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Renewable Energy 31 (2006) 1505–1520
RENEWABLE ENERGY
www.elsevier.com/locate/renene

Spatial analysis methodology applied to rural electrification

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Received 21 March 2005; accepted 3 September 2005
Available online 11 November 2005

Abstract

The use of geographical information systems (GISs) in studies of regional integration of renewable energies provides advantages such as speed, amount of information, analysis capacity and others. However, these characteristics make it difficult to link the results to the initial variables, and therefore to validate the GIS. This makes it hard to ascertain the reliability of both the results and their subsequent analysis. To solve these problems, a GIS-based method is proposed with renewable energies for rural electrification structured in three stages, with the aim of finding out the influence of the initial variables on the result. In the first stage, a classic sensitivity analysis of the equivalent electrification cost (LEC) is performed; the second stage involves a spatial sensitivity analysis and the third determines the stability of the results. This methodology has been verified in the application of a GIS in Lorca (Spain).

Keywords: GIS; LEC; Geographic distribution; Spatial sensitivity analysis; Renewable energy sources; Rural areas

1. Introduction

Usually, in rural electrification geographical information system (GIS), the allocation of the potential of various technologies in the studied area is determined by comparing their LEC values [1–5]. Each isolated household will "belong" to the technology offering the lowest LEC in the point corresponding to that household. In this way, the potential of each

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0960-1481/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.renene.2005.09.008

technology in the studied area can be expressed by the number of households, or by the surface area in which such a technology offers the best cost per kWh throughout the life of the installation.

But the real potential of each technology involved will be determined not only by minimizing the cost per kWh but also by the difference between its own costs and those of the other technologies which are in most direct competition with it. Obviously, a technology's potential does not depend only on its cost per kWh, but also on other matters related to the problems of regional integration of renewable energies [6]. Furthermore, the influence that various parameters may have on these costs will be of vital importance, since a slight variation in a parameter might change the results significantly.

For these reasons, a spatial sensitivity analysis methodology is proposed to determine the influence of various parameters on the results, linking them clearly with the initial variables. This method is structured in three stages:

1. Determination of the main influencing parameters by a sensitivity analysis of each LEC technology.
2. Spatial sensitivity analysis of the potential of the studied zone with respect to the parameters found in the previous stage, selecting the most significant variables in the distribution of the rural electrification potential.
3. Study of the spatial behaviour of the variables of the previous stage in order to determine the "stability" of the result obtained.

The following points describe the application of this method to the rural electrification study of Lorca (Murcia, Spain) carried out by a GIS developed by the authors [7] from an initial version of Solargis [8–11], GIS prepared by several Research Institutions in the framework of the JOULE II Program of the European Union.

2. First stage: sensitivity analysis of LEC

The method consists of applying a classic procedure considering the risk in the economic analysis of the investment selection: an analysis of the sensitivity of project costs with respect to variations of the technical and economical parameters. This type of analysis is conducted by establishing the value of all the parameters except the one being considered, which it is made to vary about a central value, usually the "best" estimate of that parameter.

Figs. 1–6 show the results of the sensitivity analysis for each technology considered in the GIS. In these graphs, the influence of the variation of the parameter values with respect to the reference value can be observed. It must be taken into account that the slopes of the resulting curves cannot be compared directly, since the meaning of the variation of each parameter is different, as well as the probability that each variation will occur. As a rule, the causes of variation of the various parameters considered can be grouped into four categories:

- Uncertainty in the establishment of the renewable resources, in this case solar radiation and wind speed.
- Evolution of the technology, causing changes in the efficiency and equipment lifetime.
- Changes in the socio-economic scenario that affect consumption, load density and discount rate, among other parameters.