ELSEVIER

Energy Policy 33 (2005) 235–244

ENERGY POLICY

www.elsevier.com/locate/enpol

A multicriteria approach to evaluate wind energy plants on an Italian island

Fausto Cavallaro[a,*], Luigi Ciraolo[b]

[a] University of Molise, Department SEGES, Via De Sanctis, 86100 Campobasso, Italy
[b] University of Messina, Department R. I. A. M, Piazza S. Pugliatti, 1-98121 Messina, Italy

Abstract

The decision-making process regarding the choice of alternative energy is multidimensional, made up of a number of aspects at different levels—economic, technical, environmental, and social. In this respect multicriteria analysis appears to be the most appropriate tool to understand all the different perspectives involved and to support those concerned with the decision making process by creating a set of relationships between the various alternatives. The main aim of this paper is to make a preliminary assessment regarding the feasibility of installing some wind energy turbines in a site on the island of Salina (Aeolian islands—Italy). Thus, a multicriteria method will be applied in order to support the selection and evaluation of one or more of the solutions proposed. Having analysed the local environmental conditions and its energy profile, four wind turbine configurations were postulated as options. These options were then appraised by comparison against a family of criteria and calculations were performed using a multicriteria algorithm to rank the solutions, from the best to worst. The option at the top of the ranking refers to the installation of a plant of 150 kW and this emerged as the right *compromise* between the costs of realization, local energy requirements and the need to conserve the area and the environment especially in view of the high/medium-bracket tourism business on the island. The sensitivity analysis performed subsequently backed up the findings. As this work demonstrates, multicriteria analysis can provide a valid tool to aid decision making for achieving targets relating to more sustainable green energy.

Keywords: Multicriteria; Wind energy; Renewable energy sources

1. Introduction

Renewable energy sources (RES) catalysed the interest of the public and the institutions at the beginning of the 1970s when they were known as *complementary* (and therefore subordinate to fossil fuels). Rather than being a ‘‘reality’’ in industrial terms they represented the ‘‘hoped for’’ solution in the search for an alternative energy supply as a consequence of the oil crisis. During these years, decision makers and energy planners mainly concentrated their efforts on the development of econometric models aimed at interpreting and analysing the interrelations between energy and the related economic sector. In that phase of economic development modelling was oriented towards increasingly accurate forecasting of future movements in energy demand and at analysing the technological options for the most efficient energy production.

In the 1980s interest in the RES started to fade and this can be attributed to the stabilization of the oil market and the record minimum price for crude recorded in that period (Lorenzoni, 1997, p. 5). The low price for crude led energy producing companies to intensify their investments in the fossil fuel sector.

In the early 1990s, when the 1973 crisis seemed a distant memory, the energy problem cropped up again. This time it was connected above all to its impact on the environment in global and local terms and thus renewable energy recaptured the attention of politicians and decision makers. This intense attention directed towards the environment gave priority to those RES that would have a minimal impact not only on the environment, but also on health and the quality of life. Therefore, this growing awareness of the environmental problem partially modified the traditional decision making structure in the energy field. Indeed, the need to insert strictly environmentally related considerations into

*Corresponding author. Tel.: +39-0874-404334; fax: +39-0874-311124.

E-mail addresses: cavallaro@unimol.it (F. Cavallaro), luigi.ciraolo@unime.it (L. Ciraolo).

0301-4215/$ - see front matter
doi:10.1016/S0301-4215(03)00228-3

energy planning resulted in the adoption of multicriteria decision models. Various studies have been developed to illustrate the potential applications of this approach: for the evaluation of energy options when compared to a set of criteria and in order to make the choices clearer (Siskos and Hubert, 1983; Roy and Bouyoussou 1986; Georgopoulou et al., 1998; Goumas and Lygerou, 2000; for the assessment of geothermal energy projects (Goumas et al., 1999); for the siting of power plants (Barda et al., 1990); and for the evaluation of energy strategies for small islands (Cavallaro, 1999).

The central aim of this work is the application of a multicriteria method to aid the evaluation of a number of energy solutions regarding the installation of wind turbines. Accordingly, the first part of this work introduces the aspects related to methodology while the second illustrates the application of a case study on the island of Salina (Italy) followed by a discussion of the results obtained from this analysis.

2. Multicriteria evaluation approach

The use of decision making tools under a multicriteria approach are intended to aid the decision maker in the creation of a set of relations between various alternatives. A decision support system can be defined as an interactive system that is able to produce data and information and, in some cases, even promote understanding related to a given application domain in order to give useful assistance in resolving complex and ill-defined problems. Decision making processes are analysed from different viewpoints and the implementation of analytical methods and models and support tools must take into consideration not only the organizational structure in question, but also the procedures, processes and the dynamics of the decision makers involved. At the core of classic decision making tools lies the idea that for any given problem there is only one solution (the optimum). In Roy's opinion a *decision procedure* is not a valid one if it is based on the principle of discovering pre-existing truths or on mathematical convergence (the decision will reach an optimum) (Roy, 1985, 1996). The final solution according to Roy is a *creation* rather than a *discovery* (Roy, 1985, 1990). Thus the main objective of a *Multiple Criteria Decision Aid* (MCDA) is to build or create a support tool for decision makers that conforms to their objectives and priorities (a constructive or creative approach) (Roy, 1990, p. 28). The "ideal" solution, the option that performs best for *all* the criteria selected, is difficult to achieve. Therefore it is necessary instead to find a compromise from among the different hypothetical solutions. It is for this reason that a choice resulting from MCDA is "justified" and not "optimum".

We outline below the main steps relating to the formulation of a multicriteria problem:

(1) *Defining the nature of the decision.* Here the problem is to come up with, as an end result, an order of merit of admissible actions ranking them from the best to the worst (ranking of alternatives). The actions are compared and grouped into classes of equivalence, after which they are sorted partially or completely in accordance with the model of preferences.
(2) *Selecting potential actions.* The decision making procedure under MCDA normally involves making a choice between different elements that the decision maker examines and assesses via a set of criteria. These elements are part of an overall set of *actions or alternatives*.
(3) *Defining a set of criteria*. The criteria represent the tools which enable alternatives to be compared from a specific point of view. It must be remembered that the selection of criteria is of prime importance in the resolution of a given problem, meaning that it is vital to identify a coherent family of criteria and not just any set of criteria whatsoever (Bouyssou, 1990, pp. 58–68).
(4) Once the set of criteria and the alternatives have been selected then the *payoff matrix* is built. This matrix tabulates, for each criterion–alternative pair, the quantitative and qualitative measures of the effect produced by that alternative with respect to that criterion. The matrix may contain data measured on a cardinal or an ordinal scale.
(5) *Aggregation of preferences and comparison of criteria: outranking relations*. Under this procedure comparisons are first of all made between all pairs of admissible actions to obtain binary relations and then these results are grouped together.

Energy planning involves making many value judgements regarding technical, socio-economic, and environmental issues. Therefore, reaching clear and unambiguous solutions may be very difficult. It is from this difficulty that the need arises to develop a tool for resource planning and management. Such a tool should enable the policy maker to draw up a series of alternatives (based on a variety of, often conflicting, viewpoints) and to choose the best "compromise", i.e. the one held to be the most acceptable. The work involved in seeking a compromise solution requires an adequate assessment method and there are many multicriteria methods available that appear to be admirably suited to handle this task. The most important belonging to MCDA are the following: the ELECTRE family developed by Roy B. and his co-workers, PROMETHEE (Brans), ORESTE (Pastijin and Leysen), MELCHIOR (Leclercq), QUALIFLEX (Paelink), REGIME (Hinloopen, Nijkamp, Rietvald), MACBETH