Renewable Energy 69 (2014) 60–73

Contents lists available at ScienceDirect

Renewable Energy

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

Geothermal power in Italy: A social multi-criteria evaluation

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ARTICLE INFO

Article history:
Received 31 May 2013
Accepted 10 March 2014
Available online

Keywords:
Geothermal power
Multi-criteria analysis
Integrated assessment
Conflict management

ABSTRACT

Italy was the first country in the world to exploit geothermal resources for electricity production. In Europe it is still the first country in terms of installed capacity. Currently, the only region in Italy with geothermal power plants is Tuscany. This study focuses on Mt. Amiata, one of the two geothermal areas in Tuscany. In Mt. Amiata a strong opposition to the exploitation of geothermal resources is rising. The context is characterized by contested scientific results regarding crucial issues such as the impact of geothermal exploitation on human health and the conservation of water resources. A social multi-criteria evaluation is proposed to explore the different legitimate perspectives of the actors involved. Scenarios are distinguished in terms of their technology, plant site and installed capacity. Criteria reflect economic considerations, social aspects and environmental concerns. A Condorcet consistent aggregation algorithm is applied and results are analyzed using a sensitivity analysis. The alternative scenarios are evaluated by attaching different weights to the criteria reflecting divergent points of view.

1. Introduction

This paper intends to show the potential use of a social multi-criteria evaluation (SMCE) in managing problems related with conflicts arising around geothermal power. Specifically, it explores the case of Mt. Amiata, in the region where geothermal power originated: Tuscany.

The first experiments to use geothermal energy to produce electricity took place in Tuscany in 1904 in Larderello. Since then Italy has remained the first producer of electricity from geothermal sources in Europe and is the fifth internationally [2]. All the geothermal power plants in Italy are located in Tuscany. Here geothermal power made up 24% in 2010 of electricity consumption [3]. Currently there are 35 power plants with 882.5 MW of installed capacity [4,5] in two areas: Larderello and Mt. Amiata. The focus of this study is in Mt. Amiata, where geothermal energy has been facing strong opposition during the last few years.

Opposition to renewable energies is not uncommon and it is often considered as a NIMBY attitude. The geothermal power industry therefore tends to classify such behavior as a social acceptance problem [6,7]. However more than simple social acceptance, opposition should be considered as being part of a more general environmental and energy management problem which presents elements of energy policy, economic considerations, local pollution, water conservation concerns, employment effects, quality of life and aesthetical aspects. This kind of problems reflect conflicts of interests and values. In such conditions, it is very difficult to arrive at a straightforward and unambiguous solution. This implies that planning processes should be characterized by the search for acceptable compromise solutions through an adequate evaluation methodology [8].

Multi-criteria decision aid has proven to be a powerful tool to deal with complex environmental and energy management problems [9]. Some examples can be found in Gamboa and Munda [10], Munda and Russi [11], Beccali et al. [12], San Cristóbal [13] Aras et al. [14], Stagl [15], and Sittaro [16].

From a practical point of view, one of the main advantages of multi-criteria decision aid is that it makes it possible to handle great amounts of data in a multi-dimensional way. It is a very transparent method because different valuations are not translated into a single numeraire. Using data from different scientific dimensions it is also suitable for interdisciplinary approaches [17].

The most common use of multi-criteria analysis is in providing a final ranking of alternatives based on different criteria. Typically, decision makers' priorities are elicited in the form of weights by means of different techniques. However, such weights are often not precisely determined. Consequently, a sensitivity analysis is regularly added in order to check the robustness and stability of results with respect to the initial vector of estimated weights. This work applies sensitivity analysis with a slightly different purpose, which consists in exploring the sensitiveness of results under divergent assumptions. The final rankings thus represent "politically sensitivity maps", to use Stirling's [18] words.

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http://dx.doi.org/10.1016/j.renene.2014.03.026
0960-1481/

The next section describes the methodological framework. Section 3 provides a historical-institutional analysis of the context of this study and includes a brief summary of the main social actors involved. Section 4 introduces the chosen alternatives and explains which criteria were used and how they were estimated. The results are included in Section 5. The last section presents some final remarks on the overall process and on the specific results.

2. Methodological framework

Social multi-criteria evaluation (SMCE) explicitly includes direct inputs from social actors [17]. The whole evaluation process can be summarized as follows (adapted from Refs. [10,19]):

- Historical-institutional analysis
  - Identification of social actors
  - Definition of preferences and aspirations
- Design of alternatives
- Identification and scoring of criteria
- Selection and application of a ranking algorithm
- Analysis of results and sensitivity analysis

These phases are not intended to follow a chronological order. Rather, they influence each other dynamically.

The historical-institutional analysis is mainly aimed at defining the given problem by identifying social actors and eliciting their preferences and aspirations. The institutional analysis in this research involved a review of various documents such as laws, policy documents, press releases and newspapers. This phase made it possible to identify the main actors. Subsequently semi-structured interviews (SSI) were held with exponents and representatives of the identified social actors. A question guide was previously prepared based on the information collected during the secondary data review. The information collected during the interviews were of qualitative nature. The main objective of the interviews was to collect information on qualitative nature on the perceptions, needs and aspirations of the social actors. In addition, following a snowball methodology, the interviews made it possible to identify other actors. Finally we made a list of those social actors that had an evident interest in the geothermal exploitation or that resulted to have been most active.

A complete list of the actors interviewed is reported in Table 1.

The preference model used to evaluate the alternatives is not based on the alternatives themselves but on their consequences [20], which are evaluated using certain criteria. As Gamboa and Munda specify [10] in SMCE the choice of criteria is a technical translation of the social actors' desires and needs operated by the research team. Essentially, the criteria represent the different points of view of the social actors.

Given the set A of alternatives $(a_1, a_2 \ldots a_n)$ and the set of criteria $G\,(g_1, g_2 \ldots g_m)$, it is possible to build a $n \times m$ matrix whose elements report the performance of each alternative according to each criterion. In order to state that a_1 is preferred to a_2, it is sufficient that $g_i\,(a_1) > g_i\,(a_2)$. In this case, any difference between $g_i\,(a_1)$ and $g_i\,(a_2)$ implies a strict preference relation. However, even when the decision maker is a real person, their preferences are seldom clearly stated. Among areas of firm conviction may lie nebulous zones of uncertainty. Moreover, the data used to evaluate the performance of each alternative may be imprecise. This is why the introduction of discrimination thresholds is advisable. Here an indifference threshold is used, i.e. the greatest value of the difference between two alternatives which is not large enough to differentiate between them.

Given the context of this study, one important characteristic of the aggregation procedure is that the result should not be an isolated alternative but a ranking. Thus, if the first alternative cannot be chosen because of political reasons (e.g. it gives rise to a strong conflict), other alternatives can be considered in their ranked order. Furthermore, it is important that the algorithm be simple, transparent, and non-compensatory so that a very good performance in one criterion (e.g. economic) cannot compensate for a bad one (e.g. in an environmental criterion). It is also advisable that the intensity of the preference information is not accounted for in order to avoid compensability. Weights should reflect importance coefficients and not trade-offs[1] [21,22]. The Condorcet consistent rule developed by Munda [23,24] has such properties. This is based on the maximum likelihood concept, that is, the maximum likelihood ranking supported by the maximum number of criteria for each pair-wise comparison, summed over pairs of alternatives. A full explanation of the model is reported in Appendix A1.

Table 1
Interviews.

Social actor	Participants	Place	Date
Piancastagnaio municipality	Mayor	Mountain authority office, Arcidosso	09/03/2011
Santa Fiora branch Communist Party	1	Santa Fiora	09/03/2011
Arpat	1	Arpat office, Siena	11/03/2011
Prospettiva Comune Piancastagnaio	3	Piancastagnaio	17/03/2011
WWF	1	Monte Labbro	17/03/2011
Comitato per la Tutela dell'Ambiente dell'Amiata – Abbadia San Salvatore	3	Abbadia San Salvatore	18/03/2011
Arcidosso municipality	Mayor	Town hall, Arcidosso	18/03/2011
Rete Comitati per la Difesa del Territorio	1	Abbadia San Salvatore	18/03/2011
Enel Green Power Ricerche	2	Enel Green Power office, Pisa	22/03/2011
Residents' association of Arcidosso (no more active)	1	Arcidosso	25/03/2011
Santa Fiora municipality	Mayor Mayor's deputy	Mountain authority office, Arcidosso	26/03/2011
Abbadia San Salvatore municipality	Mayor	Florence	05/04/2011

3. Historical-institutional analysis

3.1. Historical and geographic context

In Tuscany the geothermal power plants are located in two areas: the so-called traditional area around Larderello where 30 plants (and 794,5 MW of installed capacity) are located, and Mt. Amiata area where five plants (with 88 MW) have been installed (Fig. 1).

Until the beginning of 1900 Mt. Amiata was a typical mountain area of volcanic origin where the main activities included agriculture, forestry and animal production, after which the mining for cinnabar radically changed the economic profile of the area. The mining sector grew so much that in 1965 it satisfied 35% of the world's mercury demand. Subsequently, a fast decline took place

[1] Weights as trade-offs indicate how much a good performance in one criterion can compensate for a bad one in another. Weights as importance coefficients indicate how important a criterion is, but no compensation is implied.