Renewable Energy 60 (2013) 388–401

Contents lists available at SciVerse ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Visibility analysis and visibility software for the optimisation of wind farm design

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ARTICLE INFO

Article history:
Received 11 December 2012
Accepted 8 May 2013
Available online 13 June 2013

Keywords:
Visual Impact Assessment (VIA)
Visibility analysis
Computer aided VIA
VIA software
Visual mitigation

ABSTRACT

Some advances in our methodological approach for visibility analysis (VA) and some relevant improvements of the software tool (MOYSES v4.0) are presented. Usually visibility studies and Visual Impact Assessments (VIA) are expressed as reports that are carried out only when design of projected structures is already completed. The proposal presented here provides methods and tools that can help to measure and incorporate visibility as a part of the engineering design process. Different queries can be formulated and alternative solutions can be compared during the design stage. The tools are interactive and designers can use them to visually optimise their final solutions.

1. Introduction

The effects of large structures in the landscape have been extensively analysed for over three decades. The analysis and assessments carried out go from strictly visibility-geometrical aspects to the consideration of character and functionality of landscape, including its different resources, and dynamics as well as the social implications of its use and modification. That is, considering landscape from a more general environmental point of view. Two important contributions in this field are those referring to Visual Resource Management (VRM) [1] and Visual Management System (VMS) [2].

The modification of the character of a landscape is particularly significant in the case of wind farms, in which a number of very large and highly visible structures are placed on a fairly extensive area. The concepts and approaches presented in the above-mentioned works had to be adapted for the analysis of these and other large installations. The concept of Visual Impact Assessment (VIA) is now normally used when trying to describe and assess the effects of such installations.

1.1. Visual Impact Assessment (VIA) and Landscape Visual Impact Assessment (LVIA)

The combination of strictly visual and more general landscape factors (that is, alterations that can be objectively described or measured and the consequences of these for human perception [3]) concerning the analysis of wind farms has been discussed by Refs. [4–6]. Free-access, good-practice manuals for visual and landscape analysis are available [7], some of them including the consideration of cumulative effects [8], purely technological issues related to visual representation [9], or the selection of most suitable locations for wind parks within a given area [10]. The methodological approaches presented are quite similar in all those cases but there are some terminological differences that should be kept in mind. For instance, the VIA (Visual Impact Assessment) process of wind parks proposed by Ref. [6] includes the following steps: i) project description, ii) project visibility, appearance and landscape context, iii) scenic resource values and sensitivity levels, iv) assessment of visual impacts, v) mitigation techniques, vi) determination of unacceptable or undue aesthetic impacts. That is, VIA includes both visibility analysis and assessment of the landscape effect of the projected structures.

However, for Ref. [5] visibility, landscape character, interactions and possible cumulative effects are designated with specific terms, such as VIA (Visual Impact Assessment), LIA (Landscape Impact

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0960-1481/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.renene.2013.05.026

Assessment), LVIA (Landscape and Visual Impact Assessment) or CLVIA (Cumulative Landscape and Visual Impact Assessment). In this case the term VIA is restricted to visibility analysis and assessment. In other words, what for Ref. [6] is VIA is labelled as LVIA by Ref. [5].

1.2. Visibility analysis(VA)

For other authors [11–15] VIA focuses on visibility, assessed essentially on the basis of measurable indicators, and does not pay much attention to landscape considerations. Landscape character or landscape perception is not normally considered, although in some cases [14,15] they are included to some extent. In the context of the present contribution, we prefer to refer to this type of approach as visibility analysis (VA). This is not a terminological proposal, simply indicates that our analysis, based on indicators that can be objectively determined, does not intend to include visual effects related to perception (VIA or LVIA).

VA is based on an algorithm described in the literature by means of keywords such as Viewsheds, Zones of Visual Influence (ZVI), Zones of Theoretical Visibility (ZTV) or Visual Exposure Zones (VEZ). The delimitation of such zones is essentially a geometrical problem, based on the inter-visibility principle (if A is seen from B, the latter is visible from the former). Visibility maps are thus obtained, from which a variety of visibility indicators can be derived (up to fourteen [16], again based on quite different initial considerations). This is not surprising because VA faces quite different problems when trying to determine potentially suitable zones for wind farm construction [17–20], determining and measuring the visibility of a specific farm [13], or that of a residential development [21]. The first case implies the analysis of a large territory, the potential visual effects of the second would be restricted to a much smaller area, and those of the third would be essentially local. Visibility thresholds, areas of no visual effect, mitigation measures, etc., must therefore be considered differently.

1.3. VIA and VA existing tools

A variety of software tools have been developed and applied to address the different issues related to visibility characterisation and assessment. Software support tools for visibility and visual assessment process, such as VIEWIT or CAVIA [23–25], have been developed for quite a number of years. The former works contain the basic elements of the presently understood as VA or VIA applications. In fact, the conceptual functional specification with which CAVIA was constructed remains basically valid. Later developments are mainly the result of improved hardware and software capabilities. With presently existing machines and programmes the process of viewshed calculation, graphic representation and terrain simulation have become much more efficient and accessible. The analysis and graphic representation functions described in CAVIA are presently available to EIA and VIA practitioners. SIG software suppliers such as SURFER or ARCGIS, and other, more specific applications (among others WINDPRO [26], WINFARM [27], WINFARMER [28], OPENWIND [29], LSS [30] or ENVISION [31], developed mainly for visual assessment of wind farms) provide those capabilities.

The applications above perform a series of operations basically included in the original CAVIA functional specification [24]:

- Determination of ZVI or ZTV. Visibility can be calculated for the whole or a part of a structure. Local visibility obstacles can be incorporated into the calculation. Cumulative effects can also

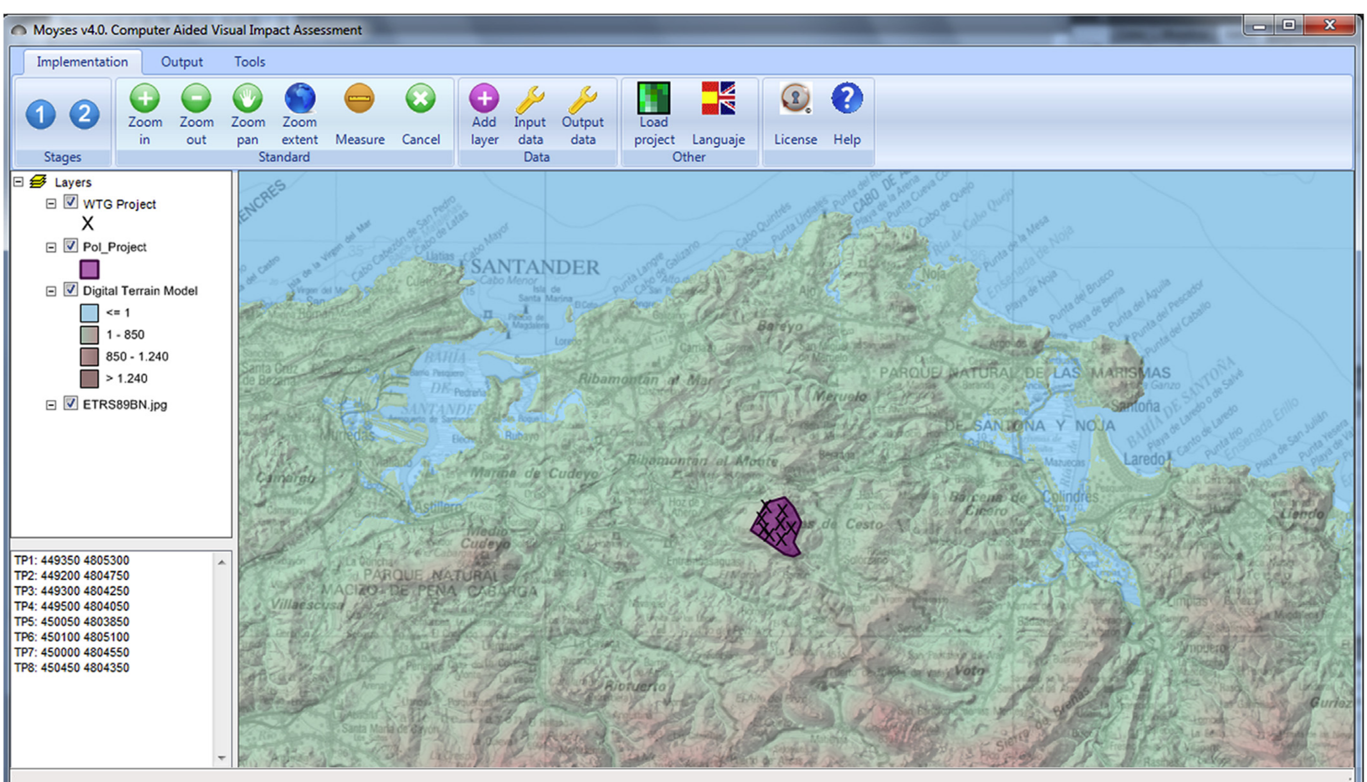

Fig. 1. Results of the first computations stage. Graphic elements are shown in the map window. Coordinates of target points are indicated in the lower left box of the interface.