivity, which describes individuals who are more likely to pay attention to sound, evaluate sound negatively and have stronger emotional reactions to noise. The result is chronic stress, the effects of which could be monitored through detecting stress related outcomes such as hypertension in exposed individuals. An alternative approach is to monitor health related quality of life (HRQOL). This study examines whether there is a change in this metric over time in a turbine exposed community. **Methods.** This is a 2 year follow up of a base-line survey carried out on individuals living within two kilometres of industrial wind turbines compared with a matched control group[1]. We have repeated the self administered questionnaire survey in which self-reported HRQOL was measured using the abbreviated version of the WHOQOL-BREF. **Results.** The base-line survey found that residents living within 2 km of a turbine installation experienced significantly lower overall quality of life, physical quality of life, and environmental quality of life than a control group. The turbine group showed no change in WHOQOL or amenity scores with time, however compared to the 2012 control group, the turbine group had lower physical domain scores, and rated their overall health as being poorer. The results do not therefore support any improvement in this global health metric with time.

McCallum, L. C., et al. (2014). "Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern?" Environ Health **13**(1): 9.

BACKGROUND: The past five years has seen considerable expansion of wind power generation in Ontario, Canada. Most recently worries about exposure to electromagnetic fields (EMF) from wind turbines, and associated electrical transmission, has been raised at public meetings and legal proceedings. These fears have not been based on any actual measurements of EMF exposure surrounding existing projects but appear to follow from worries from internet sources and misunderstanding of the science.

METHODS: The study was carried out at the Kingsbridge 1 Wind Farm located near Goderich, Ontario, Canada. Magnetic field measurements were collected in the proximity of 15 Vestas 1.8 MW wind turbines, two substations, various buried and overhead collector and transmission lines, and nearby homes. Data were collected during three operational scenarios to characterize potential EMF exposure: 'high wind' (generating power), 'low wind' (drawing power from the grid, but not generating power) and 'shut off' (neither drawing, nor generating power).

RESULTS: Background levels of EMF (0.2 to 0.3 mG) were established by measuring magnetic fields around the wind turbines under the 'shut off' scenario. Magnetic field levels detected at the base of the turbines under both the 'high wind' and 'low wind' conditions were low (mean = 0.9 mG; n = 11) and rapidly diminished with distance, becoming indistinguishable from background within 2 m of the base. Magnetic fields measured 1 m above buried collector lines were also within background (< 0.3 mG). Beneath overhead 27.5 kV and 500 kV transmission lines, magnetic field levels of up to 16.5 and 46 mG, respectively, were recorded. These levels also diminished rapidly with distance. None of these sources appeared to influence magnetic field levels at nearby homes located as close as just over 500 m from turbines, where measurements immediately outside of the homes were < 0.4 mG.

CONCLUSIONS: The results suggest that there is nothing unique to wind farms with respect to EMF exposure; in fact, magnetic field levels in the vicinity of wind turbines were lower than those produced by many common household electrical devices and were well below any existing regulatory guidelines with respect to human health.

McCombie, C. and M. Jefferson (2016). "Renewable and nuclear electricity: Comparison of environmental impacts." Energy Policy **96**: 758-769.

Given the widely acknowledged negative impacts of fossil fuels, both on human health and on potential climate change, it is of interest to compare the impacts of low carbon alternative energy sources such as nuclear energy, hydropower, solar, wind and biomass. In this paper, we review the literature in order to summarise the impacts of the different technologies in terms of their materials and energy requirements, their emissions during operation, their health effects during operation, the accident risks, and the associated waste streams. We follow up these comparisons with some more anecdotal evidence

on selected impacts that are either particularly topical or are important but less commonly addressed. These include impacts of wind turbines on persons and on bird life, the underestimated problems with biomass, and concerns about biodiversity reduction. Finally we address the public attitudes towards both renewable energy technologies and to nuclear power. The conclusion is drawn that energy policies of many countries are perhaps more strongly influenced by public and political perceptions of available technologies than they are by rational assessment of the actual benefits and drawbacks. Policy recommendations follow from this conclusion. © 2016 Elsevier Ltd

McCunney, R. J., et al. (2015). "Wind turbines and health: An examination of a proposed case definition." Noise Health **17**(77): 175-181.

Renewable energy demands have increased the need for new wind farms. In turn, concerns have been raised about potential adverse health effects on nearby residents. A case definition has been proposed to diagnose "Adverse Health Effects in the Environs of Industrial Wind Turbines" (AHE/IWT); initially in 2011 and then with an update in 2014. The authors invited commentary and in turn, we assessed its scientific merits by quantitatively evaluating its proposed application. We used binomial coefficients to quantitatively assess the potential of obtaining a diagnosis of AHE/IWT. We also reviewed the methodology and process of the development of the case definition by contrasting it with guidelines on case definition criteria of the USA Institute of Medicine. The case definition allows at least 3,264 and up to 400,000 possibilities for meeting second- and third-order criteria, once the limited first-order criteria are met. IOM guidelines for clinical case definitions were not followed. The case definition has virtually no specificity and lacks scientific support from peer-reviewed literature. If applied as proposed, its application will lead to substantial potential for false-positive assessments and missed diagnoses. Virtually any new illness that develops or any prevalent illness that worsens after the installation of wind turbines within 10 km of a residence could be considered AHE/IWT if the patient feels better away from home. The use of this case definition in the absence of a thorough medical evaluation with appropriate diagnostic studies poses risks to patients in that treatable disorders would be overlooked. The case definition has significant potential to mislead patients and its use cannot be recommended for application in any health-care or decision-making setting.

McCunney, R. J., et al. (2014). "Wind turbines and health: a critical review of the scientific literature." J Occup Environ Med **56**(11): e108-130.

OBJECTIVE: This review examines the literature related to health effects of wind turbines.

METHODS: We reviewed literature related to sound measurements near turbines, epidemiological and experimental studies, and factors associated with annoyance.

RESULTS: (1) Infrasound sound near wind turbines does not exceed audibility thresholds. (2) Epidemiological studies have shown associations between living near wind turbines and annoyance. (3) Infrasound and low-frequency sound do not present unique health risks. (4) Annoyance seems more strongly related to individual characteristics than noise from turbines.

DISCUSSION: Further areas of inquiry include enhanced noise characterization, analysis of predicted noise values contrasted with measured levels postinstallation, longitudinal assessments of health pre- and postinstallation, experimental studies in which subjects are "blinded" to the presence or absence of infrasound, and enhanced measurement techniques to evaluate annoyance.

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McCunney, R. J., et al. (2014). "Wind turbines and health: A critical review of the scientific literature." Journal of occupational and environmental medicine **56**(11): e108-e130.

McCunney, R. J., et al. (2015). ""Wind Turbines and Health: A Critical Review of the Scientific Literature"." J Occup Environ Med **57**(10): e133-135.

McMurtry, R. and C. Krogh (2016). "Response to McCunney et al.: Wind turbines and health: An examination of a proposed case definition." Noise and Health **18**(85): 399-402.

McMurtry, R. Y. and C. M. Krogh (2014). "Diagnostic criteria for adverse health effects in the environs of wind turbines." JRSM Open **5**(10): 2054270414554048.

In an effort to address climate change, governments have pursued policies that seek to reduce greenhouse gases. Alternative energy, including wind power, has been proposed by some as the preferred approach. Few would debate the need to reduce air pollution, but the means of achieving this reduction is important not only for efficiency but also for health protection. The topic of adverse health effects in the environs of industrial wind turbines (AHE/IWT) has proven to be controversial and can present physicians with challenges regarding the management of an exposure to IWT. Rural physicians in particular must be aware of the possibility of people presenting to their practices with a variety of sometimes confusing complaints. An earlier version of the diagnostic criteria for AHE/IWT was published in August 2011. A revised case definition and a model for a study to establish a confirmed diagnosis is proposed.

McMurtry, R. Y. and C. M. Krogh (2016). "Response to McCunney et al.: Wind turbines and health: An examination of a proposed case definition." Noise Health **18**(85): 399-402.

McMurtry, R. Y. and C. M. E. Krogh (2014). "Diagnostic criteria for adverse health effects in the environs of wind turbines." JRSM Short Reports **5**(10): 1-5.

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Merlin, T., et al. (2013). "Systematic review of the human health effects of wind farms."

Michaud, D. S. (2015). Self-reported and objectively measured outcomes assessed in the health Canada wind turbine noise and health study: Results support an increase in community annoyance. INTER-NOISE 2015 - 44th International Congress and Exposition on Noise Control Engineering.

A cross-sectional epidemiological study was initiated by Health Canada to investigate the prevalence of health effects or health indicators among a sample of Canadians exposed to wind turbine noise (WTN) using both self-reported and objectively measured health outcomes. The sample was drawn from communities in Ontario (ON) and Prince Edward Island (PEI) where there were a sufficient number of dwellings within the vicinity of wind turbine installations. One participant between the ages of 18-79 years was randomly selected from each household. The final sample included 1238 participants (606 males, 632 females) living between 0.250 and 11.22 km from operational wind turbines. The response rate was 78.9% and did not significantly vary across sampling strata or between provinces. Modelled A- and C-weighted WTN levels reached 46 dBA and 63 dBC, respectively. Sample characteristics were relatively homogenous, with some minor differences found in age, employment, type and ownership of dwelling. WTN exposure was not found to be related to hair cortisol concentrations, blood pressure, resting heart rate or any of the measured sleep parameters (i.e., sleep latency, sleep time, rate of awakenings, sleep efficiency). Self-reported results obtained through an in-person questionnaire do not provide support for an association between increasing WTN levels and self-reported sleep disturbance, use of sleep medication, or diagnosed sleep disorders. Similarly, no significant association was found

between WTN levels and self-reported migraines, tinnitus, dizziness, diabetes, hypertension, perceived stress or any measure of quality of life. Statistically significant exposure-response relationships were observed between increasing WTN levels and an increase in the prevalence of long term high annoyance towards several wind turbine features, including: noise, shadow-flicker, visual impacts, blinking lights and vibrations. The association between WTN annoyance and other reported and measured outcomes is presented. © 2015 by ASME.

Michaud, D. S., et al. (2016). "Self-reported and measured stress related responses associated with exposure to wind turbine noise." *J Acoust Soc Am* **139**(3): 1467-1479.

The current study was the first to assess stress reactions associated with wind turbine noise (WTN) exposure using self-reported and objective measures. Randomly selected participants, aged 18-79 yr (606 males; 632 females), living between 0.25 and 11.22km from wind turbines, were exposed to outdoor calculated WTN levels up to 46dBA (response rate 78.9%). Multiple regression modeling left the great majority (77%-89%) of the variance in perceived stress scale (PSS) scores, hair cortisol concentrations, resting blood pressure, and heart rate unaccounted for, and WTN exposure had no apparent influence on any of these endpoints. PSS scores were positively, but weakly, related to cortisol concentrations and resting heart rate (Pearson $r=0.13$ and $r=0.08$, respectively). Across WTN categories, modeled mean PSS scores ranged from 13.15 to 13.84 ($p=0.8614$). Modeled geometric means for hair cortisol concentrations, resting mean systolic, diastolic blood pressure, and heart rate were 150.54-191.12ng/g ($p=0.5416$), 113.38-116.82mmHg ($p=0.4990$), 67.98-70.34mmHg ($p=0.5006$), and 68.24-70.71 bpm ($p=0.5223$), respectively. Irrespective of WTN levels, diastolic blood pressure appeared to be slightly (2.90mmHg 95% CI: 0.75,5.05) higher among participants highly annoyed by blinking lights on turbines ($p=0.0081$). Collectively, the findings do not support an association between exposure to WTN up to 46 dBA and elevated self-reported and objectively defined measures of stress.

Michaud, D. S., et al. (2016). "Erratum: Exposure to wind turbine noise: Perceptual responses and reported health effects [J. Acoust. Soc. Am. 139(3), 1443-1454 (2016)]." *J Acoust Soc Am* **140**(4): 2457.

Michaud, D. S., et al. (2016). "Exposure to wind turbine noise: Perceptual responses and reported health effects." *J Acoust Soc Am* **139**(3): 1443-1454.

Health Canada, in collaboration with Statistics Canada, and other external experts, conducted the Community Noise and Health Study to better understand the impacts of wind turbine noise (WTN) on health and well-being. A cross-sectional epidemiological study was carried out between May and September 2013 in southwestern Ontario and Prince Edward Island on 1238 randomly selected participants (606 males, 632 females) aged 18-79 years, living between 0.25 and 11.22km from operational wind turbines. Calculated outdoor WTN levels at the dwelling reached 46 dBA. Response rate was 78.9% and did not significantly differ across sample strata. Self-reported health effects (e.g., migraines, tinnitus, dizziness, etc.), sleep disturbance, sleep disorders, quality of life, and perceived stress were not related to WTN levels. Visual and auditory perception of wind turbines as reported by respondents increased significantly with increasing WTN levels as did high annoyance toward several wind turbine features, including the following: noise, blinking lights, shadow flicker, visual impacts, and vibrations. Concern for physical safety and closing bedroom windows to reduce WTN during sleep also increased with increasing WTN levels. Other sample characteristics are discussed in relation to WTN levels. Beyond annoyance, results do not support an association between exposure to WTN up to 46 dBA and the evaluated health-related endpoints.

Michaud, D. S., et al. (2016). "Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep." *Sleep* **39**(1): 97-109.

STUDY OBJECTIVES: To investigate the association between self-reported and objective measures of sleep and wind turbine noise (WTN) exposure.

METHODS: The Community Noise and Health Study, a cross-sectional epidemiological study, included an in-house computer-assisted interview and sleep pattern monitoring over a 7 d period. Outdoor WTN levels were calculated following international standards for conditions that typically approximate the highest long-term average levels at each dwelling. Study data were collected between May and September 2013 from adults, aged 18-79 y (606 males, 632 females) randomly selected from each household and living between 0.25 and 11.22 kilometers from operational wind turbines in two Canadian provinces. Self-reported sleep quality over the past 30 d was assessed using the Pittsburgh Sleep Quality Index. Additional questions assessed the prevalence of diagnosed sleep disorders and the

magnitude of sleep disturbance over the previous year. Objective measures for sleep latency, sleep efficiency, total sleep time, rate of awakening bouts, and wake duration after sleep onset were recorded using the wrist worn Actiwatch2 from a subsample of 654 participants (289 males, 365 females) for a total of 3,772 sleep nights.

RESULTS: Participant response rate for the interview was 78.9%. Outdoor WTN levels reached 46 dB(A) with an arithmetic mean of 35.6 and a standard deviation of 7.4. Self-reported and objectively measured sleep outcomes consistently revealed no apparent pattern or statistically significant relationship to WTN levels. However, sleep was significantly influenced by other factors, including, but not limited to, the use of sleep medication, other health conditions (including sleep disorders), caffeine consumption, and annoyance with blinking lights on wind turbines.

CONCLUSIONS: Study results do not support an association between exposure to outdoor WTN up to 46 dB(A) and an increase in the prevalence of disturbed sleep. Conclusions are based on WTN levels averaged over 1 y and, in some cases, may be strengthened with an analysis that examines sleep quality in relation to WTN levels calculated during the precise sleep period time. Copyright © 2016 Associated Professional Sleep Societies, LLC.

Michaud, D. S., et al. (2012). Health impacts and exposure to wind turbine noise: Research design and noise exposure assessment C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

The last decade has seen a sharp increase in wind turbine generated electricity in Canada. As of May 2012, Canada's installed capacity was 5.4 Gigawatts, representing almost a 7fold increase since 2005 and 2.3 percent of Canada's current electricity demands. The wind energy industry has set a vision that by 2025 wind energy will supply 20% of Canada's electricity demands. Development has been challenged by public resistance to wind farms based on various concerns, including the potential health impacts of wind turbine noise. The health effects reported by individuals living in communities in close proximity to wind turbine installations are poorly understood due to limited scientific research in this area. This is coupled with the many challenges faced in measuring and modeling wind turbine noise, in particular low frequency noise, which continue to be knowledge gaps in this area. The continued success and viability of wind turbine energy in Canada, and around the world, will rely upon a thorough understanding of the potential health impacts and community concerns that underscore public resistance. Health Canada, in collaboration with Statistics Canada, will undertake a cross-sectional field study to evaluate these self-reported health impacts and symptoms of illness against objective biomarkers of stress and the sound levels generated by wind turbines, including low frequency noise. This data will be correlated with calculated wind turbine noise so that any potential relationship to reported health symptoms can be reliably determined. The research design includes a computer-assisted personal interview using a questionnaire consisting of modules that probe endpoints such as noise annoyance, quality of life, sleep quality, stress, chronic illnesses and perceived impacts on health. Following the 25-minute interview, the subject will be invited to participate in the health measures collection part of the study. This will include an automated blood pressure measurement and the collection of a small hair sample that will provide a 90-day retroactive average cortisol level. An objective evaluation of sleep will be undertaken using actigraphy for a period of 7 consecutive days, which will be synchronised with wind turbine operational data. Environmental sound level measurements, including low frequency noise, will be conducted inside and outside a sub-sample of homes in order to validate parameters ensuring accurate sound level modeling. The sample will consist of 2000 dwellings at setback distances ranging from less than 500 metres to greater than 5 kilometres from 8-12 wind turbine power plants. The results of the research study will contribute to the body of peer-reviewed scientific research examining the health impacts of wind turbine noise.

Michaud, D. S., et al. (2016). "Erratum: Personal and situational variables associated with wind turbine noise annoyance [J. Acoust. Soc. Am. 139(3), 1455-1466 (2016)]." J Acoust Soc Am **140**(4): 2234.

Michaud, D. S., et al. (2016). "Personal and situational variables associated with wind turbine noise annoyance," J Acoust Soc Am **139**(3): 1455-1466.

The possibility that wind turbine noise (WTN) affects human health remains controversial. The current analysis presents results related to WTN annoyance reported by randomly selected participants (606 males, 632 females), aged 18-79, living between 0.25 and 11.22km from wind turbines. WTN levels reached 46dB, and for each 5dB increase in WTN levels, the odds of reporting to be either very or

extremely (i.e., highly) annoyed increased by 2.60 [95% confidence interval: (1.92, 3.58), $p < 0.0001$]. Multiple regression models had R^2 's up to 58%, with approximately 9% attributed to WTN level. Variables associated with WTN annoyance included, but were not limited to, other wind turbine-related annoyances, personal benefit, noise sensitivity, physical safety concerns, property ownership, and province. Annoyance was related to several reported measures of health and well-being, although these associations were statistically weak ($R^2 < 9\%$), independent of WTN levels, and not retained in multiple regression models. The role of community tolerance level as a complement and/or an alternative to multiple regression in predicting the prevalence of WTN annoyance is also provided. The analysis suggests that communities are between 11 and 26 dB less tolerant of WTN than of other transportation noise sources.

Michaud, D. S., et al. (2016). "Personal and situational variables associated with wind turbine noise annoyance." *Journal of the Acoustical Society of America* **139**(3): 1455-1466.

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Miedema, H. and C. Oudshoorn (2001). "Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals." *Environmental health perspectives* **109**(4): 409.

Miedema, H. M. and H. Vos (1998). "Exposure-response relationships for transportation noise." *The Journal of the Acoustical Society of America* **104**(6): 3432-3445.

Miedema, H. M. and H. Vos (2004). "Noise annoyance from stationary sources: Relationships with exposure metric day-evening-night level (DENL) and their confidence intervals." *The Journal of the Acoustical Society of America* **116**(1): 334-343.

Mirasgedis, S., et al. (2014). "Valuing the visual impact of wind farms: An application in South Evia, Greece." *Renewable and Sustainable Energy Reviews* **39**: 296-311.

This study presents an application of the Contingent Valuation Method (CVM) for valuing the landscape externalities associated with the large-scale exploitation of wind power at the local level. The survey was undertaken in South Evia, Greece, which is a region with rich wind energy potential and a considerable number of wind farms in operation during the period of the study. The results showed that 57% of the households are not willing to contribute financially in order to implement interventions to mitigate the visual impact of wind farms. The mean willingness to pay per household to avoid the visual impact attributed to the installation of new wind farms in the area in question was estimated at €41.6/year taking into account all households of the sample. This estimate is relatively lower compared to the results of other relevant studies. As shown by a meta-analysis developed based on these studies, this is mainly attributed to the great recession in Greece and the reduced available income of households. © 2014 Elsevier Ltd.

Moller, H. and C. S. Pedersen (2004). "Hearing at low and infrasonic frequencies." *Noise and Health* **6**(23): 37.

Moller, H. and C. S. Pedersen (2011). "Low-frequency noise from large wind turbines." *J Acoust Soc Am* **129**(6): 3727-3744.

As wind turbines get larger, worries have emerged that the turbine noise would move down in frequency and that the low-frequency noise would cause annoyance for the neighbors. The noise

emission from 48 wind turbines with nominal electric power up to 3.6 MW is analyzed and discussed. The relative amount of low-frequency noise is higher for large turbines (2.3-3.6 MW) than for small turbines (≤ 2 MW), and the difference is statistically significant. The difference can also be expressed as a downward shift of the spectrum of approximately one-third of an octave. A further shift of similar size is suggested for future turbines in the 10-MW range. Due to the air absorption, the higher low-frequency content becomes even more pronounced, when sound pressure levels in relevant neighbor distances are considered. Even when A-weighted levels are considered, a substantial part of the noise is at low frequencies, and for several of the investigated large turbines, the one-third-octave band with the highest level is at or below 250 Hz. It is thus beyond any doubt that the low-frequency part of the spectrum plays an important role in the noise at the neighbors. Copyright 2011 Acoustical Society of America

Møller, H. and C. S. Pedersen (2011). "Low-frequency noise from large wind turbines." The Journal of the Acoustical Society of America **129**(6): 3727-3744.

Møller, H. and C. S. Pedersen (2011). "Low-frequency noise from large wind turbines." The Journal of the Acoustical Society of America **129**(6): 3727-3744.

Molnarova, K., et al. (2012). "Visual preferences for wind turbines: Location, numbers and respondent characteristics." Applied Energy **92**: 269-278.

There is a dichotomy in the view of wind farms among members of the public: on one hand, there is a desire for renewable energy sources, and on the other hand, there is a major concern about the visual impact of wind turbines used for power production. This concern for visual impact is a major factor in the reaction of the public to the development of new wind farms. Our study aims to objectify this influence and to establish the factors that determine how people evaluate these structures. We tested the visual quality of landscapes in which these structures are to be placed, the number of structures and their distance from the viewer, and various characteristics of our respondents. We found that the physical attributes of the landscape and wind turbines influenced the respondents' reactions far more than socio-demographic and attitudinal factors. One of the most important results of our study is the sensitivity of respondents to the placement of wind turbines in landscapes of high aesthetic quality, and, on the other hand, a relatively high level of acceptance of these structures in unattractive landscapes. Wind turbines also receive better acceptance if the number of turbines in a landscape is limited, and if the structures are kept away from observation points, such as settlements, transportation infrastructure and viewpoints. The most important characteristic of the respondents that influenced their evaluation was their attitude to wind power. On the basis of these results, recommendations are presented for placing wind turbines and for protecting the character of the landscape within the planning and policy making processes. © 2011 Elsevier Ltd.

Moorhouse, A. T., et al. (2009). "A procedure for the assessment of low frequency noise complaints." Journal of the Acoustical Society of America **126**(3): 1131-1141.

The development and application of a procedure for the assessment of low frequency noise (LFN) complaints are described. The development of the assessment method included laboratory tests addressing low frequency hearing threshold and the effect on acceptability of fluctuation, and field measurements complemented with interview-based questionnaires. Environmental health departments then conducted a series of six trials with genuine "live" LFN complaints to test the workability and usefulness of the procedure. The procedure includes guidance notes and a pro-forma report with step-by-step instructions. It does not provide a prescriptive indicator of nuisance but rather gives a systematic procedure to help environmental health practitioners to form their own opinion. Examples of field measurements and application of the procedure are presented. The procedure and examples are likely to be of particular interest to environmental health practitioners involved in the assessment of LFN complaints. © 2009 Acoustical Society of America.

Moorhouse, A. T., et al. (2009). "A procedure for the assessment of low frequency noise complaints." J Acoust Soc Am **126**(3): 1131-1141.

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Morel, J., et al. (2012). "A laboratory study on total noise annoyance due to combined industrial noises." Acta Acustica united with Acustica **98**(2): 286-290.

In this study, broadband noises are combined on the one hand with low-frequency content noises and on the other hand with 100 Hz-main-component noises. The total noise annoyance due to the 2 types of combinations is assessed through two laboratory experiments. Six classical models of total annoyance due to combined noises are tested and discussed. The strongest component model appears to be a weak total annoyance predictor for the studied combined noises. One reason may be that it fails to take into account the asymmetries between the annoyance-inhibiting properties between the combined noises. Overall classical models of total annoyance, the weighted-summation model yields the best prediction. By integrating the features of two classical models into a new mixed model, total annoyance prediction is more improved. © S. Hirzel Verlag EAA.

Motosu, M. and Y. Maruyama (2016). "Local acceptance by people with unvoiced opinions living close to a wind farm: A case study from Japan." Energy Policy **91**: 362-370.

The local acceptance of wind energy projects has received significant attention because local opposition is a barrier to implementing a wind energy project. To decrease objections from local residents, previous studies identified factors that evoke negative attitudes. However, little research has focused on the acceptance of people who remain silent. Therefore, the situation in which there is no marked opposition has been regarded as a success for the project. This research focused on the acceptance of people who are not objecting to a wind farm in their backyard and clarifies the implications of the silent situation. One of the principal findings is that while most of the respondents accept the existing local wind farm, they have negative attitudes towards a new wind farm. This result means that the silent situation does not support further wind development. We conclude that the purpose of consensus building needs to be set to encouraging local residents to express their opinions instead of simply aiming for the absence of opposing opinions. Finally, we discuss a council model through a budgetary provision, eliciting opinions from people who remain silent, and adaptable management as the policy implications for sustainable wind development. © 2016 Elsevier Ltd.

Moynihan, M. J. (2013). "Wind energy presents new challenges for worker health and safety." Workplace Health Saf **61**(5): 232.

Wind technology jobs present uncertainties for worker health. More investigation is needed to ensure the safety of employees working on wind farms. Copyright 2013, SLACK Incorporated.

Mroczek, B., et al. (2015). "Evaluation of Quality of Life of Those Living near a Wind Farm." Int J Environ Res Public Health **12**(6): 6066-6083.

OBJECTIVES: Health-related quality of life (HRQoL) can serve as a multidimensional means of evaluating the relationship between the presence of wind turbines in residential areas and their consequence for health. The purpose of this study was to determine whether a relationship exists between the presence of wind farms at different stages of development and the HRQoL of people living in their vicinity in Poland.

METHOD: The instruments employed in this study were the SF-36v2, a questionnaire measuring self-reported health problems, and a sociodemographic questionnaire. The study involved 1277 people who lived within 2 km from a wind turbine.

RESULTS: The highest overall QoL scores were obtained by respondents living the closest to wind turbines. The mental health, role emotional, and social functioning scores were significantly higher among respondents living near wind farms and wind-farm construction sites than among those living close to locations where wind farms were planned but where construction had not yet begun. Positive correlations were found between physical and mental component scores and reactions to the news of plans to construct a wind farm. Significant differences in physical and mental component scores were observed between residents who reacted calmly and those who responded with apprehension.

Residents who expected the improvement of their financial standing as a result of the wind farm assessed their general health higher than those who did not expect to receive any economic benefits. The lowest QoL scores corresponded to frequent headaches, stomach aches, and back pain over the previous three months, as well as recurrent problems with falling asleep, anxiety, and a lack of acceptance of the project.

CONCLUSION: The lowest overall QoL and general health scores were noted among residents of places where wind-farm developments were either at the stage of planning or under construction. In order to find ways of reducing environmental stress and its adverse effects on health, it is necessary to conduct research on residents of places where a wind farm is either planned or under construction, or has just been completed.

Mroczek, B., et al. (2010). "Health behaviour of adult inhabitants of towns located near wind farms in Poland." *Family Medicine and Primary Care Review* **12**(3): 736-737.

Background. Health behaviour is a direct factor determining human health. **Objectives.** The purpose of the study was to diagnose risky behaviour of inhabitants of towns located in the vicinity of wind farms in Poland. **Material and methods.** Information was obtained from 1276 inhabitants of villages, F - 55% and M - 45%; average age 45.5±16 years. Education level: 31% secondary, 31% vocational secondary. 45% of the respondents were employed. 40% lived in the vicinity of wind farms. **Results.** 25% drinks alcohol almost every day, 27% smokes tobacco habitually. Average BMI in women is 25.8 ± 5.7, in men 27.2 ± 5.3; obesity was diagnosed in 37%. 43% stated chronic diseases: arterial hypertension 25%, rheumatic disorder 13% and alcohol disorder - 4%. 23% feels head and back pain every day; 12% has difficulties in falling asleep; 11% is nervous. Very good health condition was quoted by 27%. Average VAS was 66.6 ± 26. **Conclusion.** Risky alcohol drinking and habitual smoking as well as obesity are significant factors threatening the health of inhabitants of villages. © Wydawnictwo Continuo.

Mroczek, B., et al. (2012). "Influence of distances between places of residence and wind farms on the quality of life in nearby areas." *Ann Agric Environ Med* **19**(4): 692-696.

BACKGROUND: The quality of life has three main characteristics: it always refers to the living conditions of an individual; it is measured both with subjective and objective indicators; and it is a multidimensional concept.

AIM OF THE STUDY: To assess how the quality of life is affected by the close proximity of wind farms.

MATERIAL AND METHODS: The study group consisted of 1,277 Polish adults (703 women and 574 men), living in places located near wind farms. The mean age was 45.5 +/- 16.10. Some 33.2% of participants lived more than 1,500 m from wind farms; 17% - below 700 m. The research tool consisted of the Norwegian version of the SF-36 General Health Questionnaire, the Visual Analogue Scale (VAS) for health assessment, and original questions.

RESULTS: Regardless of the distance between a place of residence and a wind farm, the highest quality of life was noted within the physical functioning subscale (mean 76+/-27.97), and the lowest within the general health (mean 55.3+/-24.06). Within all scales, the quality of life was assessed highest by residents of areas located closest to wind farms, and the lowest by those living more than 1,500 m from wind farms.

CONCLUSIONS: Close proximity of wind farms does not result in the worsening of the quality of life. Similar research should be conducted before any intended investment, and at least 6 months after construction of a wind farm.

Mroziński, A. and I. Piasecka (2015). "Selected Aspects of Building, Operation and Environmental Impact of Offshore Wind Power Electric Plants." *Polish Maritime Research* **22**(2): 86-92.

This paper describes essence of work of offshore wind power electric plants and crucial aspects of their building and operating. Prospects for development of global, European and domestic markets of offshore wind power industry have been delineated. A comparative analysis of environmental impact of an offshore and land-based 2MW wind power electric plant has been performed by using LCA method and Ecoindex - 99 (Ekowskaznik 99) modelling. © 2015 Adam Mroziński et al.

Mulvaney, K. K., et al. (2013). "Different shades of green: a case study of support for wind farms in the rural midwest." *Environ Manage* **51**(5): 1012-1024.

Benton County, in north-central Indiana, USA has successfully sited more than 500 turbines. To understand Benton County's acceptance of wind farms, a holistic case study was conducted that included a document review, a survey of local residents and interviews with key stakeholders. Survey questionnaires were sent to 750 residents asking questions about attitudes toward the wind farms,

perceived benefits and impacts from the wind farms, environmental attitudes, and demographic information. Key stakeholders were also interviewed for a deeper understanding of the historical timeline and community acceptance of the wind farm development. While there is limited opposition to the turbines, on the whole the community presents a front of acceptance. Financial, rather than environmental, benefits are the main reason for the acceptance. Although significant in other case studies, transparency and participation do not play a large role in Benton County's acceptance. Most residents are not concerned with either visual impacts or noise from the wind turbines. More concrete benefits to the community, such as reduced energy bills for county residents, could help to extend acceptance even further within the community. Although there are concerns about the acceptance of wind farms and the impacts of those farms on local residents in both peer-reviewed literature and popular media, we found little evidence of those concerns in Benton County. Instead, we found Benton County to be a community largely accepting of wind farms.

Nadaï, A. and O. Labussière (2015). "Wind Power and the Emergence of the Beauce Landscape, Eure-et-Loir, France." Landscape Research **40**(1): 76-98.

Abstract: In 2003 wind power arrived massively in the Beauce (on the outskirts of the Parisian basin). This article follows the evolving practice of landscape planning over the course of wind power development in this region of France. Our analysis suggests that landscape is regulated through practices, discourses and aesthetic codes, which define what is important about landscape and attempt to protect it. It shows that wind power not only affects existing landscapes, but also challenges the working of these underlying practices and discourses, triggering the emergence of new codes. By calling for a renewal in the way in which we regulate and experience our landscapes, wind power enables us better to understand the way in which the energy transition might raise issues about landscape protection. © 2013, Landscape Research Group Ltd.

Napoli, C. D. (2011). "Wind turbine noise assessment in a small and quiet community in Finland." Noise Control Engineering Journal **59**(1): 30-37.

The noise measurement case presented in this work took place in August 2007 in a small community located on the Finnish west coast, where an 1.1 MW pitch regulated variable speed wind turbine caused many complaints from the nearby holiday residents after its initial start-up in 2006. New specific receiver testing procedures were introduced prior to the test for performing just one overnight measurement under desired weather conditions. The goal was to test the sound power level and outdoor far field sound pressure levels at receiver point, including the verification of narrow band and impulsive sounds, during the night time and downwind conditions. © 2011 Institute of Noise Control Engineering.

Nichifor, M. A. (2016). "Public reactions towards wind energy instalments. Case study: Romania and the Netherlands." Management and Marketing **11**(3): 532-543.

Wind energy experienced an exponential development in the past two decades, forming a main source of energy today, but also a frequently encountered issue of debate due to the increased proximity of wind turbines to citizens' residence, especially in the case of the Western part of the European Union. Although the benefits of renewable sources of energy represent a compulsory effort towards ensuring sustainable energy strategies for the future, due to the increased pressure of balancing climate change, limitation of traditional energy resources and economic competition, the expansion of wind parks has caused strong reactions of local communities in many regions leading to the reorganization of public exposure strategies of many companies in the field. This research intends to offer a sample of public perceptions of wind turbines depending on several influence factors, based on the answers of 64 Dutch citizens and 40 Romanian respondents. Through the implementation of the Delphi method based on questionnaires and interviews, an overview of perceptions towards placement of wind turbines in the two analyzed countries has been offered, providing significant answers to the influence factors of public reactions for or against wind turbines. The main results of the research revealed the importance of financial benefits in increasing public acceptance of wind farms, as well as several subjective factors, such as the visual impact of wind turbines and onshore or offshore placement, that contribute to a positive or negative behavior of citizens towards it. © 2016, Editura Economică. All rights reserved.

Nimráček, T., et al. (2015). Comparison of two variants of wind power plant in terms of environmental impact. International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM.

The topic of this article is comparison of two considered variants of the solution of wind power plants construction in terms of the environmental impact. The goal is to choose a concrete variant of the construction which brings a lower impact on the environment and health of the population. Especially in terms of the noise, landscape, fauna and flora impact. The article also deals with concrete selected impacts especially of tall wind power plants in near proximity of inhabited locations. The first option includes the construction of number 8 wind turbines with a total size of 175 m, then the second six wind turbines with a total size of 196 m, each with power of 3.3 MW. The study has been prepared in accordance with Annex No. 3 of the Act no. 100/2001 Coll. on the assessment of environmental impact, as amended, known EIA (Environmental Impact Assessment). The results of the study will therefore be deciding which of the possible solutions planned construction of a wind park will have the least impact on the environment, through noise studies, expertise, faunistic, floristic observation and evaluation of health risks and impacts on public health. © SGEM2015.

Nishimura, A., et al. (2014). "Impact of building layouts on wind turbine power output in the built environment: A case study of tsu city." *Nihon Enerugi Gakkaishi/Journal of the Japan Institute of Energy* **93**(4): 315-322.

In city planning, it is important to consider the future growth of renewable energy systems in the built environment. Wind speed analysis in the built environment is very important for analysing the wind turbine performance installed in the built environment. In this work, building topologies / layouts in Tsu city are considered for investing the wind speed distributions and directions. Wind speed profile in the built environment are developed by using CFD-ACE+. This work focusses on the analysis of the wind speed directions and distribution characteristics for finding out the proper location of the wind turbines in the built environment. The wind speed profiles and their directions and wind turbine characteristics are always changing; therefore a model has to put forward for estimation of the wind turbine power outputs. This work is useful for designing the building layouts in such a way to make the nozzle of the wind by using wind directions and then finding out the proper location of the wind turbine in the built environment. In this work, building layouts like nozzle is proposed and investigated to obtain the contracted flow by blowing wind through the buildings.

Nissenbaum, M. A., et al. (2012). "Effects of industrial wind turbine noise on sleep and health." *Noise Health* **14**(60): 237-243.

Industrial wind turbines (IWTs) are a new source of noise in previously quiet rural environments. Environmental noise is a public health concern, of which sleep disruption is a major factor. To compare sleep and general health outcomes between participants living close to IWTs and those living further away from them, participants living between 375 and 1400 m (n = 38) and 3.3 and 6.6 km (n = 41) from IWTs were enrolled in a stratified cross-sectional study involving two rural sites. Validated questionnaires were used to collect information on sleep quality (Pittsburgh Sleep Quality Index - PSQI), daytime sleepiness (Epworth Sleepiness Score - ESS), and general health (SF36v2), together with psychiatric disorders, attitude, and demographics. Descriptive and multivariate analyses were performed to investigate the effect of the main exposure variable of interest (distance to the nearest IWT) on various health outcome measures. Participants living within 1.4 km of an IWT had worse sleep, were sleepier during the day, and had worse SF36 Mental Component Scores compared to those living further than 1.4 km away. Significant dose-response relationships between PSQI, ESS, SF36 Mental Component Score, and log-distance to the nearest IWT were identified after controlling for gender, age, and household clustering. The adverse event reports of sleep disturbance and ill health by those living close to IWTs are supported.

Nordman, E. and J. Mutinda (2016). "Biodiversity and wind energy in Kenya: Revealing landscape and wind turbine perceptions in the world's wildlife capital." *Energy Research and Social Science* **19**: 108-118.

People vary in their perceptions of wind turbines. Perceptions have been well-documented in European and North American studies and have been attributed to constructs like place attachment. Genius loci, or "spirit of a place," is an ancient Roman idea that has new relevance in the study of landscape perceptions, including perceptions of wind turbines. As wind energy development expands to developing countries, new studies of public perceptions in unique cultural landscapes are required. We surveyed visitors to Nairobi National Park about their perceptions of the park landscape and the six-turbine Ngong Hills wind farm. Two complementary theories were used to analyze perceptions: place attachment and genius loci. The Ngong Hills Wind Farm had a slightly positive effect on the visitors who saw them. Additional turbine development would have no effect on their visitor experience but additional urban growth would have a very negative effect. Responses show that place attachment

and genius loci explain aspects of visitor perceptions of the Nairobi National Park landscape. The human aspects of the landscape, including wind turbines and the Nairobi skyline, interact with the natural elements and the visitors' own experiences to create a distinct genius loci and evokes feelings of place attachment. © 2016 Elsevier Ltd. All rights reserved.

Nordman, E., et al. (2016). "Enhancing public engagement on offshore wind energy using "Genius loci": A case study from the Lake Michigan Coast." *International Journal of Sustainability Policy and Practice* **12**(4): 19-32.

We describe a novel approach to public engagement on offshore wind energy based on "genius loci" ("spirit of a place"). North America has only one offshore wind farm but they could be viable in the Great Lakes. Cultural ties between coastal Michigan, USA, and the Netherlands offered opportunities to learn from the Dutch offshore wind experience. Residents from a Lake Michigan coastal region with Dutch heritage video conferenced with a Netherlands based tourism specialist regarding the Egmond aan Zee offshore wind farm. Experts from public agencies and the Coast Guard also made presentations about potential regulation of offshore wind energy development. Important differences and similarities between the regions emerged, including the clustering of technological expertise, tourism effects, and perspectives on working seascapes. Michigan has more private coastal property than the Netherlands, which has implications for the visual/aesthetic impact. About 80% of seminar participants agreed that the Netherlands' experience with offshore wind was applicable to coastal Michigan suggesting the place-based forum grounded in "genius loci" may have enhanced the public engagement efforts. © Common Ground, Caterina Cavicchi, All Rights Reserved.

Nordman, E., et al. (2015). "An integrated assessment for wind energy in Lake Michigan coastal counties." *Integr Environ Assess Manag* **11**(2): 287-297.

The benefits and challenges of onshore and offshore wind energy development were assessed for a 4-county area of coastal Michigan. Economic, social, environmental, and spatial dimensions were considered. The coastal counties have suitable wind resources for energy development, which could contribute toward Michigan's 10% renewable energy standard. Wind energy is cost-effective with contract prices less than the benchmark energy price of a new coal-fired power plant. Constructing a 100MW wind farm could have a \$54.7 million economic impact. A patchwork of township-level zoning ordinances regulates wind energy siting. Voluntary collaborations among adjacent townships standardizing the ordinances could reduce regulatory complexity. A Delphi Inquiry on offshore wind energy in Lake Michigan elicited considerable agreement on its challenges, but little agreement on the benefits to coastal communities. Offshore turbines could be acceptable to the participants if they reduced pollution, benefited coastal communities, involved substantial public participation, and had minimal impact on property values and tourism. The US Coast Guard will take a risk-based approach to evaluating individual offshore developments and has no plans to issue blanket restrictions around the wind farms. Models showed that using wind energy to reach the remainder of the 10% renewable energy standard could reduce SO₂, NO_x, and CO₂ pollution by 4% to 7%. Turbines are highly likely to impact the area's navigational and defense radar systems but planning and technological upgrades can reduce the impact. The integrated assessment shows that responsible wind energy development can enhance the quality of life by reducing air pollution and associated health problems and enhancing economic development. Policies could reduce the negative impacts to local communities while preserving the benefits to the broader region. Copyright © 2015 SETAC.

Nussbaum, D. and S. Reinis (1985). Some individual differences in human response to infrasound, University of Toronto.

Oerlemans, S., et al. (2007). "Location and quantification of noise sources on a wind turbine." *Journal of sound and vibration* **299**(4): 869-883.

Öhlund, O. and C. Larsson (2015). "Meteorological effects on wind turbine sound propagation." *Applied Acoustics* **89**: 34-41.

Oles, T. and K. Hammarlund (2011). "The European landscape convention, wind power, and the limits of the local: Notes from Italy and Sweden." *Landscape Research* **36**(4): 471-485.

The European Landscape Convention is the first international agreement to deal with all aspects of landscape planning, protection, and management. It emphasizes transparency, democracy, and good governance as integral parts of 'landscape'. The ELC may inspire member states of the Council of Europe

to develop better tools for planning land use and the environment; however its utility in practice is still largely untested. This article considers the relevance of the ELC to a major land use conflict in Europe today: the development of wind power. Two countries are used as case studies of this conflict. Italy and Sweden both contain iconic European landscapes, and both have become important sites of large-scale wind power development over the last decade. But the two countries also have divergent political, economic, and institutional traditions. The debate around wind power and landscape has therefore unfolded differently in the two countries. The article consists of three parts. The first part gives an overview of the growth in wind power, and the forms that opposition to wind power have taken, in Italy over the past decade. It is argued that implementation of the ELC's clauses on democratic, locally-based landscape planning process will encounter in Italy a major impediment in the form of political and economic corruption. The second part summarizes the development of wind power as part of the Swedish national energy strategy. Using a case study of a wind power planning process guided by the ELC, it is argued that what appear to be common landscape values in local communities often conceal fundamental conflicts among individuals, groups, and institutions. On the basis of these two cases, the third and concluding part sketches both the potential of the ELC to transform the planning process for wind power, and the real challenges it will face, as a non-binding, 'global' agreement, in 'local' places with their own histories, traditions, and social actors. © 2011 Landscape Research Group Ltd.

Ollson, C. A., et al. (2013). "Are the findings of "Effects of industrial wind turbine noise on sleep and health" supported?" *Noise Health* **15**(63): 148-150.

Olson-Hazboun, S. K., et al. (2016). "Public views on renewable energy in the Rocky Mountain region of the United States: Distinct attitudes, exposure, and other key predictors of wind energy." *Energy Research and Social Science* **21**: 1-13.

Renewable energy is often framed by policymakers and the media as an environmental or 'green' issue motivated by global climate change and the need for greenhouse gas reductions. However, some researchers studying social responses to renewables have found that factors other than opinions about climate change may be more influential in determining support for renewables. This study analyzes survey data from a study of five communities in the Rocky Mountain region of the U.S. experiencing wind energy development to examine the relationship between environmental beliefs, climate change opinions, and support for renewable energy. Results show that views on renewable energy comprise a distinct dimension of public views on energy, environment, and climate, suggesting that public support for renewable energy is less related to environmental beliefs than to some other factors, including beliefs about economic benefits and concerns about landscape impacts. Findings also indicate that the frequency with which individuals see nearby wind turbines are strongly related to their level of support for renewable energy, while physical proximity is not. Overall, results suggest that ceasing to frame renewable energy as an environmental issue and instead framing it in a way that invokes locally relevant social values may garner broader public support. © 2016 Elsevier Ltd

Onakpoya, I. J., et al. (2015). "The effect of wind turbine noise on sleep and quality of life: A systematic review and meta-analysis of observational studies." *Environ Int* **82**: 1-9.

Noise generated by wind turbines has been reported to affect sleep and quality of life (QOL), but the relationship is unclear. Our objective was to explore the association between wind turbine noise, sleep disturbance and quality of life, using data from published observational studies. We searched Medline, Embase, Global Health and Google Scholar databases. No language restrictions were imposed. Hand searches of bibliography of retrieved full texts were also conducted. The reporting quality of included studies was assessed using the STROBE guidelines. Two reviewers independently determined the eligibility of studies, assessed the quality of included studies, and extracted the data. We included eight studies with a total of 2433 participants. All studies were cross-sectional, and the overall reporting quality was moderate. Meta-analysis of six studies (n=2364) revealed that the odds of being annoyed is significantly increased by wind turbine noise (OR: 4.08; 95% CI: 2.37 to 7.04; p<0.00001). The odds of sleep disturbance was also significantly increased with greater exposure to wind turbine noise (OR: 2.94; 95% CI: 1.98 to 4.37; p<0.00001). Four studies reported that wind turbine noise significantly interfered with QOL. Further, visual perception of wind turbine generators was associated with greater frequency of reported negative health effects. In conclusion, there is some evidence that exposure to wind turbine noise is associated with increased odds of annoyance and sleep problems. Individual attitudes could influence the type of response to noise from wind turbines. Experimental and observational studies

investigating the relationship between wind turbine noise and health are warranted. Copyright © 2015 Elsevier Ltd. All rights reserved.

Oosterlaken, I. (2015). "Applying value sensitive design (VSD) to wind turbines and wind parks: an exploration." *Sci Eng Ethics* **21**(2): 359-379.

Community acceptance still remains a challenge for wind energy projects. The most popular explanation for local opposition, the Not in My Backyard effect, has received fierce criticism in the past decade. Critics argue that opposition is not merely a matter of selfishness or ignorance, but that moral, ecological and aesthetic values play an important role. In order to better take such values into account, a more bottom-up, participatory decision process is usually proposed. Research on this topic focusses on either stakeholder motivations/attitudes, or their behavior during project implementation. This paper proposes a third research focus, namely the 'objects' which elicit certain behavioral responses and attitudes-the wind turbine and parks. More concretely, this paper explores Value Sensitive Design (VSD) as way to arrive at wind turbines and parks that better embed or reflect key values. After a critical discussion of the notion of acceptance versus acceptability and support, the paper discusses existing literature on ecology and aesthetics in relation to wind turbine/park design, which could serve as 'building blocks' of a more integral VSD approach of the topic. It also discusses the challenge of demarcating wind park projects as VSD projects. A further challenge is that VSD has been applied mainly at the level of technical artifacts, whereas wind parks can best be conceptualized as socio-technical system. This new application would therefore expand the current practice of VSD, and may as a consequence also lead to interesting new insights for the VSD community. The paper concludes that such an outcome-oriented approach of wind turbines and park is worth exploring further, as a supplement to rather than a replacement of the process-oriented approach that is promoted by the current literature on community acceptance of wind parks.

Palmer, J. F. (2015). "Effect size as a basis for evaluating the acceptability of scenic impacts: Ten wind energy projects from Maine, USA." *Landscape and Urban Planning* **140**: 56-66.

Visual impact assessments generally lack a reliable and valid procedure to evaluate the impact's magnitude. Stamps (2000) proposed effect size thresholds that are adapted to evaluate judgments of scenic impact, effect on enjoyment and continued use of scenic resources affected by ten proposed wind energy project in the State of Maine, USA. Users of scenic resources were interviewed at 15 locations evaluating 20 viewpoints. Overall, respondents found that the scenic impacts were very large (Hedges $g < 1.1$), while the effect of the change on enjoyment was so small that it is difficult to distinguish ($0.2 < g < 0.5$), and respondents say that the change will have a trivial effect ($g < 0.2$) on their continued use of the scenic resource where they were surveyed. The implications of these results are discussed, including the congruence with permitting orders, the relative merits of using scenic impact or measures of impact acceptability in decision-making, problems of measuring cumulative scenic impacts, and issues concerning survey quality control. © 2015 Elsevier B.V.

Palmer, W. K. G. (2011). "Learning from evidence of sound experienced from wind turbines." *Canadian Acoustics - Acoustique Canadienne* **39**(3): 88-89.

The article identifies key findings related to the subject of sound of wind turbines identified by others at the Fourth International Meeting on Wind Turbine Noise held in Rome in April 2011, and the 161st Meeting of the American Acoustical Society, in Seattle, in May 2011. Salt presented a physiological link between the response of the ear to low frequency sound unrelated to audibility. Specifically, the response of the outer hair cells of the ear and the response of the fluid in the inner ear to infrasound may be enhanced. Digitized sound samples were recorded at 6 nearby sites in the environment of a wind power development during all seasons of the year. The method is explained in detail and detailed results are presented in the reference. The link between annoyance and sleep disturbance is known. The link between sleep disturbance and adverse health effects is well established.

Palmer, W. K. G. (2016). "Considerations regarding an acoustic criterion for wind turbine acceptability." *Canadian Acoustics - Acoustique Canadienne* **44**(3): 42-43.

Park, S. J., et al. (2016). "Comparisons of hearing threshold changes in male workers with unilateral conductive hearing loss exposed to workplace noise: A retrospective cohort study for 8 years." *Annals of Occupational and Environmental Medicine* **28**(1).

Background: The purpose of this study was to investigate hearing threshold changes of workers with unilateral conductive hearing loss who were exposed to workplace noise for 8-years. **Methods:** Among 1819 workers at a shipyard in Ulsan, 78 subjects with an air-bone gap ≥ 10 dBHL in unilateral ears were selected. Factors that could affect hearing were acquired from questionnaires, physical examinations, and biochemistry examinations. Paired t-test was conducted to compare the hearing threshold changes over time between conductive hearing loss (CHL) ear and sensorineural hearing loss (SNHL) ear. **Results:** The study included male subjects aged 48.7 ± 2.9 , having worked for 29.8 ± 2.7 years. Hearing thresholds increased significantly in CHL ears and SNHL ears at all frequencies (0.5-6 kHz) during follow-up period ($p < 0.05$). The threshold change at 4 kHz was 3.2 dBHL higher in SNHL ears which was statistically significant ($p < 0.05$). When workers were exposed to noise levels of 85 dBA and above, threshold change at 4 kHz was 5.6 dBHL higher in SNHL ears which was statistically significant ($p < 0.05$). Among workers aged below 50, the threshold change values were lower in low-frequency (0.5-2 kHz) in SNHL ears, with a small range of changes, whereas in high-frequency (3-6 kHz), the range of changes was greater SNHL ears ($p < 0.05$). Among workers aged 50 and above, SNHL ears showed a wider range of changes in both high- and low-frequency areas ($p < 0.05$). **Conclusions:** At high-frequencies, particularly at 4 kHz, the range of hearing threshold changes was lower in ears with conductive hearing loss than in contralateral ears. This is suggested as a protective effect against noise exposure.

Parks, J. M. and K. S. Theobald (2013). "Public engagement with information on renewable energy developments: The case of single, semi-urban wind turbines." *Public Underst Sci* **22**(1): 49-64.

This paper explores perceptions of public engagement with information on renewable energy developments. It draws on a case study of proposals by a major supermarket chain to construct single wind turbines in two semi-urban locations in the UK, analysing data from interviews with key actors in the planning process and focus groups with local residents. The paper concludes that key actors often had high expectations of how local people should engage with information, and sometimes implied that members of the public who were incapable of filtering or processing information in an organised or targeted fashion had no productive role to play in the planning process. It shows how the specific nature of the proposals (single wind turbines in semi-urban locations proposed by a commercial private sector developer) shaped local residents' information needs and concerns in a way that challenged key actors' expectations of how the public should engage with information.

Pasqualetti, M. J. (2011). "Opposing wind energy landscapes: A search for common cause." *Annals of the Association of American Geographers* **101**(4): 907-917.

Although wind power is local, sustainable, affordable, and carbon free, mounting public opposition to the landscape changes it produces threatens its expansion. In an era when many countries are looking to renewable energy as an answer to questions about national security and the risks of climate change, it is important to explain the sources of this reaction. This article looks for similarities in public resistance to wind developments in four diverse settings: Palm Springs, California; Cape Cod, Massachusetts; the Isle of Lewis, Scotland; and Oaxaca State, Mexico. Despite the natural and cultural diversity among these places, there are five common threads in the opposition that has been experienced: immobility, the site specificity of the resource; immutability, an expectation of landscape permanence; solidarity, the close relationship between people and the land; imposition, a sense of marginalization; and place identity, a loss of security. Considering more deeply the relationship between land and life, in advance of the development of renewable energy resources, will help smooth the otherwise bumpy road toward a more sustainable future. © 2011 by Association of American Geographers Initial submission, March 2010.

Pasqualetti, M. J. (2011). "Social barriers to renewable energy landscapes." *Geographical Review* **101**(2): 201-223.

After many years of slow progress, we find that worldwide environmental, political, and economic pressures are providing greater purchase for the accelerated development of renewable energy. Although many people would consider this quickening pace good news, the transition from conventional resources has encountered public resistance. In this article I examine the nature of challenges to the development of geothermal, wind, and solar energy projects in three places: the United States, Scotland, and Mexico. The common thread in the public reservations about renewable energy is landscape change and the consequent disruption such change produces to established ways of life for those who are nearby. It also suggests the importance of rebalancing the emphasis of renewable energy programs away from the traditional technical focus that dominates development

planning. The more suitable and expedient approach would be to consider the challenges of development as predominantly social matters with technical components, rather than the other way around. To accept this view is to unlock the door to a renewable energy future. © 2011 by the American Geographical Society of New York.

Pawlaczyk-Luszczynska, M., et al. (2010). "Evaluation of annoyance from low frequency noise under laboratory conditions." *Noise Health* **12**(48): 166-181.

The aim of the study was to investigate the annoyance of low frequency noise (LFN) at levels normally prevailing at workplaces in control rooms and office-like areas. Two different laboratory experiments were carried out. The first experiment included 55 young volunteers and the second one comprised 70 older volunteers, categorized in terms of sensitivity to noise. The subjects listened to noise samples with different spectra, including LFNs at sound pressure level (SPL) of 45-67 dBA, and evaluated annoyance using a 100-score graphical rating scale. The subjective ratings of annoyance were compared to different noise metrics. In both the experiments, there were no differences in annoyance assessments between females and males. A significant influence of individual sensitivity to noise on annoyance rating was observed for some LFNs. Annoyance of LFN was not rated higher than annoyance from broadband noises without or with less prominent low frequencies at similar A-weighted SPLs. In both the experiments, median annoyance rating of LFN highly correlated with A-weighted SPL ($L(Aeq,T)$), low frequency A-weighted SPL ($L(LFAeq,T)$) and C-weighted SPL ($L(Ceq,T)$). However, it is only the two latter noise metrics (i.e. $L(LFAeq,T)$ and $L(Ceq,T)$) which seem to be reliable predictors of annoyance exclusively from LFN. The young and older participants assessed similar annoyance from LFN at similar $L(LFAeq,T)$ or $L(Ceq,T)$ levels. Generally, over half of the subjects were predicted to be highly annoyed by LFN at the low frequency A-weighted SPL or C-weighted SPL above 62 and 83 dB, respectively.

Pawlaczyk-Luszczynska, M., et al. (2009). "Annoyance related to low frequency noise in subjective assessment of workers." *Journal of Low Frequency Noise Vibration and Active Control* **28**(1): 1-17.

The aim of this study was to assess annoyance related to low frequency noise (LFN) in employees of the control rooms and office-like areas. Subjects were 276 workers, aged 26-62 years, exposed to noise at A-weighted sound pressure level (SPL) of 41-66 dB. They were asked to assess noise annoyance at their workplace using a 100 point graphical scale. The subjective ratings were compared with various noise metrics and objective evaluations based on proposed LFN exposure criteria for occupational settings. There was a difference in annoyance assessment related to noise with and without (or with less prominent) low frequency content. Low frequency noise was rated as more annoying even though it was at lower dBA levels. Among the noise metrics, the low frequency A-weighted SPL yielded the highest correlation with subjective evaluations of LFN. There was also a quite good agreement between individual annoyance ratings and limit excesses corresponding to preliminary Swedish and Polish exposure criteria.

Pawlaczyk-Luszczynska, M., et al. (2013). *Assessment of annoyance due to wind turbine noise C3 - Proceedings of Meetings on Acoustics*. 21st International Congress on Acoustics, ICA 2013 - 165th Meeting of the Acoustical Society of America, Montreal, QC.

The overall aim of this study was to evaluate the perception and annoyance of noise from wind turbines in populated areas of Poland. The study group comprised 156 subjects. All subjects were interviewed using a questionnaire developed to enable evaluation of their living conditions, including prevalence of annoyance due to noise from wind turbines, and the self-assessment of physical health and wellbeing. In addition, current mental health status of respondents was assessed using Goldberg General Health Questionnaire GHQ-12. For areas where respondents lived, A-weighted sound pressure levels (SPLs) were calculated as the sum of the contributions from the wind power plants in the specific area. It has been shown that the wind turbine noise at the calculated A-weighted SPL of 30-48 dB was perceived as annoying outdoors by about one third of respondents, while indoors by one fifth of them. The proportions of the respondents annoyed by the wind turbine noise increased with increasing A-weighted sound pressure level. Subjects' attitude to wind turbines in general and sensitivity to landscape littering was found to have significant impact on the perceived annoyance. Further studies are needed, including a larger number of respondents, before firm conclusions can be drawn. © 2013 Acoustical Society of America.

Pawlaczyk-Luszczynska, M., et al. (2012). *Annoyance related to noise from wind turbines in subjective assessment of people living in their vicinity C3 - 41st International Congress and Exposition on Noise Control Engineering*

2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

The aim of this study was to evaluate the perception and annoyance of noise from wind turbines in populated areas. The study group comprised 156 subjects aged 15-82 years. All subjects were interviewed using a questionnaire developed to enable evaluation of their living conditions as well as health status and wellbeing. In addition, current mental health status of respondents was assessed using Goldberg General Health Questionnaire GHQ-12. For each subject, A-weighted sound pressure levels (SPLs) were calculated as the sum of the contributions from the wind power plants in the specific area. It has been shown that the wind turbine noise at the calculated A-weighted SPL of 30-48 dB was noticed outdoors and assessed as annoying by 60.3% and 32.1% of respondents, respectively. The percentage of subjects who noticed noise increased from 54.2% at SPL of 35-40 dB to 62.7% at SPL of 40-45 dBA. Similarly, the higher the SPL, the higher the percentage of those annoyed (23.7% at SPL of 35-40 dBA and 37.3% at 40-45 dBA). Subjects' attitude to wind turbines in general and to their visual impact on the landscape in particular was found to have impact on the perceived annoyance.

Pawlaczyk-Luszczynska, M., et al. (2014). "Evaluation of annoyance from the wind turbine noise: a pilot study." *Int J Occup Med Environ Health* 27(3): 364-388.

OBJECTIVES: The overall aim of this study was to evaluate the perception of and annoyance due to the noise from wind turbines in populated areas of Poland.

MATERIAL AND METHODS: The study group comprised 156 subjects. All subjects were asked to fill in a questionnaire developed to enable evaluation of their living conditions, including prevalence of annoyance due to the noise from wind turbines and the self-assessment of physical health and well-being. In addition, current mental health status of the respondents was assessed using Goldberg General Health Questionnaire GHQ-12. For areas where the respondents lived, A-weighted sound pressure levels (SPLs) were calculated as the sum of the contributions from the wind power plants in the specific area.

RESULTS: It has been shown that the wind turbine noise at the calculated A-weighted SPL of 30-48 dB was noticed outdoors by 60.3% of the respondents. This noise was perceived as annoying outdoors by 33.3% of the respondents, while indoors by 20.5% of them. The odds ratio of being annoyed outdoors by the wind turbine noise increased along with increasing SPLs (OR = 2.1; 95% CI: 1.22-3.62). The subjects' attitude to wind turbines in general and sensitivity to landscape littering was found to have significant impact on the perceived annoyance. About 63% of variance in outdoors annoyance assessment might be explained by the noise level, general attitude to wind turbines and sensitivity to landscape littering.

CONCLUSIONS: Before firm conclusions can be drawn further studies are needed, including a larger number of respondents with different living environments (i.e., dissimilar terrain, different urbanization and road traffic intensity).

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Pawlaczyk-Łuszczynskaw, M., et al. (2014). "Annoyance related to wind turbine noise." *Archives of Acoustics* **39**(1): 89-102.

A questionnaire inquiry on response to wind turbine noise was carried out on 361 subjects living in the vicinity of 8 wind farms. Current mental health status of respondents was assessed using Goldberg General Health Questionnaire GHQ-12. For areas where respondents lived, A-weighted sound pressure levels (SPLs) were calculated as the sum of the contributions from the wind power plants in the specific area. Generally, 33.0% of respondents were annoyed outdoors by wind turbine noise at the calculated A-weighted SPL of 31-50 dB, while indoors the noise was annoying to 21.3% of them. The proportion of subjects evaluating the noise produced by operative wind turbines as annoying decreased with increasing the distance from the nearest wind turbine (27.6% at the distance of 400-800 m vs 14.3% at the distance above 800 m, $p < 0.016$). On the other hand, the higher was the noise level, the greater was the percentage of annoyed respondents (14.0% at SPL up to 40 dB vs 28.1% at SPL of 40-45 dB, $p < 0.016$). Besides noise and distance categories, subjective factors, such as general attitude to wind turbines, sensitivity to landscape littering and current mental health status, were found to have significant impact on the perceived annoyance. About 50% of variance in annoyance rating might be explained by the aforesaid subjective factors. © 2014 by PAN - IPPT.

Pedersen, E. (2011). "Health aspects associated with wind turbine noise-Results from three field studies." *Noise Control Engineering Journal* **59**(1): 47-53.

Wind farms are a new source of environmental noise. The impact of wind turbine noise on health and well-being has not yet been well-established and remains under debate. Long-term effects, especially, are not known, because of the short time wind turbines have been operating and the relatively few people who have so far been exposed to wind turbine noise. As the rate of new installations increases, so does the number of people being exposed to wind turbine noise and the importance of identifying possible adverse health effects. Data from three cross-sectional studies comprising A-weighted sound pressure levels of wind turbine noise, and subjectively measured responses from 1,755 people, were used to systematically explore the relationships between sound levels and aspects of health and well-being. Consistent findings, that is, where all three studies showed the same result, are presented, and possible associations between wind turbine noise and human health are discussed. © 2011 Institute of Noise Control Engineering.

Pedersen, E., et al. (2009). "Response to noise from modern wind farms in The Netherlands." *J Acoust Soc Am* **126**(2): 634-643.

The increasing number and size of wind farms call for more data on human response to wind turbine noise, so that a generalized dose-response relationship can be modeled and possible adverse health effects avoided. This paper reports the results of a 2007 field study in The Netherlands with 725 respondents. A dose-response relationship between calculated A-weighted sound pressure levels and reported perception and annoyance was found. Wind turbine noise was more annoying than transportation noise or industrial noise at comparable levels, possibly due to specific sound properties such as a "swishing" quality, temporal variability, and lack of nighttime abatement. High turbine visibility enhances negative response, and having wind turbines visible from the dwelling significantly increased the risk of annoyance. Annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape. The study further demonstrates that people who benefit economically from wind turbines have a significantly decreased risk of annoyance, despite exposure to similar sound levels. Response to wind turbine noise was similar to that found in Sweden so the dose-response relationship should be generalizable.

Pedersen, E., et al. (2010). "Can road traffic mask sound from wind turbines? Response to wind turbine sound at different levels of road traffic sound." *Energy Policy* **38**(5): 2520-2527.

Wind turbines are favoured in the switch-over to renewable energy. Suitable sites for further developments could be difficult to find as the sound emitted from the rotor blades calls for a sufficient distance to residents to avoid negative effects. The aim of this study was to explore if road traffic sound could mask wind turbine sound or, in contrast, increases annoyance due to wind turbine noise. Annoyance of road traffic and wind turbine noise was measured in the WINDFARMperception survey in

the Netherlands in 2007 (n=725) and related to calculated levels of sound. The presence of road traffic sound did not in general decrease annoyance with wind turbine noise, except when levels of wind turbine sound were moderate (35-40 dB(A) Lden) and road traffic sound level exceeded that level with at least 20 dB(A). Annoyance with both noises was intercorrelated but this correlation was probably due to the influence of individual factors. Furthermore, visibility and attitude towards wind turbines were significantly related to noise annoyance of modern wind turbines. The results can be used for the selection of suitable sites, possibly favouring already noise exposed areas if wind turbine sound levels are sufficiently low. © 2010 Elsevier Ltd. All rights reserved.

Pedersen, E. and K. P. Waye (2009). Wind turbine sound - How often is it heard by residents living nearby? 8th European Conference on Noise Control 2009, EURONOISE 2009 - Proceedings of the Institute of Acoustics, Edinburgh.

Sound power levels of wind turbines and consequently also the immission sound pressure levels at nearby residents vary with the wind speed. A standard meteorological situation is therefore commonly used when the immission levels are discussed; wind speed 8 m/s at 10 m height downwind. There is a need for a more comprehensive description of the sound that could be included in the Environmental Impact Assessment. The objectives of this study were to explore if it is possible to measure how often the sound is heard, and if the occurrence could be related to the standardized immission levels or the performance of the wind turbine. Twenty four people living in three wind turbine areas (A-weighted sound pressure levels 29.6 - 45.9 dB) filled in diaries for three weeks, noting when they were at home, when they were outdoors, and when they could hear sound from wind turbines. The incidents when the wind turbines were heard varied largely from 0% to 100% of the times spent outdoors. The percentage increased with increasing standardized immission levels ($r = 0.56$, $p < 0.01$). In two of the areas it was possible to get data from the nearest turbines for the study period. The sound was more easily heard at wind speeds above 5 m/s than at lower wind speeds. No indication of a decreased possibility to hear the sound when the wind increased further was found. Possibility to hear the sound was most closely related to the electrical power generation.

Pedersen, E. and K. P. Waye (2012). Exploring perception and annoyance due to wind turbine noise in dissimilar living environments. EURONOISE 2006 - The 6th European Conference on Noise Control: Advanced Solutions for Noise Control, Tampere.

A cross-sectional study with the aim to explore differences in perception and annoyance between dissimilar living environments was carried out in seven different geographical areas in Sweden 2005. Responses to wind turbine noise were measured using a questionnaire (response rate: 58.4%; 765 respondents) and outdoor A-weighted sound pressure levels were calculated for each respondent. The result indicated that the proportion of people hearing and being annoyed by noise from wind turbines was higher among those who could see one or more wind turbines compared to among those who could not see any turbine at all sound levels. When comparing agricultural areas with suburban areas, a tendency towards higher degrees of perception and annoyance in the agricultural areas was observed. The differences could be due to (i) shortcomings of the sound propagation calculations not taking local barriers into account, (ii) variation in background sound pressure levels between agricultural and suburban areas, (iii) the variation in visibility of the wind turbines influencing the rate of noise annoyance and (iiii) resident's personal values of their living environment due to the level of urbanization of the areas (e.g. rural versus suburban).

Perkins, R. A., et al. (2016). A review of research into human response to the amplitude modulated component on wind turbine noise and development of a planning control method for implementation in the UK. Proceedings of the Institute of Acoustics.

Perkins, R. A., et al. (2016). A review of research into the human response to amplitude-modulated wind turbine noise and development of a planning control method. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

WSP | Parsons Brinckerhoff was commissioned by the United Kingdom (UK) Government Department of Energy and Climate Change (DECC) to undertake a review of research into the effects of and response to the acoustic character of wind turbine noise known as Amplitude Modulation (AM). More specifically the review dealt with the increased level of modulation of aerodynamic noise as perceived at neighbouring dwellings, with a view to providing protection where it is justified within the planning regime. This paper describes how the literature review was undertaken and the key findings from the

review of those papers on the state of knowledge of AM, its effect on people, and the dose-response relationships that exist. It goes on to highlight the gaps in the knowledge base, the risks of bias in the studies reviewed, and how those deficiencies can be overcome in the short term in the absence of a new dose response study. Also described are potential methods to control AM, an approach to quantifying the potential impact on energy yields during periods of control, the recommended method suggested to DECC, and how that condition may be written in accordance with UK Planning Policy. © 2016, German Acoustical Society (DEGA). All rights reserved.

Persinger, M. A. (2014). "Infrasound, human health, and adaptation: An integrative overview of recondite hazards in a complex environment." *Natural Hazards* **70**(1): 501-525.

Infrasound displays a special capacity to affect human health and adaptation because its frequencies and amplitudes converge with those generated by the human body. Muscle sounds and whole-body vibrations are predominately within the 5- to 40-Hz range. The typical amplitudes of the oscillations are within 1-50 μm , which is equivalent to the pressures of about 1 Pa and energies in the order of 10-11 W m⁻². Infrasound sources from the natural environment originate from winds, microbaroms, geomagnetic activity, and microseisms and can propagate for millions of meters. Cultural sources originate from air moving through duct systems within buildings, large machinery, and more recently, wind turbines. There are also unknown sources of infrasound. It is important to differentiate the effects of infrasound from the awareness or experience of its presence. Moderate strength correlations occur between the incidences of infrasound and reports of nausea, malaise, fatigue, aversion to the area, non-specific pain, and sleep disturbances when pressure levels exceed about 50 db for protracted periods. Experimental studies have verified these effects. Their validity is supported by convergent quantitative biophysical solutions. Because cells interact through the exchange of minute quanta of energy that corresponds with remarkably low levels of sound pressure produced by natural phenomena and wind turbines upon the body and its cavities, traditional standards for safety and quality of living might not be optimal. © 2013 The Author(s).

Petrova, M. A. (2013). "NIMBYism revisited: Public acceptance of wind energy in the United States." *Wiley Interdisciplinary Reviews: Climate Change* **4**(6): 575-601.

The acronym NIMBY, known to stand for 'Not-In-My-Back-Yard', generally describes resistance to siting specific projects close to one's area of residence while exhibiting acceptance of similar projects elsewhere. As wind energy continues to be recognized as a successful technology for meeting renewable energy targets and decreasing carbon dioxide emissions, the siting of wind turbines is a growing challenge that policy makers, facility planners, and wind developers face. The most often cited motivations for public support and opposition are reviewed here with a focus on wind energy developments in the United States. The purpose is to present the existing state of research on community responses to wind energy and to answer the following questions: What motivates support and opposition to facility siting, and in particular to wind energy facilities? Does the literature provide substantial evidence that NIMBYism is the determining motivation for opposition in the United States and, by extension, does the term's widespread use help to explain opposition? What mechanisms have been proposed for 'overcoming' NIMBYism, if it is present? This paper, following the recommendations of other social scientists, provides a collective call for a significant course shift: rather than proposing strategies to 'overcome' opposition, research should focus on proposing how to make siting successful. Drawing on a review of the relevant literature, the 'ENUF' framework-which stands for 'Engage, Never use NIMBY, Understand, and Facilitate'-is introduced as a step in that direction. © 2013 John Wiley & Sons, Ltd.

Phillips, J. (2015). "A quantitative-based evaluation of the environmental impact and sustainability of a proposed onshore wind farm in the United Kingdom." *Renewable and Sustainable Energy Reviews* **49**: 1261-1270.

Abstract In this paper, a quantitative-based evaluation of the environmental impact of a proposed wind farm is presented using the Rapid Impact Assessment Matrix (RIAM). The paper uses the revised Environmental Statement of the Grove Farm Wind Energy Project, which was rejected during the planning decision consent stage initially and upheld on appeal. The paper evaluates quantitatively the potential impact of an onshore wind farm at the construction and operation stages. Based on the RIAM evaluation conducted, the paper then goes on to apply a mathematical model to the results to determine the indicated potential level and nature of sustainability of the proposed wind farm. The results indicate that the Grove Farm project was deemed, as a whole, detrimental to the environment-human system, particularly in respect to impacts to visual amenity and cultural heritage.

The application of the model to the RIAM indicated that in both the construction and operation stages, the project was considered as unsustainable. The results obtained raised legitimate questions as to the benefits of such projects as a major contributor to the UK's renewable and sustainable energy mix. © 2015 Elsevier Ltd.

Pierpont, N. (2009). Wind turbine syndrome: A report on a natural experiment, K-Selected Books Santa Fe, NM.

Pohl, J., et al. (2015). "Noise effects of wind turbines on residents - An inter-disciplinary analysis." Lärmbekämpfung 10(3): 133-142.

The aim of this interdisciplinary research project was to analyse the impact of wind turbine noise emission on residents and, if necessary, to develop recommendations for action. As a model the wind farm Wilstedt in Lower Saxon, Germany, was used. Physical emission and immission 'measurements were associated with resident surveys. In addition, the residents contributed by audio recorder and complaint sheet for noise diagnosis. About 10 % of respondents felt at the first interview strongly annoyed by wind turbine noise; 2 years later, only 7%. On the other hand, traffic noise was strongly annoying for 16%. A complaint cause could be revealed by the sound recordings of residents: amplitude-modulated noise. A modified mode of Operation (noise mitigation measure) and the distance to the wind turbines had no detectable effect on noise annoyance. In contrast, the design and construction process proves to be central - it is recommended urgently to make this possible positive and early involve citizens informally.

Poulsen, A. H. and M. Sørensen (2016). Wind Turbine Noise and health, a nationwide prospective study in Denmark. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

There is mounting concern regarding health effects from residential exposure to wind turbine noise. Small numbers and reliance on self-reported data often hamper the existing scientific literature. We are therefore conducting a register-based nationwide study of all Danes exposed to wind turbine noise since 1982, addressing potential associations of wind turbine noise with: diabetes, cardiovascular diseases, perinatal birth factors and use of medication for hypertension, sleep problems and depression. For 550.000 Danish dwellings, hourly noise exposure since 1982, has been established from detailed register data on location and type of all (7.500) wind turbines, type-specific wind turbine noise characteristics and historical wind data. For all buildings, we have data on building characteristics, landscape features, neighborhood socioeconomic conditions as well as air pollution and distance to major roads. We have formed a cohort of all subjects ever inhabiting these houses, with data on age, gender, migration histories, marital status, income, education, affiliation to the work market, as well as information on diseases and medication from national registers. This is by far the largest study to date, of health effects from wind turbines. The first result is a detailed description of the associations between noise level and distance from wind turbines and building related factors such as building characteristics, landscape features, neighborhood socioeconomic conditions, air pollution and distance to major roads. As well as detailed individual data on factors such as age, gender, migration history, marital status, income, education, affiliation to the work market, as well as health information from national registers on all adults ever inhabiting these houses. This information is central for the design and interpretation of all studies on wind turbines and health. © 2016, German Acoustical Society (DEGA). All rights reserved.

Qu, F. and J. Kang (2014). Effects of spatial configuration on the wind turbine noise distribution in residential areas. Proceedings of Forum Acusticum.

With onshore wind farms increasingly installed all over the world, a growing number of residents living in suburban areas are affected by the noise from wind turbines. This research sampled four kinds of typical suburban areas in the UK and identified five morphological indices, aiming at exploring the effects of those parameters in terms of wind turbine noise resistance through noise mapping of sampled sites and quantitative analyses. The results show that morphological parameters have considerable effects (up to 7.4dBA) on the minimum noise level that a dwelling exposed to. Although the effects of morphological indices on noise exposures vary at different frequencies, the building length, orientation, its spacing to adjacent buildings, and the building shape are found to be effective on decreasing the 50Hz noise exposures for up to 6dB.

Rajendran, V. G. and S. Teki (2016). "Periodicity versus prediction in sensory perception." *Journal of Neuroscience* **36**(28): 7343-7345.

Reilly, K., et al. (2015). "Attitudes and perceptions of fishermen on the island of Ireland towards the development of marine renewable energy projects." *Marine Policy* **58**: 88-97.

The expansion of the marine renewable energy (MRE) sector will increase pressure on sea space and existing maritime users which could potentially lead to conflict. Commercial fishing has been identified by many as the industry most likely to be affected by the development of MRE. In order to reduce the risk of spatial conflict and to enable decision-making based on the co-existence of the two sectors, it is important to gain a better understanding of the attitudes of fishermen towards the development of MRE projects in their locality. A survey was designed to provide quantitative information on fishermen's attitudes to marine renewable energy and the perceived impacts and opportunities. Three MRE developments which have been proposed around the island of Ireland (comprising Republic of Ireland and Northern Ireland) were chosen as case study sites in which to carry out the survey. The sites represent offshore wind, wave and tidal energy respectively and are in differing stages of development. In total, 104 complete surveys were conducted with fishermen located at ports in the vicinity of the case study sites. 40% of those surveyed agreed that it is important to develop marine renewable energy in their locality. A further 15% were neutral on this matter. It is encouraging for developers and policy makers that the majority of respondents (70%) were of the opinion that fisheries and MRE projects can co-exist. © 2015 Elsevier Ltd.

Reinhold, K., et al. (2014). "Exposure to high or low frequency noise at workplaces: Differences between assessment, health complaints and implementation of adequate personal protective equipment." *Agronomy Research* **12**(3): 895-906.

Employees are exposed to high and low frequency noise which may cause different health effects. Hearing loss first occurs in the high frequency range, low frequency usually causes sleeping disturbances and annoyance. TES 1358 sound analyzer with 1/3 octave band was used to measure the equivalent sound pressure level, the peak sound pressure level, and the noise frequency spectrum at different workplaces. All the results were compared to Estonian and International legislations. High frequency noise was studied in metal, electronics and wood processing industries. The results showed that in several cases, the normative values were exceeded and the highest values appeared in the range of speech frequencies. Frequency analysis indicated that the noise level spectra at work stations of various machines differed in patterns. The low frequency spectra on a ship showed peaks in the frequency range of 50...1,250 Hz. Most employers provided workers with personal protective equipment against noise, but when selecting ear muffs, noise frequency had not been taken into consideration and therefore workers in the same enterprise used similar ear muffs. Knowledge of the prevailing frequencies assists to decide which ear protection should be used to avoid damage. An adequate hearing protector device can reduce the noise exposure significantly.

Roberts, J. D. and M. A. Roberts (2013). "Wind turbines: is there a human health risk?" *J Environ Health* **75**(8): 8-13. The term "Wind Turbine Syndrome" was coined in a recently self-published book, which hypothesized that a multitude of symptoms such as headache and dizziness resulted from wind turbines generating low frequency sound (LFS). The objective of this article is to provide a summary of the peer-reviewed literature on the research that has examined the relationship between human health effects and exposure to LFS and sound generated from the operation of wind turbines. At present, a specific health condition has not been documented in the peer-reviewed literature that has been classified as a disease caused by exposure to sound levels and frequencies generated by the operation of wind turbines. Communities are experiencing a heightened sense of annoyance and fear from the development and siting of wind turbine farms. High-quality research and effective risk communication can advance this course from one of panic to one of understanding and exemplification for other environmental advancements.

Rodrigues, M., et al. (2010). "A method for the assessment of the visual impact caused by the large-scale deployment of renewable-energy facilities." *Environmental Impact Assessment Review* **30**(4): 240-246.

The production of energy from renewable sources requires a significantly larger use of the territory compared with conventional (fossil and nuclear) sources. For large penetrations of renewable technologies, such as wind power, the overall visual impact at the national level can be substantial, and may prompt public reaction. This study develops a methodology for the assessment of the visual impact

that can be used to measure and report the level of impact caused by several renewable technologies (wind farms, solar photovoltaic plants or solar thermal ones), both at the local and regional (e.g. national) scales. Applications are shown to several large-scale, hypothetical scenarios of wind and solar-energy penetration in Spain, and also to the vicinity of an actual, single wind farm. © 2009 Elsevier Inc. All rights reserved.

Rubin, G. J., et al. (2014). "Possible psychological mechanisms for "wind turbine syndrome". On the windmills of your mind." *Noise Health* **16**(69): 116-122.

Throughout history, people have suffered from physical symptoms that they have attributed to modern technologies. Often these attributions are strongly held, but not supported by scientific evidence. Symptoms attributed to the operation of wind turbines (called "wind turbine syndrome" by some) may fit into this category. Several psychological mechanisms might account for symptoms attributed to wind turbines. First, the "nocebo effect" is a well-recognized phenomenon in which the expectation of symptoms can become self-fulfilling. Second, misattribution of pre-existing or new symptoms to a novel technology can also occur. Third worry about a modern technology increases the chances of someone attributing symptoms to it. Fourth, social factors, including media reporting and interaction with lobby groups can increase symptom reporting. For wind turbines, there is already some evidence that a nocebo effect can explain the attributed symptoms while misattribution seems likely. Although worry has not been directly studied, research has shown that people who are annoyed by the sound that turbines produce are more likely to report symptoms and that annoyance is associated with attitudes toward the visual impact of wind farms and whether a person benefits economically from a wind farm. Given that these mechanisms may be sufficient to account for the experiences reported by sufferers, policy-makers, clinicians and patients should insist on good-quality evidence before accepting a more direct causal link.

Ruotolo, F., et al. (2012). "Individual reactions to a multisensory immersive virtual environment: the impact of a wind farm on individuals." *Cognitive Processing*: 1-5.

The aim of this study was to assess the impact of a wind farm on individuals by means of an audio-visual methodology that tried to simulate biologically plausible individual-environment interactions. To disentangle the effects of auditory and visual components on cognitive performances and subjective evaluations, unimodal (Audio or Video) and bimodal (Audio + Video) approaches were compared. Participants were assigned to three experimental conditions that reproduced a wind farm by means of an immersive virtual reality system: bimodal condition, reproducing scenarios with both acoustic and visual stimuli; unimodal visual condition, with only visual stimuli; unimodal auditory condition, with only auditory stimuli. While immersed in the virtual scenarios, participants performed tasks assessing verbal fluency, short-term verbal memory, backward counting, and distance estimations (egocentric: how far is the turbine from you?; allocentric: how far is the turbine from the target?). Afterwards, participants reported their degree of visual and noise annoyance. The results revealed that the presence of a visual scenario as compared to the only availability of auditory stimuli may exert a negative effect on resource-demanding cognitive tasks but a positive effect on perceived noise annoyance. This supports the idea that humans perceive the environment holistically and that auditory and visual features are processed in close interaction. © 2012 Marta Olivetti Belardinelli and Springer-Verlag.

Ruotolo, F., et al. (2012). "Individual reactions to a multisensory immersive virtual environment: the impact of a wind farm on individuals." *Cogn Process* **13 Suppl 1**: 319-323.

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Rydin, Y., et al. (2015). "Public engagement in decision-making on major wind energy projects." *Journal of Environmental Law* **27**(1): 139-150.

This article examines a small body of decisions on applications for nationally significant wind energy projects under the Planning Act 2008, focussing on the ways in which Examining Authority reports respond to concerns expressed by publics. We draw three closely related conclusions. First, while there is nuance and flexibility, national policy tends to limit the scope for dissenting views to bear much weight, if any, in decisionmaking. Secondly, the strong national policy support for nationally significant wind farm development means that in many cases the Examining Authority is trying to find a way to deal with the publics' concerns without dismissing them completely or classifying them as unimportant, and yet still allow the development to proceed. This leads to a 'focus on mitigation'; a 'how not whether' approach to participation. Finally, albeit a little more tentatively, we conclude that these decisions confirm studies in a range of areas and jurisdictions that suggests a preference among decision makers for expert over lay constructions of knowledge. © The Author 2015.

Ryherd, E. E. and L. M. Wang The (2010). *The effects of noise from building mechanical systems with tonal components on human performance and perception*. ASHRAE Transactions, Albuquerque, NM.

This study investigated the effects of noise from building mechanical systems with tonal components on human task performance and perception. Six different noise conditions based on in-situ measurements were reproduced in an office-like setting; all were set to approximately the same sound level (47 dBA) but could have one particular tonal frequency (120 Hz, 235 Hz, or 595 Hz) at one of two tonal prominence ratios (5 or 9). Thirty participants were asked to complete typing, grammatical reasoning, and math tasks plus subjective questionnaires, while being exposed for approximately 1 hour to each noise condition. Results show that the noise conditions that had tonal prominence ratios of 9 were generally perceived to be more annoying than those of 5, although statistically significant differences in task performance were not found. Other findings are (1) that higher annoyance/distraction responses were significantly correlated with reduced typing task performance; (2) that the noise characteristics most closely correlated to higher annoyance/distraction responses in this study were higher ratings of loudness followed by roar, rumble, and tones; and (3) that perception of more low frequency rumble in particular was significantly linked to reduced performance on both the routine and cognitively demanding tasks. ©2010 ASHRAE.

Salt, A. N. and T. E. Hullar (2010). "Responses of the ear to low frequency sounds, infrasound and wind turbines." *Hear Res* **268**(1-2): 12-21.

Infrasound sounds are generated internally in the body (by respiration, heartbeat, coughing, etc) and by external sources, such as air conditioning systems, inside vehicles, some industrial processes and, now

becoming increasingly prevalent, wind turbines. It is widely assumed that infrasound presented at an amplitude below what is audible has no influence on the ear. In this review, we consider possible ways that low frequency sounds, at levels that may or may not be heard, could influence the function of the ear. The inner ear has elaborate mechanisms to attenuate low frequency sound components before they are transmitted to the brain. The auditory portion of the ear, the cochlea, has two types of sensory cells, inner hair cells (IHC) and outer hair cells (OHC), of which the IHC are coupled to the afferent fibers that transmit "hearing" to the brain. The sensory stereocilia ("hairs") on the IHC are "fluid coupled" to mechanical stimuli, so their responses depend on stimulus velocity and their sensitivity decreases as sound frequency is lowered. In contrast, the OHC are directly coupled to mechanical stimuli, so their input remains greater than for IHC at low frequencies. At very low frequencies the OHC are stimulated by sounds at levels below those that are heard. Although the hair cells in other sensory structures such as the saccule may be tuned to infrasonic frequencies, auditory stimulus coupling to these structures is inefficient so that they are unlikely to be influenced by airborne infrasound. Structures that are involved in endolymph volume regulation are also known to be influenced by infrasound, but their sensitivity is also thought to be low. There are, however, abnormal states in which the ear becomes hypersensitive to infrasound. In most cases, the inner ear's responses to infrasound can be considered normal, but they could be associated with unfamiliar sensations or subtle changes in physiology. This raises the possibility that exposure to the infrasound component of wind turbine noise could influence the physiology of the ear. Copyright (c) 2010 Elsevier B.V. All rights reserved.

Salt, A. N. and J. A. Kaltenbach (2011). "Infrasound from wind turbines could affect humans." Bulletin of Science, Technology & Society **31**(4): 296-302.

Salt, A. N. and J. T. Lichtenhan (2012). Perception-based protection from low-frequency sounds may not be enough C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

Hearing and perception in the mammalian ear are mediated by the inner hair cells (IHC). IHCs are fluid-coupled to mechanical vibrations and have been characterized as velocity-sensitive, making them quite insensitive to low-frequency sounds. But the ear also contains more numerous outer hair cells (OHC), which are not fluid coupled and are characterized as displacement sensitive. The OHCs are more sensitive than IHCs to low frequencies and respond to very low-frequency sounds at levels below those that are perceived. OHC are connected to the brain by type II afferent fibers to networks that may further attenuate perception of low frequencies. These same pathways are also involved in alerting and phantom sounds (tinnitus). Because of these anatomic configurations, low-frequency sounds that are not perceived may cause influence in ways that have not yet been adequately studied. We present data showing that the ear's response to low-frequency sounds is influenced by the presence of higher-frequency sounds such as those in the speech frequency range, with substantially larger responses generated when higher-frequency components are absent. We conclude that the physiological effects of low-frequency sounds are more complex than is widely appreciated. Based on this knowledge, we have to be concerned that sounds that are not perceived are clearly transduced by the ear and may still affect people in ways that have yet to be fully understood.

Schaffer, B., et al. (2016). "Short-term annoyance reactions to stationary and time-varying wind turbine and road traffic noise: A laboratory study." J Acoust Soc Am **139**(5): 2949.

Current literature suggests that wind turbine noise is more annoying than transportation noise. To date, however, it is not known which acoustic characteristics of wind turbines alone, i.e., without effect modifiers such as visibility, are associated with annoyance. The objective of this study was therefore to investigate and compare the short-term noise annoyance reactions to wind turbines and road traffic in controlled laboratory listening tests. A set of acoustic scenarios was created which, combined with the factorial design of the listening tests, allowed separating the individual associations of three acoustic characteristics with annoyance, namely, source type (wind turbine, road traffic), A-weighted sound pressure level, and amplitude modulation (without, periodic, random). Sixty participants rated their annoyance to the sounds. At the same A-weighted sound pressure level, wind turbine noise was found to be associated with higher annoyance than road traffic noise, particularly with amplitude modulation. The increased annoyance to amplitude modulation of wind turbines is not related to its periodicity, but seems to depend on the modulation frequency range. The study discloses a direct link of different acoustic characteristics to annoyance, yet the generalizability to long-term exposure in the field still needs to be verified.

Schäffer, B., et al. (2016). "Short-term annoyance reactions to stationary and time-varying wind turbine and road traffic noise: A laboratory study." *Journal of the Acoustical Society of America* **139**(5): 2949-2963.

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Schiavi, A. and L. Rossi (2015). *Vibration perception in buildings: A survey. From the historical origins to the present day.* Energy Procedia.

The paper provides a literature overview regarding the perception of vibrations, with a particular attention to the issues of comfort in buildings. Nowadays, an increasing number of mechanical sources generate vibrations in building structures, causing discomfort to the inhabitants. However, what «comfort» or «discomfort» do really mean? From a purely metrological point of view, it is not possible to define accurately the boundary of «comfort» without performing subjective evaluations. Nevertheless, a promising attempt can be found perspectives and methods of the recent Soft-Metrology. In this context, theoretical and empirical models and measurement procedures are devoted to define and quantify objective and subjective responses to external stimuli on human, on the basis of several aspects (e.g. annoyance, physiological and psychological effects, behavioural effects...). © 2015 The Authors.

Schiavi, A., et al. (2016). "The perception of vibration in buildings: A historical literature review and some current progress." *Building Acoustics* **23**(1): 59-70.

The article provides a literature overview regarding the perception of vibrations, with a particular attention to the issues of comfort in buildings. Nowadays, an increasing number of mechanical sources generate vibrations in building structures, causing discomfort to the inhabitants. However, what does "comfort" or "discomfort" really mean? From a purely metrological point of view, it is not possible to define accurately the boundary of "comfort" without performing subjective evaluations. Nevertheless, a promising attempt can be found in perspectives and methods of the recent Soft-Metrology. In this context, theoretical and empirical models and measurement procedures are devoted to define and quantify objective and subjective responses to external stimuli on human, on the basis of several aspects (e.g. annoyance, physiological and psychological effects, behavioral effects). © The Author(s) 2016 Reprints and permissions.

Schmidt, J. H. and M. Klokke (2014). "Health effects related to wind turbine noise exposure: a systematic review." *PLoS ONE* **9**(12): e114183.

BACKGROUND: Wind turbine noise exposure and suspected health-related effects thereof have attracted substantial attention. Various symptoms such as sleep-related problems, headache, tinnitus and vertigo have been described by subjects suspected of having been exposed to wind turbine noise.

OBJECTIVE: This review was conducted systematically with the purpose of identifying any reported associations between wind turbine noise exposure and suspected health-related effects.

DATA SOURCES: A search of the scientific literature concerning the health-related effects of wind turbine noise was conducted on PubMed, Web of Science, Google Scholar and various other Internet sources.

STUDY ELIGIBILITY CRITERIA: All studies investigating suspected health-related outcomes associated with wind turbine noise exposure were included.

RESULTS: Wind turbines emit noise, including low-frequency noise, which decreases incrementally with increases in distance from the wind turbines. Likewise, evidence of a dose-response relationship between wind turbine noise linked to noise annoyance, sleep disturbance and possibly even psychological distress was

present in the literature. Currently, there is no further existing statistically-significant evidence indicating any association between wind turbine noise exposure and tinnitus, hearing loss, vertigo or headache.

LIMITATIONS: Selection bias and information bias of differing magnitudes were found to be present in all current studies investigating wind turbine noise exposure and adverse health effects. Only articles published in English, German or Scandinavian languages were reviewed.

CONCLUSIONS: Exposure to wind turbines does seem to increase the risk of annoyance and self-reported sleep disturbance in a dose-response relationship. There appears, though, to be a tolerable level of around LAeq of 35 dB. Of the many other claimed health effects of wind turbine noise exposure reported in the literature, however, no conclusive evidence could be found. Future studies should focus on investigations aimed at objectively demonstrating whether or not measureable health-related outcomes can be proven to fluctuate depending on exposure to wind turbines.

Schmidt, J. H. and M. Klokke (2014). "Health effects related to wind turbine noise exposure: a systematic review." *PLoS ONE* **9**(12): e114183.

BACKGROUND: Wind turbine noise exposure and suspected health-related effects thereof have attracted substantial attention. Various symptoms such as sleep-related problems, headache, tinnitus and vertigo have been described by subjects suspected of having been exposed to wind turbine noise.

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Schomer, P. and P. Pamidighantam (2014). A critical analysis of: Wind turbine health impact study: Report of independent expert panel C3 - Proceedings of Meetings on Acoustics. 166th Meeting of the Acoustical Society of America 2013, San Francisco, CA, Acoustical Society of America.

The "Wind Turbine Health Impact Study: Report of Independent Expert Panel" study says: "The Massachusetts Department of Environmental Protection (MassDEP) in collaboration with the Massachusetts Department of Public Health (MDPH) convened a panel of independent experts to identify any documented or potential health impacts of risks that may be associated with exposure to wind turbines, and, specifically, to facilitate discussion of wind turbines and public health based on scientific findings." It continues, saying: "The scope of the Panel's effort was focused on health impacts of wind turbines per se." The Massachusetts study treats health affects broadly in accordance with WHO and includes direct health effects, annoyance, and sleep disruption. In many ways the Massachusetts study is a critique of the literature relating to wind farm acoustic emissions and health effects. This paper is a critique of the critics. In particular, this critique examines some of the physical acoustic findings and some of the social survey findings. The Massachusetts study reveals itself to have problems similar to those that it criticizes in other reports. © 2014 Acoustical Society of America.

Schomer, P. D., et al. (2015). "A theory to explain some physiological effects of the infrasonic emissions at some wind farm sites." *The Journal of the Acoustical Society of America* **137**(3): 1356-1365.

Seltenrich, N. (2014). "Wind turbines: a different breed of noise?" *Environ Health Perspect* **122**(1): A20-25.

Seong, Y., et al. (2013). "An experimental study on annoyance scale for assessment of wind turbine noise." Journal of Renewable and Sustainable Energy 5(5).

Wind turbine noise referred to as "swishing sound" causes annoyance due to the amplitude modulation of the noise aerodynamically generated from blades. For the propagation characteristic of sound emitted from blade, the noise can be heard differently from place to place. For that reason, many studies on numerical index evaluating annoyance caused by wind turbine noise have been examined. The results, however, showed little correlation with change of equivalent continuous sound pressure level. In the present study, twenty-eight stimuli created by numerical simulation for the test were provided and thirty-two subjects assessed noise-induced annoyance. Additionally, a correlation analysis between sound descriptors and subjective annoyance was performed by using regression analysis with SAS software. This study shows that the maximum sound pressure level with fast time A-weighting (LAF max) explains well the annoyance characteristics compared to the other descriptors considered. © 2013 AIP Publishing LLC.

Shamshirband, S., et al. (2014). "Adaptive neuro-fuzzy methodology for noise assessment of wind turbine." PLoS ONE 9(7): e103414.

Wind turbine noise is one of the major obstacles for the widespread use of wind energy. Noise tone can greatly increase the annoyance factor and the negative impact on human health. Noise annoyance caused by wind turbines has become an emerging problem in recent years, due to the rapid increase in number of wind turbines, triggered by sustainable energy goals set forward at the national and international level. Up to now, not all aspects of the generation, propagation and perception of wind turbine noise are well understood. For a modern large wind turbine, aerodynamic noise from the blades is generally considered to be the dominant noise source, provided that mechanical noise is adequately eliminated. The sources of aerodynamic noise can be divided into tonal noise, inflow turbulence noise, and airfoil self-noise. Many analytical and experimental acoustical studies performed the wind turbines. Since the wind turbine noise level analyzing by numerical methods or computational fluid dynamics (CFD) could be very challenging and time consuming, soft computing techniques are preferred. To estimate noise level of wind turbine, this paper constructed a process which simulates the wind turbine noise levels in regard to wind speed and sound frequency with adaptive neuro-fuzzy inference system (ANFIS). This intelligent estimator is implemented using Matlab/Simulink and the performances are investigated. The simulation results presented in this paper show the effectiveness of the developed method.

Shamshirband, S., et al. (2014). "Adaptive neuro-fuzzy methodology for noise assessment of wind turbine." PLoS ONE 9(7): e103414.

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Shepherd, D. (2012). "Wind farms and health: who is fomenting community anxieties?" Med J Aust 196: 108.

Shepherd, D., et al. (2011). "Evaluating the impact of wind turbine noise on health-related quality of life." Noise Health 13(54): 333-339.

We report a cross-sectional study comparing the health-related quality of life (HRQOL) of individuals residing in the proximity of a wind farm to those residing in a demographically matched area sufficiently displaced from wind turbines. The study employed a nonequivalent comparison group posttest-only design. Self-administered questionnaires, which included the brief version of the World Health Organization quality of life scale, were delivered to residents in two adjacent areas in semirural New Zealand. Participants were also asked to identify annoying noises, indicate their degree of noise sensitivity, and rate amenity. Statistically significant differences were noted in some HRQOL domain scores, with residents living within 2 km of a turbine installation reporting lower overall quality of life, physical quality of life, and environmental quality of life. Those exposed to turbine noise also reported significantly lower sleep quality, and rated their environment as less restful. Our data suggest that wind farm noise can negatively impact facets of HRQOL.

Shirvani, M., et al. (2014). "Investigating the environment impacts of the wind farms." Research Journal of Pharmaceutical, Biological and Chemical Sciences **5**(5): 866-870.

This paper investigates the environmental impacts of wind farms. In this paper, many aspects such as land and water usage, wildfire and habitat and public health are studied. This paper shows that wind farms have a significant effect on the environment and human life.

Sim, C. S., et al. (2015). "The effects of different noise types on heart rate variability in men." Yonsei Medical Journal **56**(1): 235-243.

Purpose: To determine the impact of noise on heart rate variability (HRV) in men, with a focus on the noise type rather than on noise intensity. Materials and Methods: Forty college-going male volunteers were enrolled in this study and were randomly divided into four groups according to the type of noise they were exposed to: background, traffic, speech, or mixed (traffic and speech) noise. All groups except the background group (35 dB) were exposed to 45 dB sound pressure levels. We collected data on age, smoking status, alcohol consumption, and disease status from responses to self-reported questionnaires and medical examinations. We also measured HRV parameters and blood pressure levels before and after exposure to noise. The HRV parameters were evaluated while patients remained seated for 5 minutes, and frequency and time domain analyses were then performed. Results: After noise exposure, only the speech noise group showed a reduced low frequency (LF) value, reflecting the activity of both the sympathetic and parasympathetic nervous systems. The low-to-high frequency (LF/HF) ratio, which reflected the activity of the autonomic nervous system (ANS), became more stable, decreasing from 5.21 to 1.37; however, this change was not statistically significant. Conclusion: These results indicate that 45 dB(A) of noise, 10 dB(A) higher than background noise, affects the ANS. Additionally, the impact on HRV activity might differ according to the noise quality. Further studies will be required to ascertain the role of noise type.

Skaburskis, A. (2015). "The effects of wind turbines on property values in ontario: Does public perception match empirical evidence?: Comment." Canadian Journal of Agricultural Economics **63**(2): 275-276.

Smedley, A. R., et al. (2010). "Potential of wind turbines to elicit seizures under various meteorological conditions." Epilepsia **51**(7): 1146-1151.

PURPOSE: To determine the potential risk of epileptic seizures from wind turbine shadow flicker under various meteorologic conditions. METHODS: We extend a previous model to include attenuation of sunlight by the atmosphere using the libradtran radiative transfer code. RESULTS: Under conditions in which observers look toward the horizon with their eyes open we find that there is risk when the observer is closer than 1.2 times the total turbine height when on land, and 2.8 times the total turbine height in marine environments, the risk limited by the size of the image of the sun's disc on the retina. When looking at the ground, where the shadow of the blade is cast, observers are at risk only when at a distance <36 times the blade width, the risk limited by image contrast. If the observer views the horizon and closes their eyes, however, the stimulus size and contrast ratio are epileptogenic for solar elevation angles down to approximately 5 degrees. DISCUSSION: Large turbines rotate at a rate below that at which the flicker is likely to present a risk, although there is a risk from smaller turbines that interrupt sunlight more than three times per second. For the scenarios considered, we find the risk is negligible at a distance more than about nine times the maximum height reached by the turbine blade, a distance similar to that in guidance from the United Kingdom planning authorities.

Smith, M. G., et al. (2013). "On the influence of freight trains on humans: a laboratory investigation of the impact of nocturnal low frequency vibration and noise on sleep and heart rate." *PLoS ONE* **8**(2): e55829.

BACKGROUND: A substantial increase in transportation of goods on railway may be hindered by public fear of increased vibration and noise leading to annoyance and sleep disturbance. As the majority of freight trains run during night time, the impact upon sleep is expected to be the most serious adverse effect. The impact of nocturnal vibration on sleep is an area currently lacking in knowledge. We experimentally investigated sleep disturbance with the aim to ascertain the impact of increasing vibration amplitude.

METHODOLOGY/PRINCIPAL FINDINGS: The impacts of various amplitudes of horizontal vibrations on sleep disturbance and heart rate were investigated in a laboratory study. Cardiac accelerations were assessed using a combination of polysomnography and ECG recordings. Sleep was assessed subjectively using questionnaires. Twelve young, healthy subjects slept for six nights in the sleep laboratory, with one habituation night, one control night and four nights with a variation of vibration exposures whilst maintaining the same noise exposure. With increasing vibration amplitude, we found a decrease in latency and increase in amplitude of heart rate as well as a reduction in sleep quality and increase in sleep disturbance.

CONCLUSIONS/SIGNIFICANCE: We concluded that nocturnal vibration has a negative impact on sleep and that the impact increases with greater vibration amplitude. Sleep disturbance has short- and long-term health consequences. Therefore, it is necessary to define levels that protect residents against sleep disruptive vibrations that may arise from night time railway freight traffic.

Soma, K. and C. Haggett (2015). "Enhancing social acceptance in marine governance in Europe." *Ocean and Coastal Management* **117**: 61-69.

In this article we address social acceptance in marine governance. Public support and opposition are critical to any future developments of marine areas, and are often neglected aspects. Whilst one of the main new developments in European marine areas is the increase in sites for offshore wind, social acceptance of renewable energy developments in Europe is shown to be low in a series of on-going studies. There is perhaps often a sense that renewables such as wind, wave and tidal will be 'out of sight, out of mind' when developed offshore but the empirical research evidence from across Europe suggests otherwise. People are protesting against offshore wind, and doing so very effectively, preventing and delaying the development of projects. This article articulates the term 'social acceptance' as a goal in marine policy implementation in European waters in general, and provides illustrations of the implications of social acceptance of offshore wind in a series of case studies. The experiences of social acceptance, together with theoretical insights, should be taken into account in future innovations for blue energy at sea, including the wind farms, but also wave and tidal devices and other technological developments. © 2015 Elsevier Ltd.

Søndergaard, B. (2013). *Low frequency noise from wind turbines: Do the Danish regulations have any impact.* Proceedings 5th International Conference on Wind Turbine Noise, Denver.

Søndergaard, B. (2015). "Low frequency noise from wind turbines: do the danish regulations have any impact? An analysis of noise measurements." *International Journal of Aeroacoustics* **14**(5-6): 909-915.

Songsore, E. and M. Buzzelli (2014). "Social responses to wind energy development in Ontario: The influence of health risk perceptions and associated concerns." *Energy Policy* **69**: 285-296.

This study documents and analyzes the role of health risk perceptions and other associated concerns of wind energy development (henceforth WED) in Ontario. Drawing on the risk society framework, we conduct a longitudinal media content analysis to document and analyze perceptions of and responses to WED over a nine year period. Attention is paid to temporal variations in responses relative to Ontario's Green Energy Act (2009) (henceforth GEA); legislation aimed at the rapid expansion of renewable energy. The study reveals that the most radical forms of resistance to WED on health grounds are driven by perceived injustices in the treatment of potential at-risk citizens and citizens with health concerns. The GEA is fuelling these perceptions of injustices in subtle and nuanced ways, particularly by acting as a major confounder to health risk concerns. Contrary to several existing studies, we problematize the use of financial incentives to foster the development of wind energy. We also provide policy recommendations which include the need for increased public engagement in the WED process, the importance of using third party health and environmental assessments to inform

developments as well as the need for post-development strategies to address ongoing community concerns. © 2014 Elsevier Ltd.

Songsore, E. and M. Buzzelli (2016). "Ontario's Experience of Wind Energy Development as Seen through the Lens of Human Health and Environmental Justice." *Int J Environ Res Public Health* **13**(7).

The province of Ontario has shown great commitment towards the development of renewable energy and, specifically, wind power. Fuelled by the Green Energy Act (GEA) of 2009, the Province has emerged as Canada's leader in wind energy development (WED). Nonetheless, Ontario's WED trajectory is characterized by social conflicts, particularly around environmental health. Utilizing the Social Amplification of Risk Framework, this paper presents an eight-year longitudinal media content analysis conducted to understand the role Ontario's media may be playing in both reflecting and shaping public perceptions of wind turbine health risks. We find that before and after the GEA, instances of health risk amplification were far greater than attenuations in both quantity and quality. Discourses that amplified turbine health risks often simultaneously highlighted injustices in the WED process, especially after the GEA. Based on these findings, we suggest that Ontario's media may be amplifying perceptions of wind turbine health risks within the public domain. We conclude with policy recommendations around public engagement for more just WED.

Sottek, R., et al. (2012). Perception of loudness and roughness of low-frequency sounds C3 - 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012. 41st International Congress and Exposition on Noise Control Engineering 2012, INTER-NOISE 2012, New York, NY.

Growing traffic volume or the increased use of wind turbines as another example elicit an increasingly high noise exposure especially at low frequencies, leading to more and more complaints about noise annoyance. Among other parameters, the loudness of a sound has a strong influence on annoyance. Unfortunately, the existing loudness standards do not show consistent results, especially at low frequencies. Recently, another low-frequency phenomenon has been observed: the modulated or rough impression of pure tones at frequencies below a certain frequency limit. This paper presents first results of new experimental data related to loudness and roughness perception of low-frequency sound events.

Spiess, H., et al. (2015). "Future acceptance of wind energy production: Exploring future local acceptance of wind energy production in a Swiss alpine region." *Technological Forecasting and Social Change* **101**: 263-274.

Future sustainable energy systems strongly rely on new renewable energies. Wind energy production has become an interesting option for alpine regions. In addition to grid reliability, public acceptance is an important factor that currently limits wind energy's market penetration. An interdisciplinary research team explored, through socio-economic and technical approaches, the current and future acceptance of wind energy production in the Swiss energy region of Goms, an alpine valley at 1300. m above sea level. The focus of this paper is on research questions comprising future societal challenges for the local population. For this purpose, the focus-group discussion has proven to be a valuable participatory method. Concerning future development of wind energy in the Alps, regional value creation (including workplaces) and the placement of systems where man-made infrastructure is already present were the main visions mentioned by workshop participants. So far, wind energy as implemented in the valley of Goms has not been perceived as a topic of conflict by the local community. Crucial components towards local acceptance of wind turbines are questions of aesthetics, technical performance and economic feasibility. © 2015 Elsevier Inc.

Stansfeld, S., et al. (2016). WHO environmental noise guidelines for the European Region - What is new? 2. New evidence on health effects from environmental noise and implications for research. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

The Guidelines include systematic reviews of the scientific evidence of the critical health effects of environmental noise: effects on sleep, annoyance, cognitive impairment, cardiovascular diseases, hearing impairment and tinnitus. Other potential health outcomes with less evidence are also systematically reviewed, but have less impact on the development of recommendations: adverse birth outcomes, quality of life, mental health and wellbeing, and diabetes and metabolic diseases. The noise sources considered include aircraft, rail, road, wind turbines and leisure noise. Additionally, the Guidelines review the potential health benefits from noise mitigation and interventions to decrease noise levels. The systematic reviews conducted for the Guidelines have revealed some key knowledge gaps and research needs, which will need to be filled in the future in order to provide stronger advice

for the protection of the population from the harmful effects of noise. These gaps are related to the combined health effects of different noise sources and other environmental exposures, the lack of harmonization in the methods and metrics used to measure health outcomes and noise exposure, the paucity of longitudinal studies, and other issues related to the assessment of effectiveness of interventions for the reduction of noise exposure and improvement of health outcomes. © 2016, German Acoustical Society (DEGA). All rights reserved.

Stead, M., et al. (2014). "Comparison of infrasound measured at people's ears when walking to that measured near wind farms'." Acoustics Australia **42**(3): 197-203.

Stead, M., et al. (2014). "Comparison of infrasound measured at people's ears when walking to that measured near wind farms." Acoustics Australia **42**(3): 197-203.

Infrasound is observed in all environments at varying levels and is generated by a range of natural and anthropogenic sources. Some studies have suggested that modern wind turbines can generate a relatively low level of measurable noise at frequencies corresponding to the blade pass frequency of turbines. People walk at a variety of speeds, with typical walking frequencies similar to the blade passing frequency of modern commercial wind turbines. Measurements have been conducted of the levels of infrasound generated at the human ear when walking and compared to measured levels near wind farms. The measured level of infrasound generated at the ear at blade pass frequency when people walk can be considerably higher than the level near wind farms. In both cases, measured levels were significantly below the audibility threshold for very low frequency noise.

Stigwood, M., et al. (2013). Audible amplitude modulation—results of field measurements and investigations compared to psychoacoustical assessment and theoretical research. Fifth International Conference on Wind Turbine Noise.

Strazzer, E., et al. (2012). "Combining choice experiments with psychometric scales to assess the social acceptability of wind energy projects: A latent class approach." Energy Policy **48**: 334-347.

A choice experiment exercise is combined with psychometric scales in order: (1) to identify factors that explain support/opposition toward a wind energy development project; and (2) to assess (monetary) trade-offs between attributes of the project. A Latent Class estimator is fitted to the data, and different utility parameters are estimated, conditional on class allocation. It is found that the probability of class membership depends on specific psychometric variables. Visual impacts on valued sites are an important factor of opposition toward a project, and this effect is magnified when identity values are attached to the specific site, so much that no trade-off would be acceptable for a class of individuals characterized by strong place attachment. Conversely, other classes of individuals are willing to accept compensations, in form of private and/or public benefits. The distribution of benefits in the territory, and preservation of the option value related to the possible development of an archeological site, are important for a class of individuals concerned with the sustainability of the local economy. © 2012 Elsevier Ltd.

Surana, K. and L. D. Anadon (2015). "Public policy and financial resource mobilization for wind energy in developing countries: A comparison of approaches and outcomes in China and India." Global Environmental Change **35**: 340-359.

We analyze and contrast how China and India mobilized financial resources to build domestic technological innovation systems in wind energy. To that end, we identify distinct stages of technology diffusion in the two countries in the period 1986-2012, and analyze the interplay between public policies and the development of the technological innovation system across the different stages. We show that the two countries' distinct development strategies for wind energy - China developed wind energy largely through its state-owned enterprises, while India opened up wind energy investment to the private sector in the early 1990s - influenced system outcomes in terms of technology diffusion, domestic industry structure, competitiveness, and ownership. By unraveling the interplay between public policies, investment risks and returns, and actor characteristics, we explain the differences in system outcomes and identify important policy trade-offs between the two strategies. Our analysis provides novel insights about the process of financial resource mobilization in technological innovation systems, the dynamics of innovation-system growth, and the policy trade-offs that must be reconciled by countries that aim to promote the diffusion of a particular technology. © 2015 Elsevier Ltd.

Swofford, J. and M. Slattery (2010). "Public attitudes of wind energy in Texas: Local communities in close proximity to wind farms and their effect on decision-making." *Energy Policy* **38**(5): 2508-2519.

Wind energy is now recognized as an important energy resource throughout the world. Within the United States, the state of Texas currently has the largest wind energy capacity with 8797 total megawatts and an additional 660 MW under construction. With this rapid growth, it is important to achieve a better understanding of how wind energy is being perceived by the public. This paper explores three research strands: (i) describing the environmental attitudes of a population in close proximity to a wind farm development, (ii) determining the influence that proximity has on wind energy attitudes, and (iii) determining if the Not-In-My-Backyard (Nimby) phenomenon is appropriate for explaining human perceptions of wind energy. A survey questionnaire was developed to explore perceptions of wind energy in the region as well as general attitudes about energy and the environment. Results regarding general wind energy attitudes signify overall public support for wind energy. In addition, those living closest to the wind farm indicate the lowest levels of support, while those living farthest away indicate much stronger support. Findings support the view that the use of Nimby does not adequately explain the attitudes of local wind farm opposition. Alternative explanations and planning implications are discussed with a focus on public participation and education. © 2009 Elsevier Ltd. All rights reserved.

Tamura, H., et al. (2012). "Chronic exposure to low frequency noise at moderate levels causes impaired balance in mice." *PLoS ONE* **7**(6): e39807.

We are routinely exposed to low frequency noise (LFN; below 0.5 kHz) at moderate levels of 60-70 dB sound pressure level (SPL) generated from various sources in occupational and daily environments. LFN has been reported to affect balance in humans. However, there is limited information about the influence of chronic exposure to LFN at moderate levels for balance. In this study, we investigated whether chronic exposure to LFN at a moderate level of 70 dB SPL affects the vestibule, which is one of the organs responsible for balance in mice. Wild-type ICR mice were exposed for 1 month to LFN (0.1 kHz) and high frequency noise (HFN; 16 kHz) at 70 dB SPL at a distance of approximately 10-20 cm. Behavior analyses including rotarod, beam-crossing and footprint analyses showed impairments of balance in LFN-exposed mice but not in non-exposed mice or HFN-exposed mice. Immunohistochemical analysis showed a decreased number of vestibular hair cells and increased levels of oxidative stress in LFN-exposed mice compared to those in non-exposed mice. Our results suggest that chronic exposure to LFN at moderate levels causes impaired balance involving morphological impairments of the vestibule with enhanced levels of oxidative stress. Thus, the results of this study indicate the importance of considering the risk of chronic exposure to LFN at a moderate level for imbalance.

Tatchley, C., et al. (2016). "Drivers of Public Attitudes towards Small Wind Turbines in the UK." *PLoS ONE* **11**(3): e0152033.

Small Wind Turbines (SWTs) are a growing micro-generation industry with over 870,000 installed units worldwide. No research has focussed on public attitudes towards SWTs, despite evidence the perception of such attitudes are key to planning outcomes and can be a barrier to installations. Here we present the results of a UK wide mail survey investigating public attitudes towards SWTs. Just over half of our respondents, who were predominantly older, white males, felt that SWTs were acceptable across a range of settings, with those on road signs being most accepted and least accepted in hedgerows and gardens. Concern about climate change positively influenced how respondents felt about SWTs. Respondent comments highlight visual impacts and perceptions of the efficiency of this technology are particularly important to this sector of the UK public. Taking this into careful consideration, alongside avoiding locating SWTs in contentious settings such as hedgerows and gardens where possible, may help to minimise public opposition to proposed installations.

Taylor, J., et al. (2013). "Noise levels and noise perception from small and micro wind turbines." *Renewable Energy* **55**: 120-127.

Noise concerns frequently pose a barrier to widespread implementation of wind turbines and while the perception of noise from large turbines has been investigated, there is a relative gap in the research for small and micro wind turbines. This paper presents findings from interdisciplinary research linking noise measurements from small wind installations with an investigation into the effect of individual personality traits and noise perception. A survey distributed to households living close to one of 12 micro or small turbine sites, coupled with environmental noise measurements was analysed. The survey

showed that the most commonly perceived noises are 'swooshing' and 'humming', the presence of which may be inferred from the measured frequency spectra. Exploration of survey results showed individuals with a more negative attitude to wind turbines perceive more noise from a turbine located close to their dwelling and those perceiving more noise report increased levels of general symptoms. Individuals' personality also affected attitudes to wind turbines, noise perception from small and micro turbines and symptom reporting. © 2012 Elsevier Ltd.

Thygesen, J. and A. Agarwal (2014). "Key criteria for sustainable wind energy planning - Lessons from an institutional perspective on the impact assessment literature." Renewable and Sustainable Energy Reviews **39**: 1012-1023.

An increasing number of researchers stress the importance of national planning institutions' role with respect to promoting an "effective" decision-making process in terms of bringing about sustainable energy. Impact assessment (IA) procedures are seen as having strong potential in supporting environmentally conscious energy production. This article discusses criteria for sustainable wind power planning and compares the centralised planning systems for wind energy in two countries - Norway and Scotland - as illustrating cases. We ask the following: What key criteria should be present to secure sustainable wind energy planning, and what are the critical institutional conditions to fulfil these criteria? A review of relevant IA literature reveals four key criteria for promoting sustainable wind planning: (i) clear and integrated political priorities, (ii) stakeholder involvement, (iii) strategic environmental assessment (SEA) and (iv) stringent permission and assessment requirements. We also determined that critical institutional conditions exist that effectively promote sustainable energy production: (a) coordinated energy policy institutions, (b) legitimate planning procedures, (c) that SEAs are followed in the decision-making process and (d) statutory planning regulations. © 2014 Elsevier Ltd.

Tofts, J., et al. (2013). Analysis, identification and treatment of low frequency noise sources associated with complaints against regulated industries C3 - Proceedings of the Institute of Acoustics. Annual Spring Conference, Acoustics 2013, Nottingham.

The aim of this paper is to extend the work of the University of Salford in the 'Defra NANR45 Procedure for the assessment of low frequency noise complaints' to the regulation of noise from industrial sources by the Environment Agency. Details are presented of three case studies in which residents had registered complaints against industries permitted by the Environment Agency. The use of synchronised noise meters to scrutinise potential noise sources is demonstrated. In a particular advance on the NANR45 procedure, a novel application of correlation analysis between the subjective rating recorded in the complainant's log and the exceedance over the NANR45 criteria is described to examine frequencies likely to be the environmental source triggering complaints. Appropriate noise control solutions to address identified sources using the preferred 'noise control at source' approach are illustrated. It is concluded that these techniques and analyses provide a useful complement to the NANR45 procedure by extending its applicability to the investigation and identification of noise sources where an environmental source has been found to be responsible for the low frequency noise complaint.

Tonin, R., et al. (2016). "The effect of infrasound and negative expectations to adverse pathological symptoms from wind farms." Journal of Low Frequency Noise Vibration and Active Control **35**(1): 77-90.

An investigation was conducted on the effect of reported pathological symptoms of simulated infrasound produced by wind turbines. There is ongoing debate in the scientific community concerning the cause of the negative health effects reported by people living near wind farms, whether those effects are caused by the infrasound itself, or alternatively by a psychogenic response (such as a nocebo effect) to a presumption that the infrasound is the cause. In this study, a simulated wind turbine infrasound pressure waveform was generated using a custom-built headphone apparatus. Volunteers were influenced into states of high expectancy of negative effects from infrasound, and low expectancy of negative effects and their reactions to either infrasound or a sham noise were recorded. It was found, at least for the short-term exposure times conducted here-in, that the simulated infrasound has no statistically significant effect on the symptoms reported by volunteers, but the prior concern volunteers had about the effect of infrasound has a statistically significant influence on the symptoms reported. This supports the nocebo effect hypothesis. © the Author(s) 2016.

Torija, A. J. and I. H. Flindell (2014). "Differences in subjective loudness and annoyance depending on the road traffic noise spectrum." J Acoust Soc Am **135**(1): 1-4.

There is at present no consensus about the relative importance of low frequency content in urban road traffic noise. The hypothesis underlying this research is that changes to different parts of the spectrum will have different effects depending on which part of the spectrum is subjectively dominant in any particular situation. This letter reports a simple listening experiment which demonstrates this effect using typical urban main road traffic noise in which the low frequency content is physically dominant without necessarily being subjectively dominant.

Torija, A. J. and I. H. Flindell (2015). "The subjective effect of low frequency content in road traffic noise." The Journal of the Acoustical Society of America **137**(1): 189-198.

Based on subjective listening trials, Torija and Flindell [J. Acoust. Soc. Am. 135, 1-4 (2014)] observed that low frequency content in typical urban main road traffic noise appeared to make a smaller contribution to reported annoyance than might be inferred from its objective or physical dominance. This paper reports a more detailed study which was aimed at (i) identifying the difference in sound levels at which low frequency content becomes subjectively dominant over mid and high frequency content and (ii) investigating the relationship between loudness and annoyance under conditions where low frequency content is relatively more dominant, such as indoors where mid and high frequency content is reduced. The results suggested that differences of at least +30 dB between the low frequency and the mid/high frequency content are needed for changes in low frequency content to have as much subjective effect as equivalent changes in mid and high frequency content. This suggests that common criticisms of the A-frequency weighting based on a hypothesized excessive downweighting of the low frequency content may be relatively unfounded in this application area.

Tsoutsos, T., et al. (2009). "Visual impact evaluation of a wind park in a Greek island." Applied Energy **86**(4): 546-553.

The visual impact of wind turbines is one of the main factors affecting public acceptance of wind parks. This paper evaluates the visual impact of a wind park in Chania, Crete, using the Spanish method of evaluation. The outcomes are combined with the psychometric testing of the residents by the use of questionnaires and with the values of the Spanish method about various scenarios concerning the size of the wind park (double, half, one wind turbine). The results of the study prove that the quantification of the potential visual impact could minimize this, apparently, main reason that affects public acceptance. © 2008.

Turunen, A. W., et al. (2016). Noise annoyance and sleep disturbance in the vicinity of five wind farms in Finland. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

Wind turbine noise has become a concern in many countries. Our aim was to study the prevalence of annoyance and sleep disturbance due to wind turbine noise in Finland. A total of 2,828 questionnaires were sent to randomly selected persons living <2.5, 2.5-5, and >5-10 km from five wind farms. The intention of the questionnaire was masked. The response rate was 48 % (n=1,346). Within <2.5 km of the closest turbine, 1.6 % (n=6) of the participants were very or extremely annoyed by wind turbine noise indoors (windows closed) and 4.6 % (n=17) outdoors. Very or extremely high sleep disturbance was reported by 1.6 % (n=6) of the participants living in the closest distance zone. In addition, the prevalence of symptoms, diseases and medications did not differ between the closest and the two further distance zones. High annoyance and severe sleep disturbance due to wind turbine noise were quite rare in the vicinity of five wind farms in Finland. However, this does not exclude the possibility of some local problems in the vicinity of other wind farms. © 2016, German Acoustical Society (DEGA). All rights reserved.

Unger, C. (2010). Frequencies above the harmonic range - Challenge of the future? 2010 9th International Power and Energy Conference, IPEC 2010, Singapore.

During the last two decades, the main topic in respect to power quality (beside voltage dips and outages) was and still is harmonic distortion. However, following the development in power electronics with an increasing use of self-commutated converters, problems are shifting slowly to higher frequencies. Voltages with frequencies above the "classical" harmonic range create new challenges and require new solutions. With the large-scale introduction of electric vehicles, solar power, wind turbines or similar applications, the level of voltages with frequencies in the kHz range are most likely to increase in the next years. For the operator of a network, by now there exists no sufficient guidance yet in respect to tolerable disturbance levels. Effects of significant voltage levels of higher frequencies are

known only to some extent. Such, there seems to be a lot to do in order to ensure a trouble-free operation of electric distribution networks in the future. The paper tries to give an overview on the current status of voltages above the harmonic range and to identify critical points which require some efforts in the future. ©2010 IEEE.

Upham, P. and J. García Pérez (2015). "A cognitive mapping approach to understanding public objection to energy infrastructure: The case of wind power in Galicia, Spain." *Renewable Energy* **83**: 587-596.

Historically, Spain has experienced relatively little public objection to wind power proposals, but this is changing in the region of Galicia, which now hosts a relatively concentrated level of wind turbines. To document and understand this objection, we take a cognitive mapping approach, commenting on its value as a method and focussing particularly on the issue of community compensation. Cognitive mapping structures the causal logic of individuals' thinking, revealing this and facilitating group discussion. Here we compare cognitive maps that reflect different positions on the controversy. Both monetary and in-kind compensation are dismissed by local campaigners and local stakeholder representatives alike. In-kind compensation is regarded as inadequate firstly because it cannot provide the scale of the public goods perceived as necessary by the host community. Secondly, the developer is in any case considered inappropriate as provider of public goods, which the community think should be delivered by local and regional governments. © 2015 Elsevier Ltd.

Van Den Berg, F. (2009). Why is wind turbine noise noisier than other noise? 8th European Conference on Noise Control 2009, EURONOISE 2009 - Proceedings of the Institute of Acoustics, Edinburgh.

For residents near modern wind farms wind turbine noise is more annoying than other important noise sources, when comparing equal sound levels. Acoustically this may be due to the diurnal course of the noise and the rapid fluctuation in level related to the rotation, which are not usual features of most transportation and industrial noise sources. It can also be a result of non-acoustic factors such as visual intrusion and the perceived distribution of benefits and adverse effects. In this paper the pros and cons of these possible causes will be discussed based on measurement results and surveys, and on comparisons to other industrial and transportation noise sources.

van den Berg, F. (2011). Effects of sound on people. Wind Turbines Noise. D. Bowdler and G. Leventhall. Brentwood, UK, Multi-Science Publishing Co. Ltd.

Van Den Berg, F. (2013). Wind turbine noise: An overview of acoustical performance and effects on residents C3 - Annual Conference of the Australian Acoustical Society 2013, Acoustics 2013: Science, Technology and Amenity. Annual Conference of the Australian Acoustical Society 2013: Science, Technology and Amenity, Acoustics 2013, Victor Harbor, SA, Australian Acoustical Society.

Sound from modern wind turbines is predominantly aerodynamic noise with most audible sound energy at medium and higher frequencies. Wind turbine sound is relatively annoying, probably due to acoustical characteristics, such as amplitude modulation, that increase the risk for annoyance and disturbed sleep. Other health effects, all resembling stress symptoms to at least some degree, are attributed to infrasound, but this is not supported by existing knowledge of noise or noise annoyance and the claims lack substantiation. There is certainly room for the reduction of noise and noise annoyance, perhaps at the expense of maximum energy yield. Copyright © (2013) by the Australian Acoustical Society.

Van Den Berg, F., et al. (2013). Health related guidelines for wind farms in Belgium C3 - 42nd International Congress and Exposition on Noise Control Engineering 2013, INTER-NOISE 2013: Noise Control for Quality of Life. 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, Innsbruck, OAL-Osterreichischer Arbeitsring fur Larmbekampfung.

In 2011 the Belgian authorities have asked the Superior Health Council (SHC) to advise on the health effects of wind farms. A working group of experts with different backgrounds was put together to assess all the available literature. This group considered the request in the context of sustainable development and drafted an advice that was reviewed by two international experts. It is expected that the advice will be published in the spring of 2013. The advice mentions direct effects of operational wind turbines that may have negative consequences for the health and well-being of neighbouring people. It stresses the importance of factors such as the change in landscape, the possible intrusion on people's attachment to their environment and the effect of local economic benefits and costs associated with a wind energy project. Also, the perception of the future quality of life will determine the social

acceptance of a wind project by a local community. The advice gives a number of recommendations to better deal with all these aspects. The paper will give an overview and explanation of these recommendations.

van den Berg, F., et al. (2008). "Project WINDFARMperception: visual and acoustic impact of wind turbine farms on residents." Final report, June 3(2008): 63.

Van den Berg, G. (2007). Wind profiles over complex terrain. proceedings Second International Meeting on Wind Turbine Noise.

Van den Berg, G. P. (2006). "The sound of high winds. The effect of atmospheric stability on wind turbine sound and microphone noise."

Van Renterghem, T., et al. (2013). "Annoyance, detection and recognition of wind turbine noise." Sci Total Environ **456-457**: 333-345.

Annoyance, recognition and detection of noise from a single wind turbine were studied by means of a two-stage listening experiment with 50 participants with normal hearing abilities. In-situ recordings made at close distance from a 1.8-MW wind turbine operating at 22 rpm were mixed with road traffic noise, and processed to simulate indoor sound pressure levels at LAeq 40 dBA. In a first part, where people were unaware of the true purpose of the experiment, samples were played during a quiet leisure activity. Under these conditions, pure wind turbine noise gave very similar annoyance ratings as unmixed highway noise at the same equivalent level, while annoyance by local road traffic noise was significantly higher. In a second experiment, listeners were asked to identify the sample containing wind turbine noise in a paired comparison test. The detection limit of wind turbine noise in presence of highway noise was estimated to be as low as a signal-to-noise ratio of -23 dBA. When mixed with local road traffic, such a detection limit could not be determined. These findings support that noticing the sound could be an important aspect of wind turbine noise annoyance at the low equivalent levels typically observed indoors in practice. Participants that easily recognized wind-turbine(-like) sounds could detect wind turbine noise better when submersed in road traffic noise. Recognition of wind turbine sounds is also linked to higher annoyance. Awareness of the source is therefore a relevant aspect of wind turbine noise perception which is consistent with previous research. Copyright 2013 Elsevier B.V. All rights reserved.

Van Renterghem, T., et al. (2014). "Airborne sound propagation over sea during offshore wind farm piling." J Acoust Soc Am **135**(2): 599-609.

Offshore piling for wind farm construction has attracted a lot of attention in recent years due to the extremely high noise emission levels associated with such operations. While underwater noise levels were shown to be harmful for the marine biology, the propagation of airborne piling noise over sea has not been studied in detail before. In this study, detailed numerical calculations have been performed with the Green's Function Parabolic Equation (GFPE) method to estimate noise levels up to a distance of 10km. Measured noise emission levels during piling of pinpiles for a jacket-foundation wind turbine were assessed and used together with combinations of the sea surface state and idealized vertical sound speed profiles (downwind sound propagation). Effective impedances were found and used to represent non-flat sea surfaces at low-wind sea states 2, 3, and 4. Calculations show that scattering by a rough sea surface, which decreases sound pressure levels, exceeds refractive effects, which increase sound pressure levels under downwind conditions. This suggests that the presence of wind, even when blowing downwind to potential receivers, is beneficial to increase the attenuation of piling sound over the sea. A fully flat sea surface therefore represents a worst-case scenario.

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sound speed profiles (downwind sound propagation). Effective impedances were found and used to represent non-flat sea surfaces at low-wind sea states 2, 3, and 4. Calculations show that scattering by a rough sea surface, which decreases sound pressure levels, exceeds refractive effects, which increase sound pressure levels under downwind conditions. This suggests that the presence of wind, even when blowing downwind to potential receivers, is beneficial to increase the attenuation of piling sound over the sea. A fully flat sea surface therefore represents a worst-case scenario.

Van Renterghem, T., et al. (2014). Propagation distance-of-concern for offshore wind turbine airborne sound during piling and normal operation. Proceedings of Forum Acusticum.

Offshore wind farms are being constructed all over the world at a very high rate. The underwater noise impact, especially during construction, has attracted a lot of attention and is commonly included in environmental impact assessments. In contrast, reported research on the airborne noise impact is scarce. In this work, on-site measurements during normal operation at close distance from a wind turbine show that sound pressure levels are not excessive so that noise issues after propagation over several kilometers are unlikely. In contrast, the extremely high noise levels produced during piling need more care. An emission spectrum was estimated, based on measured sound pressure levels at close distance during a specific piling operation. Detailed numerical predictions were subsequently made to estimate sound pressure levels after propagation up to 10 km above the sea surface under various meteorological conditions. Wind and atmospheric stability influence both the refractive state of the marine atmospheric boundary layer and sea surface roughness, affecting in turn long-distance airborne sound propagation. A windless situation is predicted to be most favorable for sound propagation leading to the highest sound pressure levels. Beyond 10 km, also piling sound pressure levels become sufficiently limited under all possible conditions.

Veidemane, K. and O. Nikodemus (2015). "Coherence between marine and land use planning: public attitudes to landscapes in the context of siting a wind park along the Latvian coast of the Baltic Sea." Journal of Environmental Planning and Management **58**(6): 949-975.

The aim of this paper is to contribute to coherence in marine, coastal and land use planning and management from the perspective of landscape values. At a time when new sea uses are emerging and marine spatial planning laws and regulations are being adopted, but have not yet been put into practice, research studies are required that provide spatial planners with informed insights concerning public stakeholder attitudes to controversial policies. The undertaken research explored the attitudes of two important social groups (local residents and tourists/recreational users) regarding locating wind parks in the marine and/or terrestrial environment along the Latvian coast of the Baltic Sea. The results of the study indicate that both groups support land-based wind park development versus offshore. Moreover, the visibility of wind turbines influences the willingness of tourists to visit recreation sites and impacts directly on their duration of stay. Research findings indicate that policy makers and spatial planners from both marine and land domains should adopt a broader and more integrated approach when setting priorities and allocating space for development activities where both domains are involved. © 2014, © 2014 University of Newcastle upon Tyne.

Verheijen, E., et al. (2011). "Impact of wind turbine noise in the Netherlands." Noise Health **13**(55): 459-463.

The Dutch government aims at an increase of wind energy up to 6 000 MW in 2020 by placing new wind turbines on land or offshore. At the same time, the existing noise legislation for wind turbines is being reconsidered. For the purpose of establishing a new noise reception limit value expressed in L den, the impact of wind turbine noise under the given policy targets needs to be explored. For this purpose, the consequences of different reception limit values for the new Dutch noise legislation have been studied, both in terms of effects on the population and regarding sustainable energy policy targets. On the basis of a nation-wide noise map containing all wind turbines in The Netherlands, it is calculated that 3% of the inhabitants of The Netherlands are currently exposed to noise from wind turbines above 28 dB(A) at the faetaade. Newly established dose-response relationships indicate that about 1500 of these inhabitants are likely to be severely annoyed inside their dwellings. The available space for new wind turbines strongly depends on the noise limit value that will be chosen. This study suggests an outdoor A-weighted reception limit of L den = 45 dB as a trade-off between the need for protection against noise annoyance and the feasibility of national targets for renewable energy.

Voicescu, S. A., et al. (2016). "Estimating annoyance to calculated wind turbine shadow flicker is improved when variables associated with wind turbine noise exposure are considered." J Acoust Soc Am **139**(3): 1480-1492.

The Community Noise and Health Study conducted by Health Canada included randomly selected participants aged 18-79 yrs (606 males, 632 females, response rate 78.9%), living between 0.25 and 11.22km from operational wind turbines. Annoyance to wind turbine noise (WTN) and other features, including shadow flicker (SF) was assessed. The current analysis reports on the degree to which estimating high annoyance to wind turbine shadow flicker (HAWTSF) was improved when variables known to be related to WTN exposure were also considered. As SF exposure increased [calculated as maximum minutes per day (SFm)], HAWTSF increased from 3.8% at $0 < \text{SFm} < 10$ to 21.1% at $\text{SFm} > 30$, $p < 0.0001$. For each unit increase in SFm the odds ratio was 2.02 [95% confidence interval: (1.68,2.43)]. Stepwise regression models for HAWTSF had a predictive strength of up to 53% with 10% attributed to SFm. Variables associated with HAWTSF included, but were not limited to, annoyance to other wind turbine-related features, concern for physical safety, and noise sensitivity. Reported dizziness was also retained in the final model at $p = 0.0581$. Study findings add to the growing science base in this area and may be helpful in identifying factors associated with community reactions to SF exposure from wind turbines.

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Von Frank, R. (2013). "Can the Beauty of Landscape be Calculated? Provision of a statewide planning base for the natural scenery in the Federal State of Baden-Württemberg." *Naturschutz und Landschaftsplanung* **45**(9): 265-270.

Can the Beauty of Landscape be Calculated? Provision of a statewide planning base for the natural scenery in the Federal State of Baden-Württemberg The paper presents a possible approach to a large-scale evaluation of the natural scenery. The method bases on different preparatory studies and has been successfully tested in a pilot study. The current application in Baden-Württemberg is intended to provide an area-wide base for planning projects in the context of nature conservation from the year 2013 onwards. Different analyses of the landscape structure have been used for a regression analysis, empirically based photographic evaluations of a large number of typical landscape sections served as reference data. The results of the multivariable regression analysis were the basis for the area-wide modeling of the quality of the natural scenery. The quality of the model can easily be assessed from a statistical point of view. The maps depicting the results appear to be plausible both on a regional and on a local scale. However, the small-scale applications have to consider that the model does not necessarily reflect site-specific characteristics. The visual landscape as a natural resource has particular relevance for the forthcoming increase of the use of wind power. Because of the rather weak winds in the state of Baden Württemberg, topographically exposed sites have particular relevance and but are, at the same time, particularly sensitive to environmental impact. Against this background, an objective evaluation of the visual landscape serves the criterion for the subsequent balancing of the different interests.

Vyn, R. J. and R. M. McCullough (2014). "The Effects of wind turbines on property values in Ontario: Does public perception match empirical evidence?" *Canadian Journal of Agricultural Economics* **62**(3): 365-392.

The increasing development of wind energy in North America has generated concerns from nearby residents regarding potential impacts of wind turbines on property values. Such concerns arose in

Melancthon Township (in southern Ontario) following the construction of a large wind farm. Existing literature has not reached a consensus regarding the nature of these impacts. This paper applies a hedonic approach to detailed data on 5,414 rural residential sales and 1,590 farmland sales to estimate the impacts of Melancthon's wind turbines on surrounding property values. These impacts are accounted for through both proximity to turbines and turbine visibility—two factors that may contribute to a disamenity effect. The results of the hedonic models, which are robust to a number of alternate model specifications including a repeat sales analysis, suggest that these wind turbines have not significantly impacted nearby property values. Thus, these results do not corroborate the concerns raised by residents regarding potential negative impacts of turbines on property values. © 2014 Canadian Agricultural Economics Society.

Vyn, R. J. and R. M. McCullough (2015). "The effects of wind turbines on property values in Ontario: Does public perception match empirical evidence?: Reply." *Canadian Journal of Agricultural Economics* 63(2): 277-280.

Wagner, S., et al. (2012). *Wind turbine noise*, Springer Science & Business Media.

Walker, B. J. A., et al. (2017). "Community Benefits or Community Bribes? An Experimental Analysis of Strategies for Managing Community Perceptions of Bribery Surrounding the Siting of Renewable Energy Projects." *Environment and Behavior* 49(1): 59-83.

The provision of financial incentives to local communities by energy developers has attracted cynicism across many localities, with some suggesting such community benefits are akin to "bribery." The current study used an experimental design embedded within a community postal survey to explore whether potentially damaging effects of bribery rhetoric upon local support for a wind farm can be overcome through (a) portraying community benefits as a policy requirement (rather than a discretionary gesture by developers), and/or (b) the deployment of different discursive strategies by developers to manage their stake in the outcome of the project. Participants told about community benefits as being a policy requirement showed significantly higher support for the wind farm, an effect that was mediated by heightened perceptions of individually and collectively favorable outcomes from the development. We discuss our results in relation to their implications for government policy approaches to promoting renewable energy supply. © 2015, © 2015 SAGE Publications.

Walker, B. J. A., et al. (2015). "Community benefits, framing and the social acceptance of offshore wind farms: An experimental study in England." *Energy Research and Social Science* 3(C): 46-54.

The provision of community benefits, payments to communities affected by renewable energy developments, has received significant policy-maker attention in recent years. This research explores whether the provision of community benefits associates with increased local support for a hypothetical, future offshore wind farm in Exmouth (UK), using an experimental methodology (n = 311). Participants were allocated to one of three framing conditions: (i) a 'no-framed condition', presenting basic information about a possible wind farm without mentioning community benefits; (ii) a 'community benefit frame', highlighting the likely community benefits that would accompany a wind farm; or (iii) a 'dual framing' condition, presenting information about community benefits alongside critical perspectives that commonly surround these (perceptions of 'bribery'). Support for the development was greatest under the community benefit frame. However, this heightened support diminished in a context of social contestation (the dual framing condition). Elevated perceptions of collective rather than individual outcome favourability or procedural justice explained why support was greatest under the community benefit frame. Ensuring and communicating that community benefits offer a 'good deal' to communities, rather than focusing on individual benefits, may be the most viable avenue to increase support for renewable energy developments through community benefits. © 2014 Elsevier Ltd. All rights reserved.

Walker, C., et al. (2014). "Adding insult to injury: The development of psychosocial stress in Ontario wind turbine communities." *Social Science and Medicine*.

Though historically dismissed as not-in-my-backyard (NIMBY) attitudes, reports of psychosocial stress linked to wind energy developments have emerged in Ontario, Canada. While the debate and rhetoric intensify concerning whether wind turbines 'actually' cause 'health' effects, less sincere attention has been given to the lived experience and mental well-being of those near turbines. Drawing on theories of environmental stress, this grounded theory, mixed-method (n=26 interviews; n=152 questionnaires) study of two communities in 2011 and 2012 traces how and why some wind turbine community

residents suffer substantial changes to quality of life, develop negative perceptions of 'the other' and in some cases, experience intra-community conflict. Policy-related forces, along with existing community relationships may help explain much of these differences between communities. We suggest a move beyond debating simply whether or not 'annoyance' represents a 'health impact' and instead focus on ways to minimize and attenuate these feelings of threat (risk) and stress at the community level. © 2014 Elsevier Ltd.

Walker, C., et al. (2015). "Adding insult to injury: The development of psychosocial stress in Ontario wind turbine communities." *Soc Sci Med* **133**: 358-365.

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Walker, E. D., et al. (2016). "Cardiovascular and stress responses to short-term noise exposures-A panel study in healthy males." *Environ Res* **150**: 391-397.

BACKGROUND: While previous epidemiological studies report adverse effects of long-term noise exposure on cardiovascular health, the mechanisms responsible for these effects are unclear. We sought to elucidate the cardiovascular and stress response to short-term, low (31.5-125Hz) and high (500-2000Hz) frequency noise exposures.

METHODS: Healthy male (n=10) participants were monitored on multiple visits during no noise, low- or high-frequency noise exposure scenarios lasting 40min. Participants were fitted with an ambulatory electrocardiogram (ECG) and blood pressure measures and saliva samples were taken before, during and after noise exposures. ECGs were processed for measures of heart rate variability (HRV): high-frequency power (HF), low-frequency power (LF), the root of the mean squared difference between adjacent normal heart beats (N-N) intervals (RMSSD), and the standard deviation of N-N intervals (SDNN). Systolic blood pressure (SBP), diastolic blood pressure (DPB), and pulse were reported and saliva was analyzed for salivary cortisol and amylase. Multivariate mixed-effects linear regression models adjusted for age were used to identify statistically significant difference in outcomes by no noise, during noise or after noise exposure periods and whether this differed by noise frequency.

RESULTS: A total of 658, 205, and 122, HRV, saliva, and blood pressure measurements were performed over 41 person days. Reductions in HRV (LF and RMSSD) were observed during noise exposure (a reduction of 19% (-35,-3.5) and 9.1% (-17,-1.1), respectively). After adjusting for noise frequency, during low frequency noise exposure, HF, LF, and SDNN were reduced (a reduction of 32% (-57,-6.2), 34% (-52,-15), and 16% (-26,-6.1), respectively) and during high frequency noise exposure, a 21% (-39,-2.3) reduction in LF, as compared to during no noise exposure, was found. No significant (p<0.05) changes in blood pressure, salivary cortisol, or amylase were observed.

CONCLUSIONS: These results suggest that exposure to noise, and in particular, to low-frequency noise, negatively impacts HRV. The frequencies of noise should be considered when evaluating the cardiovascular health impacts of exposure. Copyright © 2016 Elsevier Inc. All rights reserved.

Wang, L. M. and C. C. Novak (2010). Human performance and perception-based evaluations of indoor noise criteria for rating mechanical system noise with time-varying fluctuations. ASHRAE Transactions, Albuquerque, NM.

The goal of this study was to investigate the effects of noise from building mechanical systems with time-varying fluctuations on human taskperformance and perception, and to determine how well current indoor noise rating methods account for this performance and perception. Six different noise conditions with varying degrees of time-varying fluctuations, many focused in the low frequency rumble region, were reproduced in an office-like setting. Thirty participants were asked to complete typing, grammatical reasoning, and math tasks plus subjective questionnaires, while being exposed for

approximately one hour to each noise condition. Results show that the noise conditions with higher sound levels (greater than 50 dBA) combined with excessive low frequency rumble as well as those with larger timescale fluctuations (i.e., a heat pump cycling on and off every 30 seconds) were generally perceived to be more annoying than the other signals tested, although statistically significant negative relationships to task performance were not found. Other findings are (1) that the noise characteristics most closely correlated to higher annoyance/ distraction responses in this study were higher ratings of loudness followed by roar, rumble, and changes in time; and (2) that perception of more low frequency rumble in particular was significantly linked to reduced performance on cognitively demanding tasks. As for the ability of current indoor noise rating systems to match human performance or perception, none of the indoor noise rating methods evaluated were significantly correlated to task performance, but aspects of subjective perception such as loudness ratings were statistically related. Spectral quality ratings included with some noise rating methodologies were inconsistent with subjective perception, but other metrics such as RNC, L1-L99 [LF ave], and LCeq-LAeq, were strongly correlated to rumble perception. The authors use the results to suggest a framework for an 'ideal' indoor noise rating method, but further research is required towards quantifying specific guidelines for acceptable degrees of time-varying fluctuations and tonalness. ©2010 ASHRAE.

Wang, S. Q., et al. (2013). The management and relationship between different frequency noise and subjective annoyance C3 - Proceedings of 2012 3rd International Asia Conference on Industrial Engineering and Management Innovation, IEMI 2012. 2012 3rd International Asia Conference on Industrial Engineering and Management Innovation, IEMI 2012, Beijing.

This paper is aimed to explore the influence of different frequency noises to subjective annoyance. In order to analyze the impact, the surveying community-citizens were divided into different groups in accordance with the purposes of the analysis, and the different degrees of the noise-influence was analyzed by contrast with different groups. The results showed that the subject annoyance was influenced by the noise and has the positive correlation with the noise level and the noise frequency, especially the low frequency noise having obvious influence on the elders. © 2013 Springer-Verlag Berlin Heidelberg.

Wang, X. (2013). Visibility analysis of wind turbines applied to assessment of wind farms' electromagnetic impact C3 - 2013 IEEE 3rd International Conference on Information Science and Technology, ICIST 2013. 2013 IEEE 3rd International Conference on Information Science and Technology, ICIST 2013, Yangzhou, Jiangsu, IEEE Computer Society.

Wind farms have increased exponentially in the last decade around the world. Recent research revealed that wind farms may interfere with electronic equipments which employ electromagnetic wave such as radar, radio navigation instrument, etc. Therefore wind farms may threaten aviation safety and nautical safety. The wind farm is composed of several wind turbines. For evaluating the electromagnetic impact of wind farms on electronic equipment, the paper proposed a visibility analysis method for wind turbines. The method treats the wind turbine as a combination of a thin cylinder and a sphere firstly. Then the visibility is analyzed point by point in a specific section of the sphere. The result that whether a wind turbine is visible or invisible from a specified view point could be obtained by the proposed method. Also, for some wind turbines which are visible partly, which parts of the wind turbine are visible would be given further by the proposed method. Finally the proposed method is verified by simulated data. © 2013 IEEE.

Warren, C. R. and M. McFadyen (2010). "Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland." Land Use Policy **27**(2): 204-213.

This paper presents the results of a study of public attitudes to onshore windfarm development in south-west Scotland. Specifically, it explores the influences of different development models on attitudes to windfarms by comparing public attitudes towards a community-owned windfarm on the Isle of Gigha with attitudes towards several developer-owned windfarms on the adjacent Kintyre peninsula. The study, conducted in 2006, used a questionnaire-based survey (n = 106) to test the hypothesis that community ownership would lead to greater public acceptance of windfarms. It also examined the attitudes of both residents and tourists towards the impacts of onshore windfarms on landscapes and seascapes, including cumulative impacts. The data show that the Gigha respondents were consistently more positive about wind power than were the Kintyre residents. However, the differences were differences of degree rather than diametrically opposing viewpoints. The most significant concerns about windfarms were intermittent production and visual impact, but majorities in both areas

nevertheless regarded their visual impact as positive. The data also indicate that local attitudes could become even more positive if future windfarms were owned by local communities. The fact that the residents of Gigha have affectionately dubbed their turbines 'the Three Dancing Ladies' is indicative of the positive psychological effects of community ownership. These results support the contention that a change of development model towards community ownership could have a positive effect on public attitudes towards windfarm developments in Scotland. © 2009 Elsevier Ltd. All rights reserved.

Weichenberger, M., et al. (2015). "Brief bursts of infrasound may improve cognitive function - An fMRI study." *Hearing Research* **328**: 87-93.

At present, infrasound (sound frequency < 20 Hz; IS) is being controversially discussed as a potential mediator of several adverse bodily as well as psychological effects. However, it remains unclear, if and in what way IS influences cognition. Here, we conducted an fMRI experiment, in which 13 healthy participants were exposed to IS, while cognitive performance was assessed in an n-back working memory paradigm. During the task, short sinusoidal tone bursts of 12 Hz were administered monaurally with sound pressure levels that had been determined individually in a categorical loudness scaling session prior to the fMRI experiment. We found that task execution was associated with a significant activation of the prefrontal and the parietal cortex, as well as the striatum and the cerebellum, indicating the recruitment of a cognitive control network. Reverse contrast analysis (n-back with tone vs. n-back without tone) revealed a significant activation of the bilateral primary auditory cortex (Brodmann areas 41, 42). Surprisingly, we also found a strong, yet non-significant trend for an improvement of task performance during IS exposure. There was no correlation between performance and brain activity measures in tone and no-tone condition with sum scores of depression-, anxiety-, and personality factor assessment scales (BDI, STAIX1/X2, BFI-S). Although exerting a pronounced effect on cortical brain activity, we obtained no evidence for an impairment of cognition due to brief bursts of IS. On the contrary, potential improvement of working memory function introduces an entirely new aspect to the debate on IS-related effects.

Weigler, T. and D. Krahé (2011). "Multisensory perception in the presence of low frequency sound." *Lärmbekämpfung* **6**(3): 120-122.

Westerberg, V., et al. (2015). "Offshore wind farms in Southern Europe - Determining tourist preference and social acceptance." *Energy Research and Social Science* **10**: 165-179.

There is increasing consensus that resistance to the siting of wind power facilities cannot be explained by the NIMBY phenomenon alone or other localized environmental impacts. This deficiency is addressed by examining the determinants of tourist preferences for positioning of wind farms in the Mediterranean Sea. A principal component analysis is used to identify general attitudinal themes that act as covariates in a choice model. We demonstrate that the welfare economic impacts associated with spending holidays in the vicinity of an offshore wind farm do not merely depend on visibility effects, but equally on the individual's opinion of climate change, efficiency of wind energy and the substitutability of nuclear and fossil fuels with renewable power generating sources. © 2015 Elsevier Ltd. All rights reserved.

Wilson, G. A. and S. L. Dyke (2016). "Pre- and post-installation community perceptions of wind farm projects: The case of Roskrow Barton (Cornwall, UK)." *Land Use Policy* **52**: 287-296.

This study analyses community perceptions towards wind power using a case study of an operational wind farm (Roskrow Barton, Cornwall) to test current debates about pre- and post-acceptance opinions of affected stakeholders. Community members and affected stakeholders were interviewed to assess perceptions towards the development before and after the wind farm became operational. The results suggest that community perceptions towards the wind farm were influenced by a range of environmental, socio-economic and socio-political variables, but also that community opinion changes considerably over time. Although negative perceptions can be found both pre- and post-installation, collectively the community have become used to the turbines and that attitudes have generally become more favourable. The outcomes add to existing 'before and after wind turbine' studies which show that fears of living near a wind farm at least partly dispel over time, although a more nuanced pathway of acceptance emerges than suggested in other studies who suggested a generalised U-shaped development of attitudes. The results from this study suggest more complex, multi-layered and nuanced community responses to wind farms, with slightly different 'acceptance curves' for individual

areas of concern including visual intrusion, noise, property price impacts, economic benefits to the community, and environmental impacts. © 2015 Elsevier Ltd.

Windenergie, P. K. (2015). "Geluid van windturbines."

Wise, S. and G. Leventhall (2010). "Active noise control as a solution to low frequency noise problems." Journal of Low Frequency Noise Vibration and Active Control **29**(2): 129-137.

The control of low frequency noise presents special problems which do not occur at higher frequencies. These problems relate mainly to the long wavelength at low frequencies, which leads to little absorption by conventional means, unless large quantities of absorbing material or large volumes of space are used. There are many examples of low frequency noise problems which can be solved by active attenuation, without the use of thick absorbing material. Some of these are given in this paper.

Witthöft, M. and G. J. Rubin (2013). "Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF)." Journal of psychosomatic research **74**(3): 206-212.

Wszolek, T., et al. (2014). "On certain problems concerning environmental impact assessment of wind turbines in scope of acoustic effects." Acta Physica Polonica A **125**(4 A): A38-A44.

The paper deals with difficulties that are encountered by investors and decision-making authorities in the course of investment processes involving construction of wind power plants. Moreover, attention is focused on absence of standardized procedures that could be used to determine environmental impact of wind turbines, mainly in the scope of acoustic effects appearing in conditions typical for operation of such devices (strong wind), high elevation of related noise sources, and the nature of the sound emission (tonality and amplitude modulation). Lack of such procedures is a source of serious ambiguities developing in assessment of all investment stages - planning and forecasting, construction, and operation. An additional problem arises in the case of power plants located in the vicinity of Natura 2000 area, where construction projects are often obstructed on the grounds of unclear criteria concerning, among other things, the effect of acoustic phenomena on birds, bats, and other animals. It follows from the research presented in this paper that the consistent system of procedures and criteria should be worked out on the grounds of long-term monitoring studies.

Xie, H., et al. (2016). "Noise exposure of residential areas along LRT lines in a mountainous city." Science of the Total Environment **568**: 1283-1294.

Light rapid transit (LRT) has been widely used in a number of Chinese cities in recent years. Different from plain cities, the urban areas in mountainous cities are featured with dense road networks and high density of buildings. The noise impact of urban LRT could be more complex and significant due to the special morphological conditions in mountainous cities. This paper aims to investigate the noise exposure of residential areas along LRT lines in a typical mountainous city, namely Chongqing in Southwest China, through a series of field measurements and questionnaire surveys. Eight typical spatial configurations were classified to represent the relationships between LRT lines and urban mountainous environment. Both the outdoor and indoor acoustic environment of residential areas along LRT lines largely exceeded the national standards by up to 15 dBA, with dominant at low frequencies. The LRT noises tend to be more dominant on the 'below track' and 'passing through' rather than 'above track' areas or 'facing towards' locations. Good agreements were achieved between acoustic measurements and subjective evaluations from the local residents. Residents in the noisier areas tend to be more annoyed and influenced by the LRT noise, and 63.2% of interviewed residents once were awakened by the LRT noise. Among various urban noise sources, LRT noise resulted in the largest percentages of highly annoyed residents (30.9%), and acoustic environment was identified by 42.2% of the participants as the most urgent environmental factor to be improved. The preferred control strategies for LRT noise are possible but limited in practice. Moreover, noise sensitivity and age might significantly affect LRT noise annoyance and impact, whereas window glazing and residence time have no significant influence.

Yamada, S., et al. (2012). "Case studies of field measurements of low frequency sound and complaints by a non profit organization for supporting noise, vibration and low frequency noise complainants in Japan." Journal of Low Frequency Noise Vibration and Active Control **31**(4): 257-266.

The number of noise complaints of Japan is around 15,000 a year and there are about 200 complaints of low frequency noise. In our NPO (Non Profit Organization), the specialists as volunteers on noise,

vibration and low frequency noise take counsel with the complaints and measure the low frequency noise. It is difficult to measure the noise in the night by local government, and in such cases we measure the noise in the night for a long-time in complainant's house. However, sometimes we cannot find the appropriate level of low frequency noise, though the complainant appeals for the serious damage by low frequency noise. Therefore we measured the complaint's reaction at the same time with low frequency noise in the complainant's house. We analyzed the correlation between the complaint's reaction and measured low frequency noise. In many cases, we cannot find out the correlation between the measured low frequency noise and complainant's reaction.

Yano, T., et al. (2013). Dose-response relationships for wind turbine noise in Japan C3 - 42nd International Congress and Exposition on Noise Control Engineering 2013, INTER-NOISE 2013: Noise Control for Quality of Life. 42nd International Congress and Exposition on Noise Control Engineering 2013: Noise Control for Quality of Life, INTER-NOISE 2013, Innsbruck, OAL-Osterreichischer Arbeitsring fur Larmbekampfung.

In order to obtain a base for wind turbine noise policy, a socio- Acoustic survey was carried out throughout Japan from Hokkaido to Okinawa over three years (2010-2012). In total 747 responses were obtained with face- To-face interview method. The wind turbine noise was measured at several points in each site for successive five days. The LAeq,n, which was precisely measured outdoor in a day, was taken as noise exposure. A representative exposure- Annoyance relationship was drawn based on all data. The trend was consistent to those from Swedish and Dutch surveys. People at sites with sea wave sound were less annoyed by wind turbine noise than those at sites without. The effects of moderating factors such as interest in environmental problems, disturbance of landscape and sensitivity to noise were also investigated.

Yokoyama, S., et al. (2016). Perception of tonal components contained in wind turbine noise. Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future.

Tonal components in wind turbine noise increase psycho-acoustical annoyance in the areas around wind farms. Therefore, the methods to assess the characteristics of this kind of sound should be investigated in both viewpoints, physically and psycho-acoustically. Regarding the latter problem, the authors performed auditory experiments by using a test facility capable of reproducing low frequency sounds including infrasound. As the first experiment on the effect of tonal components in wind turbine noise, the change of auditory impression was examined using artificially synthesized noises containing a tonal component with varying frequencies and levels. For the test stimuli, synthesized noises modelling the frequency characteristics of the general wind turbine noise observed outdoors/indoors in immission areas were used. For the simulation of the transmitted sound from outdoors into a residential room, the proposed house-filter for a single-pane window was applied. As the second experiment, the annoyance sensation due to a tonal component in WTN was examined applying the method of subjective adjustment. For the test stimuli, artificially synthesized sounds modelling outdoor were also used. From the results of these investigations, the method for assessing the tonal components in wind turbine noise in immission areas is discussed. © 2016, German Acoustical Society (DEGA). All rights reserved.

Yokoyama, S., et al. (2014). "Perception of low frequency components in wind turbine noise." Noise Control Engineering Journal **62**(5): 295-305.

Wind turbine noise is a new environmental noise problem caused by the development of wind power generation. This problem has often been discussed as a low frequency noise issue and the psychoacoustic and health effects of low frequency components are an important matter of controversy. As a study related to this problem, the authors have conducted a series of laboratory experiments using a test facility capable of reproducing sounds of low frequencies down to infrasound. Three auditory experiments conducted to investigate the human auditory sensation of low frequency components contained in wind turbine noise are reported in this paper. In the first experiment, the audibility of low frequency components of wind turbine noise was examined by changing its spectrum characteristics by applying low-pass filtering with ten different cutoff frequencies from 10 to 125 Hz. In the second experiment, the hearing thresholds for sounds containing dominant components at low frequencies were tested by changing the width of the frequency band in seven steps and the critical spectral characteristics in 1/3-octave-bands for the hearing threshold are investigated. In the third experiment, a loudness test was performed using an artificial noise modeling general wind turbine noises, in which the frequency characteristic of the test sound was changed by applying high-pass filtering with nine different cutoff frequencies from 16 Hz to 1 kHz. Based on the results of these experimental

investigations, the suitability of single-number indices for the assessment of wind turbine noise is discussed.

Yokoyama, S., et al. (2014). "Perception of low frequency components in wind turbine noise." Noise Control Engineering Journal **62**(5): 295-305.

Yokoyama, S., et al. (2014). "Perception of low frequency components in wind turbine noise." Noise Control Engineering Journal **62**(5): 295-305.

Yoon, K., et al. (2016). "Effects of amplitude modulation on perception of wind turbine noise." Journal of Mechanical Science and Technology **30**(10): 4503-4509.

Wind turbine noise is considered to be easily detectable and highly annoying at relatively lower sound levels than other noise sources. Many previous studies attributed this characteristic to amplitude modulation. However, it is unclear whether amplitude modulation is the main cause of these properties of wind turbine noise. Therefore, the aim of the current study is to identify the relationship between amplitude modulation and these two properties of wind turbine noise. For this investigation, two experiments were conducted. In the first experiment, 12 participants determined the detection thresholds of six target sounds in the presence of background noise. In the second experiment, 12 participants matched the loudness of modified sounds without amplitude modulation to that of target sounds with amplitude modulation. The results showed that the detection threshold was lowered as the modulation depth increased; additionally, sounds with amplitude modulation had higher subjective loudness than those without amplitude modulation. © 2016, The Korean Society of Mechanical Engineers and Springer-Verlag Berlin Heidelberg.

Yuan, X., et al. (2015). "Social acceptance of wind power: A case study of Shandong Province, China." Journal of Cleaner Production **92**: 168-178.

Wind power, as a renewable energy source, plays an important role for achieving goal of the transition to post-fossil carbon societies. Despite significant environmental benefits associated with wind power, its social acceptance should not be overlooked. A case study approach was used for the research to investigate social acceptance of wind power in Shandong Province, China. A questionnaire survey was distributed to local residents, which was supplemented with a critical review of current policies. The results revealed that there are consistent concerns on environmental quality issues from local residents regardless of their age or educational level; they were generally supportive of developing wind power resources. However, their level of support dropped significantly for actions to be taken such as installing small-scale wind turbines in their own backyards or in accepting higher electricity prices. Similarly, local residents were generally aware of benefits and drawbacks of wind power. The data also revealed that local residents may accept renewable energy due to their concerns about environmental issues. The level of social acceptance by local residents for wind power was contingent upon their age, income, educational level, and location of residency. These findings provide useful inputs to both the industry and government in terms of improving social acceptance of wind power in future developments. © 2015 Elsevier Ltd. All rights reserved.

Zajamsek, B., et al. (2014). "Characterising noise and annoyance in homes near a wind farm." Acoustics Australia **42**(1): 14-19.

This study examines the relationship between indoor sound pressure level, local weather conditions, wind farm output power and resident rated annoyance in homes near a wind farm. A new methodology is presented that simultaneously records resident rated annoyance and corresponding time-series noise data while continuously monitoring one-third octave band noise levels and local weather conditions. Results of indoor noise and annoyance monitoring are presented for two homes near a wind farm whose residents claim to be annoyed by wind farm noise. Annoyance was found to be related to the overall noise level; however, noise levels were more strongly controlled by local wind speed.

Zaunbrecher, B. S. and M. Ziefle (2015). Social acceptance and its role for planning technology infrastructure: A position paper, taking wind power plants as an example. SMARTGREENS 2015 - 4th International Conference on Smart Cities and Green ICT Systems, Proceedings.

It will be argued that there are major social gaps in the planning of complex energy infrastructure for public spaces: the first "gap" concerns the question if social acceptance can be reliably measured. The second "gap" refers to the lack of an integration of results from acceptance research into current

planning procedures. Taking wind farm planning as an example, both social gaps are discussed and an integrative planning procedure is advocated. Finally, requirements for a user-centered planning process are formulated.

Zaunbrecher, B. S. and M. Ziefle (2016). "Integrating acceptance-relevant factors into wind power planning: A discussion." Sustainable Cities and Society **27**: 307-314.

In this paper, a framework is proposed which aims at including social acceptance as an integral component of planning of large scale technologies. To date, social acceptance is often considered only in the final stage of the planning process, if at all. It will be argued that acceptance-relevant factors should be integrated during the whole process in order to include the public and coordinate acceptance and planning in combination. In order to achieve this, a social gap in the planning of complex energy infrastructure needs to be closed. The social gap presents itself in a twofold manner: one issue is the critical analysis of the general measurability of acceptance factors referring to the question if it is possible to operationalize and predict social acceptance reliably. The second "gap" refers to the lack of integration of results from acceptance research into current planning procedures. Taking wind farm planning as an example, the two gaps are discussed and a new, integrative planning model is advocated. Finally, requirements for a user-centered planning procedure are derived. © 2016 Elsevier Ltd

Ziaran, S. (2013). "Potential health effects of standing waves generated by low frequency noise." Noise Health **15**(65): 237-245.

The main aim is to present the available updated knowledge regarding the potential health effects of standing waves generated by low frequency noise (LFN) from an open window in a moving car where the negative effects of LFN induced by heating components and/or heating, ventilation and air-conditioning are assessed. Furthermore, the assessment of noise in chosen enclosed spaces, such as rooms, offices, and classrooms, or other LFN sources and their effect on the human being were investigated. These types of noise are responsible for disturbance during relaxation, sleep, mental work, education, and concentration, which may reflect negatively on the comfort and health of the population and on the mental state of people such as scientific staff and students. The assessment points out the most exposed areas, and analyzes the conditions of standing wave generation in these rooms caused by outdoor and/or indoor sources. Measurements were made for three different enclosed spaces (office, flat, and passenger car) and sources (traffic specific noise at intersections, noise induced by pipe vibration, and aerodynamic noise) and their operating conditions. For the detection of LFN, the A-weighted sound pressure level and vibration were measured and a fast Fourier transform analysis was used. The LFN sources are specified and the direct effects on the human are reported. Finally, this paper suggests the possibilities for the assessment of LFN and some possible measures that can be taken to prevent or reduce them.

Ziaran, S. (2014). "The assessment and evaluation of low-frequency noise near the region of infrasound." Noise Health **16**(68): 10-17.

The main aim of this paper is to present recent knowledge about the assessment and evaluation of low-frequency sounds (noise) and infrasound, close to the threshold of hearing, and identify their potential effect on human health and annoyance. Low-frequency noise generated by air flowing over a moving car with an open window was chosen as a typical scenario which can be subjectively assessed by people traveling by automobile. The principle of noise generated within the interior of the car and its effects on the comfort of the driver and passengers are analyzed at different velocities. An open window of a car at high velocity behaves as a source of specifically strong tonal low-frequency noise which is generally perceived as annoying. The interior noise generated by an open window of a passenger car was measured under different conditions: Driving on a highway and driving on a typical roadway. First, an octave-band analysis was used to assess the noise level and its impact on the driver's comfort. Second, a fast Fourier transform (FFT) analysis and one-third octave-band analysis were used for the detection of tonal low-frequency noise. Comparison between two different car makers was also done. Finally, the paper suggests some possibilities for scientifically assessing and evaluating low-frequency sounds in general, and some recommendations are introduced for scientific discussion, since sounds with strong low-frequency content (but not only strong) engender greater annoyance than is predicted by an A-weighted sound pressure level.