Visual Impact Evaluation System for Offshore Renewable Energy (VIESORE)

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LONG-TERM GOALS

VIESORE is an analytical and visualization tool for offshore renewable energy facilities, to be used by Bureau of Ocean Energy Management (BOEM) staff to conduct National Environmental Policy Act (NEPA) and Section 106 of the National Historic Preservation Act (NHPA) consultation when assessing impacts on the human environment and examining alternatives for in-house and public outreach — systematically and transparently.

In 2009, the United States Department of Interior (DOI) completed its Final Renewable Energy Framework. This rule established a program for granting leases, easements, and rights-of-way (ROW) for the development of renewable energy. Renewable energy projects encouraged as part of this final rule include offshore wind facilities, along with wave and ocean current facilities. As a response to the increasing interest in the use of waters of the Outer Continental Shelf (OCS) for offshore renewable energy, the DOI's BOEM has sought ways to ensure that proposed projects meet all applicable environmental laws and regulations, in hopes of streamlining the development of these facilities.

As part of this effort, BOEM is sponsoring the development of an in-house computer-based system to evaluate potential visual impacts resulting from the construction and operation of offshore renewable energy facilities. The system is referred to as the Visual Impact Evaluation System for Offshore Renewable Energy (VIESORE). VIESORE is a geographic information system-based (GIS-based) software tool for creating spatially accurate and realistic visualizations of offshore renewable energy facilities, including offshore wind, wave, and ocean current facilities.

OBJECTIVES

VIESORE is a GIS-based software tool for developing highly realistic visualizations of offshore renewable energy facilities (including wind, wave, and ocean current technologies) for use in visual impact assessment. When completed, the VIESORE software will be used by BOEM staff to 1) evaluate and validate visual impact simulations submitted by developers during the offshore renewable energy project application/review process; 2) develop simulations for use in stakeholder engagement activities; and 3) develop simulations in-house to quickly determine basic visual characteristics of proposed or hypothetical projects.

VIESORE will enable BOEM users to design the spatial layout and content of an offshore facility; import and prepare geospatial data; run a collection of visual analyses; define atmospheric, lighting, and wave conditions; and finally, generate one or more realistic visualizations from single or multiple viewpoints. Outputs will include maps, tabular reports, and high-quality rendered images. Software tools developed for VIESORE will build upon base functionality in industry-standard GIS software. These tools also will provide an intuitive interface to define environmental parameter settings used to create photo-realistic visualizations using Vue 9 Infinite, a state-of-the-art visualization package.

APPROACH AND WORK PLAN

VIESORE is intended to serve as a tool for BOEM staff to perform the following tasks:

1. verify the accuracy of visual impact simulations of offshore renewable energy facilities prepared by other parties;

2. prepare simulations for use in public involvement activities; and

3. rapidly develop simulations for in-house use to evaluate visual characteristics of hypothetical or proposed offshore renewable energy facilities.

VIESORE is a GIS-based application which allows BOEM staff to import or interactively design the spatial layout and content of an offshore facility, import and prepare geospatial data that will affect visibility, run a series of visual analyses which take into account earth curvature, define atmospheric, lighting, and wave conditions, and use these data and parameters to generate one or a series of realistic visualizations from multiple viewpoints. ArcGIS 10.0 provides the framework for the user interface, while custom middle-ware reduces the complexity of the state-of-the-art Vue visualization package by using simplified parameter inputs and predefined parameter sets tuned for offshore visualizations. When deployed, the system will be used to evaluate photomontages and zones of visual influence (ZVIs) findings prepared as part of submitted environmental analyses or to independently assess proposed facilities.

Center for Advanced Spatial Technologies (CAST) software developers and visualization specialists will design and develop the software, while Argonne National Laboratory (ANL or Argonne) staff will provide technical support, especially as domain experts, and perform quality control tasks. The second year of the 2-year effort will focus on spiral development of the in-house tool and a workshop to train BOEM staff on its use.

WORK COMPLETED

Literature Review

A key element in the VIESORE project was a literature review of existing technologies and visibility factors. The review addressed the following issues:

1. Offshore Energy Technologies – A summary of information about wind, wave, and ocean current technologies, emphasizing their visible characteristics.
2. Viewsheds and Their Limiting Factors – Discussion of viewsheds and factors that influence them, including screening factors and visibility factors. Brief examples of how to calculate a viewshed using computers also are provided.
3. Visual Perception of Offshore Renewable Energy Facilities - Discussion of factors that may influence viewsheds, including topography, vegetation, structures, wave heights, and earth curvature; and visibility factors applicable to offshore settings
4. Visualizations– A summary of available technologies used to depict offshore facilities, focusing on computer technologies and photomontages.
5. Best Management Practices for Visualizations– A brief summary of recognized standards and guidelines for producing and using visualizations and simulations.

Design Brief

Before software development began, the CAST and Argonne development team traveled to BOEM headquarters to conduct product design workshop on Feb. 3, 2011 and to involve key BOEM staff. Workshop participants engaged in a structured and documented process (derived from standard methods for product design) to:

1. develop a mission statement for VIESORE;
2. define key functionality requirements for VIESORE;
3. analyze the job functions of BOEMRE staff to determine how they would use VIESORE;
4. identify and prioritize potential features and functionality; and
5. identify technological and other constraints to system functionality and performance that must be considered in the VIESORE design process.

Based on the detailed needs and use information gathered in this workshop, CAST and Argonne proposed a specific system architecture (Figure 1) and developed a detailed Design Brief describing how the system should operate and what data would be required (Table 1). The Design Brief is considered a “living document,” and it may be expanded or amended to reflect changes to the product’s mission, requirements, user needs, or constraints that justify changes to the design or to make necessary adjustments that result from discoveries and insights that come to light during the VIESORE design and development process.

Table 1: Required and Optional Data

Data Item	Source	Format	Use	Required
Digital Elevation Model (30m resolution or better)	USGS NED, various state agencies	Any ArcGIS compatible format	Describe topography of inland and coastal areas	Yes
High resolution ortho-images (<2 meters)	Various state agencies	Any ArcGIS compatible format	Describe land use	No (but will be included in demonstration site)
Land cover / Land use Maps	USGS National Land Cover Dataset, various state agencies	Any ArcGIS compatible format	Describe land use	Yes (unless aerial images are available)
Building footprints	Various state agencies, municipalities (or digitized from ortho-image	Any ArcGIS compatible format	Describe possible view obstructions, height attribute must be included or added	No (but will be included in demonstration site)
Historic locations	Various sources (TBD are part of literature review)	Any ArcGIS compatible format including XY text file	Provide key observations points for ZVI calculations	Yes
Raw LiDAR returns	USGS CLICK, supplied by various federal and state agencies	LAS or XYZ text file	Provide very high resolution terrain and surface structure heights for ZVI	No (but will be included in demonstration site)
3D Structure Models	TBD	DXF, KML/KMZ, OBJ, 3DS, DAE	Target structure	Yes

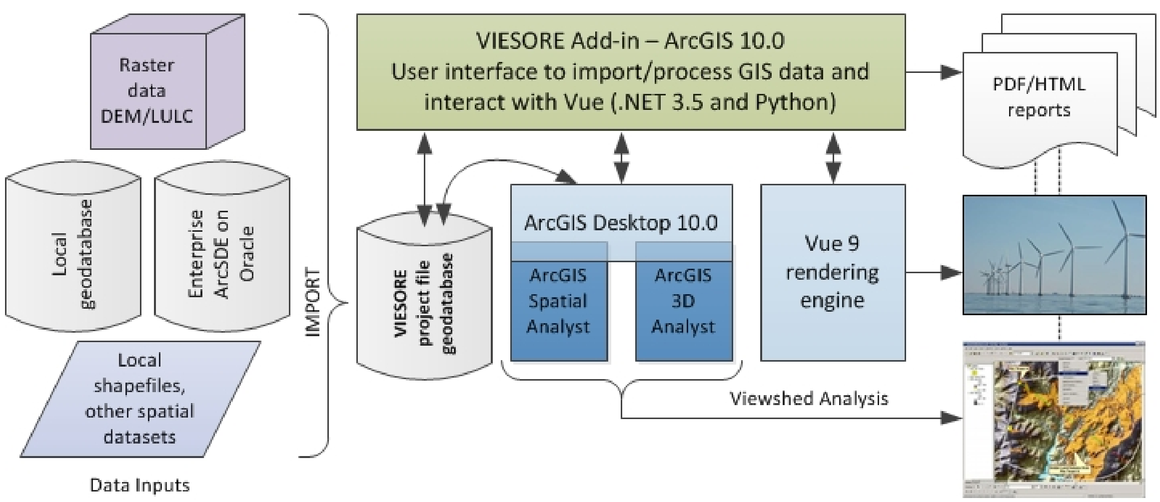

Figure 1. VIESORE system architecture and components.

Verification and Calibration Field Work

In developing design criteria for VIESORE, the design team determined that firsthand experience observing utility-scale offshore wind facilities in real landscape/seascape settings would be essential to developing tools to achieve a high level of accuracy and realism in VIESORE-generated simulations. Without firsthand experience observing offshore wind facilities, project staff would be forced to rely on photographs of offshore wind facilities as the basis for developing the highly accurate and realistic simulations that are required to achieve VIESORE performance objectives. For a variety of reasons, photographs of wind turbines are not entirely accurate or realistic representations of their visual characteristics. Extended observation of wind turbine generators (WTGs) at a range of distances and in varied lighting and atmospheric conditions in a real landscape/seascape setting provides a more complete understanding of the highly variable and dynamic visual experience that WTGs provide.

Because there are no utility-scale offshore wind facilities in the United States, travel to other countries is required to observe, photograph, and otherwise determine the visual characteristics of offshore wind facilities in a real landscape/seascape setting. The United Kingdom was chosen as the study site for the fieldwork because it provided the following advantages: 1) a large number of offshore wind facilities of varying size and at varying distances from the coast; 2) English-language documents that provide valuable information about the facilities, including the visual resource analyses and visual impact assessments prepared for the facilities' environmental assessments, which included key observation points (KOPs) and visual impact simulations; and 3) availability of in-country subject matter experts, who had pre-existing professional relationships with project staff and were able to provide valuable guidance on optimal locations for observing wind farms, as well as other helpful guidance and advice. Figure 2 shows a sample map developed for the survey, while figure 3 shows several products developed as part of the validation and calibration activities.

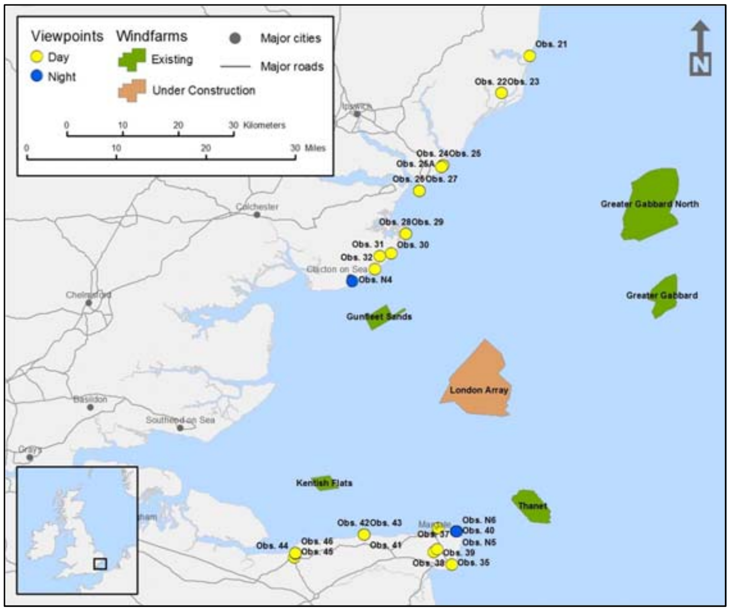

Figure 2. A sample map provided as a part of the fieldwork trip report. This particular image shows several wind farms (in brown and green) in the Thames Estuary. Potential viewpoints are shown as yellow and blue circles. Maps such as these in digital form display on global positioning system (GPS) capable portable devices (an iPad 2 in this case) were used to document the photographs taken of the

farms from the viewpoints and to inform the calculations necessary to create geometrically correct renderings.

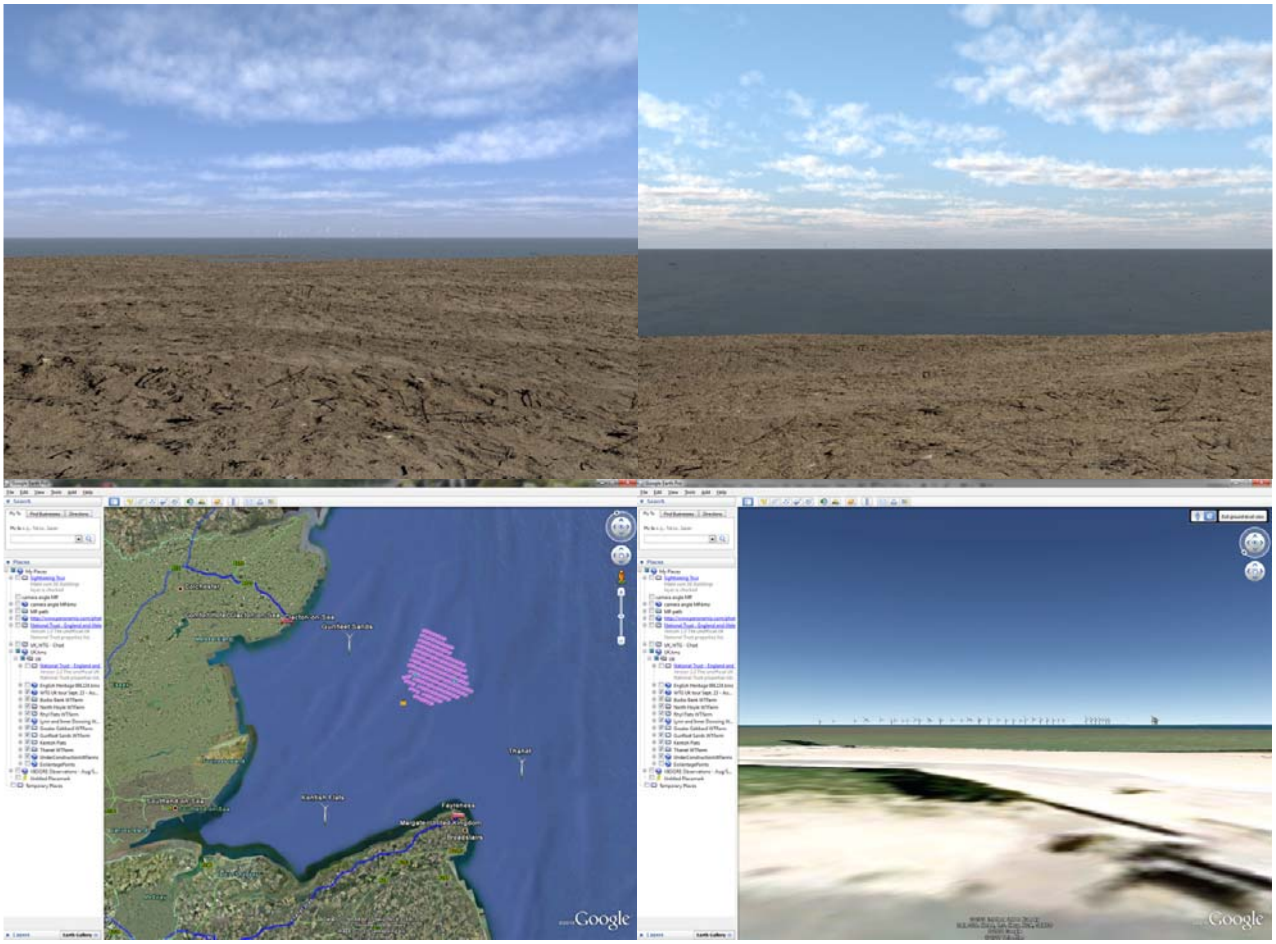

Figure 3. Upper left – a photo of the Burbo Bank offshore wind turbine facility take during fieldwork in the UK. Upper right – a rendering develop using VIESORE of the same facility from a slightly different viewpoint. Lower left – a Google Earth screenshot showing geographic location of the Thames Estuary facility. Lower right – a Google Earth screen shot showing the Thames Estuary facility from a viewer's perspective. All of these figures were developed as part of the fieldwork conducted in the UK and were produced using components of VIESORE. While Google Earth itself is not part of the application, data from VIESORE may be exported and viewed in Google Earth.

RESULTS

While work continues on both the user interface and increasing the realism of the renderings, there are several significant results to report. First, the interface for generating renderings of a particular WTG placement scenario is nearing completing. It has undergone review by Argonne National Laboratory staff and by BOEM users. Figure 4 shows the current interface.

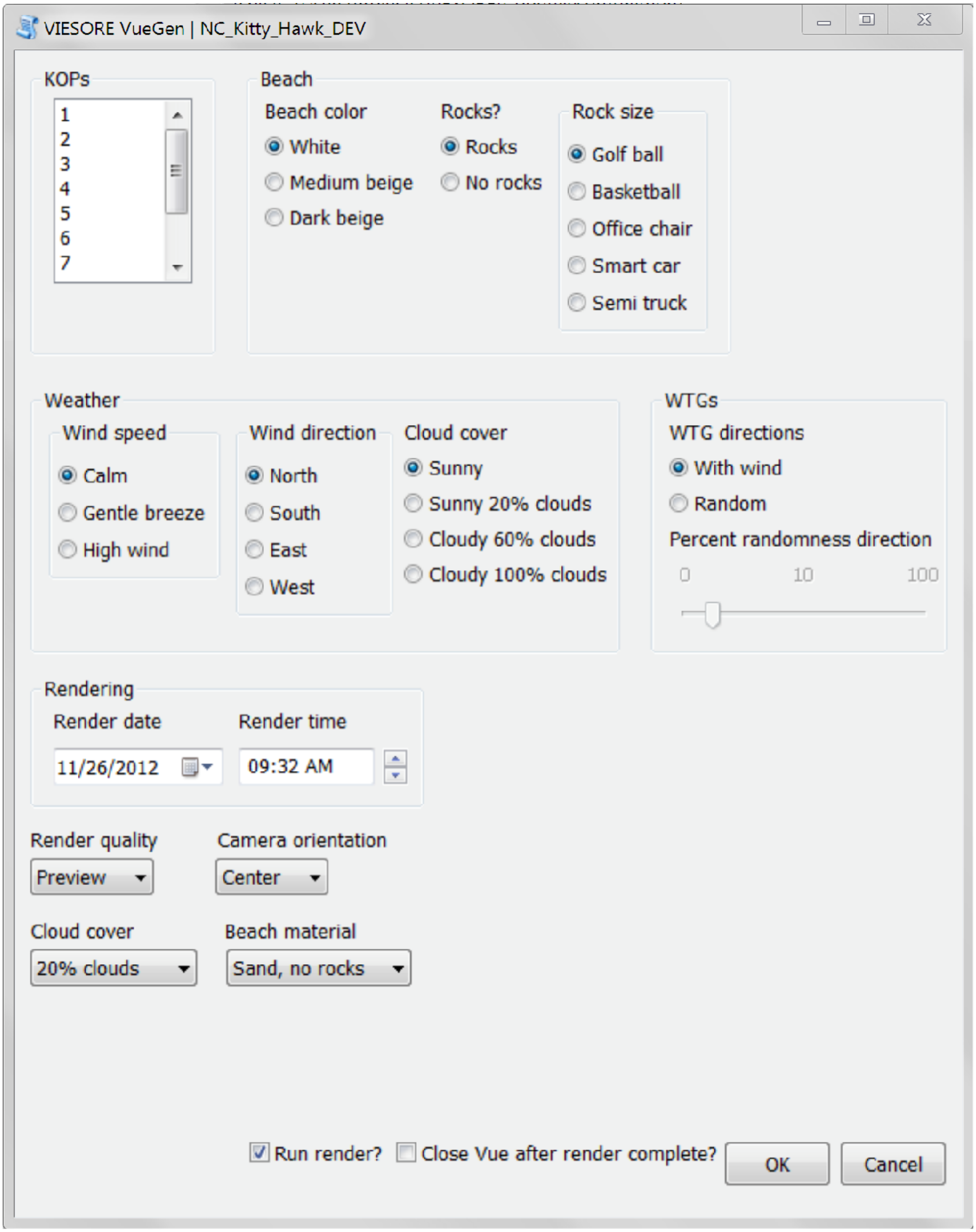

Figure 4. A screenshot of the ArcGIS toolbox VueGen showing the various options currently available to the user. Eventually the VueGen module will support animations.

The second significant development is in the generation of nighttime views. Work continues on the calibration of lighting. Again the important dataset captured in the UK and described above is proving invaluable in these calibration attempts. Figure 5 shows, on the left, a digital photograph of the Thanet facility at night while the right image shows a rendering produced by VIESORE.

Figure 5. Comparison of nighttime digital images (left) with VIESORE produced rendering (right) of the Thanet wind turbine facility in the United Kingdom.

IMPACT AND APPLICATIONS

When operational, VIESORE will allow a user to select or construct the components of an offshore facility; design the spatial layout of the facility; import and prepare accurate GIS data for coastal regions and OCS waters; site the facility in a specified location; run a series of sophisticated visual analyses; define atmospheric, lighting, and wave conditions; and then generate one or a series of spatially accurate and realistic visualizations of the proposed facility as it would be seen from any viewpoint within GIS dataset selected by the user.

TRANSITIONS

There are not transitions to report at this interim stage. As we describe above, the operational VIESORE application is expected to be used by a wide variety of BOEM staff. However, while the application is designed for offshore facilities, it could potentially be used to evaluate visual impact for inland sites on, for example, BLM lands.

REFERENCES

AEA Technology (1998). Power Generation and the Environment – a UK Perspective. Volume 1. Report AEAT 3776. Culham, Oxfordshire.

Bergsjo, A, Nilsson, K & Skarback, E (1982). Wind power in the landscape. Fourth Symposium on Wind Energy Systems, Stockholm, Sweden, 21-24 September, Paper N2.

Bishop, I. D. and D. R. Miller (2007). Visual assessment of off-shore wind turbines: The influence of distance, contrast, movement and social variables Renewable Energy Volume 32, Issue 5, April 2007, Pages 814-831. doi:10.1016/j.renene.2006.03.009

Buchan, N. (2002). Visual Assessment of Windfarms: Best Practice Report No. F01AA303A. University of Newcastle, Scottish Natural Heritage Commissioned Report F01AA303A. http://www.snh.org.uk/pdfs/publications/commissioned_reports/f01aa303a.pdf (accessed 2010-02-16)

Edsall, T. A. and Charlton, M. (1997). Nearshore Waters of the Great Lakes, State of the Lakes Ecosystem Conference, 1996. http://nsdi.epa.gov/glnpo/solec/solec_1996/Nearshore_Waters_of_the_Great_Lakes.pdf

European Commission (1997). Wind Energy – The Facts. Volume 4: The Environment. EC Directorate-General for Energy/European Wind Energy Association, London.

International Energy Agency (1998). Benign Energy? The Environmental Implications of Renewables. Appendix D: Wind Energy. Paris.

Soerensen, Hans Christian & Hansen, Lars Kjeld (2001). Social Acceptance, Environmental Impact and Politics. Concerted Action on Offshore Wind Energy in Europe. Draft Report, NNE5-1999-00562.

Thayer, R L & Freeman, H (1987). Altamount: public perception of a wind energy landscape. Landscape and Urban Planning 14, 379-398.

Wolsink, M (1989). Attitudes, expectancies and values about wind turbines and wind farms. European Wind Energy Conference, Glasgow and in Wind Engineering 13, 196-206.