Visual-Acoustic Simulations for Integrating Cultural Landscape Values into Wind Park Assessments

Madeleine MANYOKY[1], Robert G. RIBE[2],
Adrienne GRÊT-REGAMEY[3] and Ulrike WISSEN HAYEK[4]

[1,3,4]ETH Zurich, Planning of Landscape and Urban Systems, Zurich/Switzerland · manyoky@nsl.ethz.ch; gret@nsl.ethz.ch; wissen@nsl.ethz.ch
[2]University of Oregon, Eugene/OR/USA · rribe@uoregon.edu

Abstract

Instruments for capturing the experiential and social values of the landscape are not yet well developed. These are needed in a format that is suitable for a comprehensive landscape impact assessment derived from public perceptions in participatory processes. Concerning the assessment of future wind parks, a critical deficit lies in appropriate visual and aural simulation tools to garner public perceptions of alternative wind park locations and designs. We present a visual-acoustic simulation tool and demonstrate its implementation in an experiment for gathering people's preferences and values with regards to wind park scenarios in different landscape types. The results indicate there are factors that influence the acceptance of wind parks, such as the landscape type, information on the hazard level to birds, and individual attitudes. Hence, the simulations may be suitable to evaluate cultural landscape values when provided to the local public, and could help to better define thresholds for future wind parks according to landscape types.

1 Introduction

Participatory landscape planning processes that integrate local and scientific knowledge are regarded as suitable to evaluate the appropriateness of potential technical and local solutions to environmental problems (REED 2008). However, experiential and social values present in landscapes that arise from a cultural context also contribute to cultural identity and diversity. The knowledge of the range of these so-called cultural values is not yet fully integrated into such processes (STEPHENSON 2008). These cultural values influence public support for landscape management (DANIEL et al. 2012). For example, in the context of fostering renewable energy systems to master the turn towards sustainable energy, DEVINE-WRIGHT (2005) and WOLSINK (2007a) already found that the acceptance of wind parks is significantly influenced by perceptions of the values of a landscape characterized by aesthetic quality and sense of place. Furthermore, noise made by rotating turbine blades is strongly correlated with the perception of adverse impacts on the landscape (PEDERSEN & LARSMAN 2008). However, management decisions solely based on the assessment of the scenic beauty (both visual and aural) neglects the wider range of values held by the people, such as historic, social or spiritual values provided by a landscape (STEPHENSON 2008). Hence, gathering and representing site-specific future landscape conditions for planning

Buhmann, E., Ervin, S. M. & Pietsch, M. (Eds.) (2015): Peer Reviewed Proceedings of Digital Landscape Architecture 2015 at Anhalt University of Applied Sciences. © Herbert Wichmann Verlag, VDE VERLAG GMBH, Berlin/Offenbach. ISBN 978-3-87907-555-3.

wind parks with the involvement of local publics and their perceptions of alternative wind energy landscapes is crucial (WOLSINK 2007b).

However, these cultural values are difficult to evaluate because it is challenging to quantify them in biophysical or monetary terms (DANIEL et al., 2013). They can rather be identified, when they are expressed by the people (STEPHENSON 2008). With regards to the planning of wind parks, instruments to capture these cultural values of the landscape are not yet well developed. These instruments are needed in a format that is suitable for impact assessment of future wind parks derived from public perceptions ascertained in participatory processes at the planning stage. A critical deficit lies in appropriate visual and aural simulation tools to garner public perceptions of alternative wind park locations and designs (MAFFEI et al. 2013, MANYOKY et al. 2014). Moreover, the simulation tools should be suitable for identifying factors based on perceptions, values and preferences (GRÊT-REGAMEY et al. 2014) influencing the acceptance of wind parks in different landscape types. We present a visual-acoustic visualization tool, which has the potential to fill this gap.

2 Methods

2.1 Visual-Acoustic Simulation Tool (VisAsim)

A visual-acoustic simulation tool (VisAsim) for landscape impact assessment of wind parks was developed. We employed the software CryENGINE (CRYTEK GMBH) for interactive GIS-based 3D landscape visualization to generate a high level of visual realism (MANYOKY et al. 2014). In addition, soundscape simulations were generated with a pure synthesis model for wind turbine emission sounds. The input parameters of the model were obtained by elaborate signal analysis algorithms, which were applied to emission recordings of a wind turbine in the field, in this case a Vestas V 90 (PIEREN et al. 2014). A link between the visualization and the acoustical model was established by controlling and recording specific parameters in the game engine, that are required input parameters for the sound simulation, such as the coordinates of the sound source and receiver positions, the weather conditions, and the wind speed. In this way for defined locations the simulated sounds were linked to the visualizations, resulting in visual-acoustic simulations (MANYOKY et al. 2014). To present these simulations to members of the public in different locations (e.g. community hall) while keeping the conditions for perceiving the represented landscape under control for maximum validity, a mobile visual-acoustic lab was developed. Following the approach of ROHRMANN & BISHOP (2002), we have tested the visual-acoustic simulations for whether the landscape representations are realistic enough to induce responses similar to subjects' assessment of corresponding video records of real environments. The validation analysis showed that videos of simulations induced quite similar responses as videos of the corresponding real wind park with regards to how much people liked the landscape and how annoying the wind turbine noise was for them. This indicates that the visual-acoustic simulations can be used in further studies for assessing people's evaluations of future wind parks in landscapes.

2.2 Identifying Factors Influencing the Acceptance of Wind Turbines

The VisAsim tool was then employed in an acceptability study conducted in Switzerland. Wind energy development in Switzerland is often particularly subject to controversial

debates regarding the implementation of new infrastructures at the local scale (HÜBNER et al. 2013). The goal was to demonstrate an approach to analyse how factors, such as the visual-acoustic perception, people's attitudes, and reactions after perceiving further information on a wind park scenario influence the degree of acceptance of wind turbines in different landscape types.

An experiment was set up comprising two wind park scenarios (5 / 10 wind turbines) in three Swiss landscape types (plains, hills, mountains). The definition of the landscape types was based on the Landscape Typology of Switzerland, which takes into account long-term constant features (orography, topography, geology, and climate) as well as medium-term variable criteria (dominant land cover) for the delineation of landscapes (SZERENCSITS et al. 2009).

The design of the wind park was similar in all landscape types and its realism was ensured with regard to economic-technical aspects (e.g., consideration of the prevailing wind direction, sufficient wind, and distance between the wind turbines) and legal aspects (e.g., distance to settlement areas). These wind park scenarios were simulated with the VisAsim tool, whereby the acoustic simulation only comprised the noise of the wind turbines and no environmental noise, e.g., from vegetation or birds. The wind speed was set to 4-5 m/s at hub height which corresponds to the average annual wind speed in the three landscape types, sufficient enough to put the wind turbines into motion. The weather conditions were set to a sunny day with clouds.

Videos of the visual-acoustic simulations were generated suitable to compare the experiences of different wind park scenarios. The videos of the scenarios were shown in the mobile visual-acoustic lab in two locations in Switzerland (Zurich and Basel) (Fig. 1).

Fig. 1: Visual-acoustic simulations of a wind park in different landscape types (left), and their application for evaluating the impact of the wind park on the perceived landscape quality (right)

All scenarios were rated by experts and lay people for the acceptability of the wind turbines as well as people's liking of the overall perceived landscape. The participants rated the scenarios first without and then after reading additional information about the scenarios,

such as the number of wind turbines, the wind park size, the landscape type, the produced energy per year and the predicted hazard level to birds. The results were statistically analysed.

3 Results

The visual-acoustic simulations were comprehensible for the participants and served well for the acceptability analysis. The results indicate the scenarios for which the wind turbines are most accepted. Furthermore, we detected a relation between the liking of the perceived landscape and the acceptability of the wind turbines depending on the landscape type. However, if additional information for a scenario was offered regarding predicted energy production and hazard level to birds, the participants often changed their level of acceptance. Nevertheless, the landscape type had a remarkable effect on the acceptability of the wind parks.

4 Conclusion and Outlook

The application example of these visual-acoustic simulations demonstrates the potential of embedding these simulations into landscape planning processes for the more comprehensive integration of cultural values. The acceptability study successfully revealed that the landscape type, the information on the hazard level to birds, and the individual attitude of the participants influence the level of acceptance of certain wind parks. Hence, such simulations may help to evaluate cultural landscape values when provided to the local public, and to define thresholds for future wind parks in different landscape types. These thresholds may then be the input to adjust site evaluations and identify optimized locations and designs for wind parks, which then can again be simulated, assessed and discussed with local stakeholders. In such collaborative processes supported by appropriate valuation instruments the possibility of location-specific valuations may reveal regionally adjusted solutions for more sustainable and socially acceptable landscape development.

Also other studies have found that information about the landscape can change people's acceptability of landscape changes (RIBE 1999, FORD et al. 2009). A critical question, however, is whether the information provided is accurate or not. For instance, placed in context of the absolute number of birds killed, wind energy is much less a problem in comparison to fossil fuelled power stations and other causes such as windows and cats (SOVACOOL 2013). Further, the formats used to present the visual-acoustic simulation and the additional information can stress certain landscape aspects, which in turn might influence the people's acceptability rating (FORD et al. 2009). Overall, landscape impact assessment aiming at acceptability evaluations requires not only provision of information that is salient, legitimate, and credible (CASH et al. 2003) but also needs to be ethically sound with regard to the implementation format of the landscape representation media (SHEPPARD 2005). Particularly the presentation format of different information types is a topic for further research (FORD et al. 2009).

The specific results of acceptability ratings may not be generalized for Switzerland or other countries. This was also not the purpose of the study. However, if the simulations are

employed for gathering specific knowledge on the cultural values of a landscape, some limitations of the setup of the experiment should be overcome. For example, because of their influence on the overall evaluation of a setting, quiet and loud versions of the same sound as well as further sound stimuli should be integrated into the simulation (ANDERSON et al. 1983), e.g., vegetation noise (HEUTSCHI et al. 2014). Moreover, since the specific contextual visual information associated with sound source have been found to influence individual perceptions in a broad way (MAFFEI et al. 2013), the level of perceived realism as well as the choice of viewpoints or walk paths in the visual-acoustic simulation is critical to the overall representativeness of the landscape evaluation. Further studies should, thus, also investigate the influence of more immersive landscape representation modes, e.g., using virtual reality headsets, on the degree of realism in the perception of the represented landscape.

References

ANDERSON, L. M., MULLIGAN, B. E., GOODMAN, L. S. & REGEN, H. Z. (1983), Effects of Sounds on Preferences for Outdoor Settings. Environment and Behavior, 15, 539-566. doi: 10.1177/0013916583155001.

CASH, D. W., CLARK, W. C., ALCOCK, N. M., ECKLEY, N., GUSTON, D. H., JÄGER, J. & MITCHELL, R. B. (2003), Knowledge systems for sustainable development. PNAS, 100 (14), 8086-8091.

CRYTEK GMBH (n. d.), CryENGINE. http://www.crytek.com/cryengine (10.12.2014).

DANIEL, C. D., MUHAR, A., ARNBERGER, A., AZNAR, O., BOYD J. W., CHAN, K. M. A., CONSTANZA, R., ELMQVIST, T., FLINT, C. G., GOBSTER, P. H., GRÊT-REGAMEY, A., LAVE, R., MUHAR, S., PENKER, M., RIBE, R. G., SCHAUPPENLEHNER, T., SIKOR, T., SOLOVIY, I., SPIERENBURG, M., TACZANOWSKA, K., TAM, J. & VON DER DUNK, A. (2012), Contributions of cultural services to the ecosystem service agenda. PNAS, 109 (23), 8812-8819. doi: 10.1073/pnas.1114773109.

DEVINE-WRIGHT, P. (2005), Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. Wind Energy, 8 (2), 125-139. doi: 10.1002/we.124.

FORD, R. M., WILLIAMS, K. J. H., BISHOP, I. D. & HICKEY, J. E. (2009), Effects of information on the social acceptability of alternatives to clearfelling in Australian wet eucalypt forests. Environmental Management, 44, 1149-1162.

GRÊT-REGAMEY, A., BURLANDO, P., GIROT, CH., LIN, E. S., SHAAD, D. & VOLLMER, D. (2014), Digital methods and collaborative platforms for informing design values with science. In: WISSEN HAYEK, U., FRICKER, P. & BUHMANN, E. (Eds.), Peer Reviewed Proceedings of Digital Landscape Architecture 2014 at ETH Zurich (CH), Wichmann, Berlin/Offenbach, 46-56.

HEUTSCHI, K., PIEREN, R., MÜLLER, M., MANYOKY, M., WISSEN HAYEK, U. & EGGENSCHWILER, K. (2014), Auralization of Wind Turbine Noise : Propagation Filtering and Vegetation Noise Synthesis. Acta Acustica united with Acustica, 100, 13-24. doi: 10.3813/AAA.918682.

HÜBNER, G., LÖFFLER, E., HAMPL, N. & WÜSTENHAGEN, R. (2013), Wirkung von Windkraftanlagen auf Anwohner in der Schweiz: Einflussfaktoren und Empfehlungen − Abschlussbericht. Institut für Wirtschaft und Ökologie, Universität St. Gallen; Martin-Luther-Universität Halle-Wittenberg, Institut für Psychologie.

MAFFEI, L., IACHINI, T., MASULLO, M., ALETTA, F., SORRENTINO, F., SENESE, V. P. & ROTOLO, F. (2013), The Effects of Vision-Related Aspects on Noise Perception of Wind Turbines in Quiet Areas. Int. J. Environ. Res. Public Health, 10, 1681-1697. doi: 10.3390/ijerph10051681.

MANYOKY, M., WISSEN HAYEK, U., HEUTSCHI, K., PIEREN, R. & GRÊT-REGAMEY, A. (2014), Developing a GIS-based visual-acoustic 3D simulation for wind farm assessment. ISPRS International Journal of Geo-Information, 3 (1), 29-48. doi: 10.3390/ijgi3010029.

PEDERSEN, E. & LARSMAN, P. (2008), The impact of visual factors on noise annoyance among people living in the vicinity of wind turbines. Journal of Environmental Psychology, 28 (4), 379-389. doi: 10.1016/j.jenvp.2008.02.009.

PIEREN, R., HEUTSCHI, K., MÜLLER, M., MANYOKY, M., EGGENSCHWILER, K. (2014), Auralization of Wind Turbine Noise: Emission Synthesis. Acta Acustica United with Acustica, 100, 25-33. doi: 10.2813/AAA.918683.

REED, M. S. (2008), Stakeholder participation for environmental management: A literature review. Biological Conservation, 141 (10), 2417-2431. doi: 10.1016/j.biocon.2008.07.014.

RIBE, R. G. (1999), Regeneration harvests versus clearcuts: Public views of the acceptability and aesthetics of Northwest Forest Plan harvests. Northwest Science, 73, 102-117.

ROHRMANN, B. & BISHOP, I. (2002), Subjective Responses to Computer Simulations of Urban Environments. Journal of Environmental Psychology, 22 (4), 319-331. doi: 10.1006/jevp.2001.0206.

SHEPPARD, S. R. J. (2005), Validity, Reliability and Ethics in Visualization. In: Bishop, I. & Lange, E. (Eds), Visualization in Landscape and Environmental Planning. Technology and Applications. Taylor & Francis, London, New York, 79-97.

SOVACOOL, B. K. (2013), The avian benefits of wind energy: A 2009 update. Renewable Energy, 49, 19-24. doi:10.1016/j.renene.2012.01.074.

STEPHENSON, J. (2008), The Cultural Values Model: An integrated approach to values in landscapes. Landscape and Urban Planning, 84, 127-139. doi:10.1016/j.landurbplan.2007.07.003

SZERENCSITS, E., SCHÜPBACH, B., CONRADIN, H., GRÜNIG, A., NIEVERGELT, J. & WALTER, T. (2009), Landschaftstypologie Schweiz − Grundlagenanalyse. In: Forschungsanstalt Agroscope Reckenholz-Tänikon (ART) im Auftrag von ARE/BAFU/BFS, Zürich.

WOLSINK, M. (2007a), Wind power implementation: The nature of public attitudes: Equity and fairness instead of 'backyard motives'. Renewable and Sustainable Energy Reviews, 11 (6), 1188-1207. doi: 10.1016/j.rser.2005.10.005.

WOLSINK, M. (2007b), Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. Energy Policy, 35 (5), 2692-2704. doi: 10.1016/j.enpol.2006.12.002.