Renewable Energy 116 (2018) 97–108

Contents lists available at ScienceDirect

Renewable Energy

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

Willingness to pay for the preservation of geothermal areas in Iceland – The contingent valuation studies of Eldvörp and Hverahlíð

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ARTICLE INFO

Article history:
Received 4 February 2017
Received in revised form
11 September 2017
Accepted 22 September 2017
Available online 22 September 2017

Keywords:
Contingent valuation
Geothermal power
Willingness to pay
Preferences
Decision-making

ABSTRACT

Academic knowledge concerning preferences and willingness to pay for the preservation of geothermal areas is currently very limited. This paper seeks to increase understanding, using the contingent valuation method to estimate willingness to pay for the preservation of two high-temperature geothermal fields likely to be developed in the near future: Eldvörp and Hverahlíð. Both study sites are located in Iceland, a nation that has been the recipient of repeated calls by the OECD to commence accounting for environmental impacts in cost-benefit analyses, particularly those associated with power projects. We applied interval regression using log-transformation to estimate WTP for the preservation of the high-temperature Eldvörp and Hverahlíð fields. The estimated mean WTP was 8333 and 7122 ISK for Eldvörp and Hverahlíð respectively. Scaled up to the Icelandic population of national taxpayers, this equates to estimated total economic value of 2.10 and 1.77 billion ISK respectively. These results reinforce arguments in favour of accounting for environmental impacts of Iceland's future geothermal power projects as a mandatory component of the decision-making process. In Iceland and further afield, more research is necessary to develop understanding of the economic value of impacts to recreational amenity and other ecosystem services resulting from geothermal power projects.

1. Introduction

The approval of energy projects with significant environmental impacts implies that the economic costs of the affected environmental resources must be less than the financial benefits, but such irreversible decisions are frequently made without ever attempting to estimate the monetary value of the losses [1,2]. Consequently, an inequality in decision-making may occur, as Ruhl ([3]; p. 761) describes: *"failure to refine our understanding of their economic values, and the consequent inability to account for those values in regulatory and market settings and, more importantly, in the public mind, is unlikely to promote the preservation of natural systems."*

Until this paper, academic knowledge concerning preferences and willingness to pay for the preservation of geothermal areas has, for over three decades, been limited to the results published in a single paper, the contingent valuation study by Thayer [4]. Thayer applied the contingent valuation method to estimate willingness to pay to preserve the Santa Fe National Forest in New Mexico, which was a diverse, scenically attractive and popular recreational area blessed with hot springs, but potentially subject to development in order to provide energy for a geothermal power project. This study was illustrative of the land-management complexities commonly associated with harnessing geothermal resources for power projects, whereby all stages of the fuel cycle are located at the production site and a multitude of ecosystem services may have to be sacrificed through the development and operation of plant infrastructure and transmission lines [4,5].

In this paper, the total economic value of preserving two of Iceland's geothermal areas – Eldvörp and Hverahlíð – is estimated using the contingent valuation method (CVM). In the case of Eldvörp, the impacts are related to further exploratory drilling, which may or may not eventually lead to an application for a production license; for Hverahlíð, the contingent valuation scenario relates to impacts deriving from a proposed geothermal power plant. These study sites have been chosen as case studies for two

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https://doi.org/10.1016/j.renene.2017.09.072
0960-1481/

main reasons: (a) they are characterised by a range of geomorphological features, contrasting levels of pre-existing human intervention on their landscape in pursuit of geothermal power and recreational pursuits, and their development will lead to environmental and social impacts which vary in type and degree; and (b) they are both listed as approved for development by the Iceland Master Plan for Nature Protection and Energy Utilisation,[1] the nation's legally binding strategic tool for identifying suitable energy projects. They thus represent credible scenarios for survey participants to respond to.

The outcomes from these studies are potentially of interest to anyone interested in decision-making connected to the development of geothermal power, and particularly practitioners of cost-benefit analysis. However, in the case of Iceland, there is also a decidedly practical relevance in terms of advancing the decision-making apparatus. All three of the OECD's Environmental Performance Reviews of Iceland have advocated the nation strengthening its use of economic analysis in decision-making [6–8]. In particular, the OECD's 2014 assessment emphasised that it was important for Iceland to *"develop some cost-benefit analysis process which gives appropriate consideration to all dimensions of power development (environment, tourism, social and regional development, project profitability)"* ([8]; p.115). In addition, Working Group 4, currently responsible for progressing the economic knowledge base underpinning the next iteration of Iceland's Master Plan for Nature Protection and Energy Utilisation, has argued that the macroeconomic impact of the nation's future energy projects can only be properly evaluated based on knowledge of all costs and benefits of projects, and these must include the economic value of their environmental impacts [9].

In recent years there has been heated debate in Iceland concerning the trade-off between environmental goods and power projects, most notably in the case of the multiple and long-lasting impacts to flora and fauna [10] associated with the controversial 690 MW Kárahnjúkar Hydropower Plant in eastern Iceland, which has been used since 2007 to supply electricity to Alcoa's Fjardaál aluminium smelter in Reyðarfjördur. However, to date, cost-benefit assessments for Icelandic energy projects have been undertaken without conducting total economic valuations to guide decision-making, ensuring that the monetary value of socially desirable goods, such as the qualities of an undisturbed landscape in a preserved geothermal area, have been overlooked [11,12]. Moreover, only a very few academic studies have been undertaken in Iceland involving the utilisation of non-market valuation techniques, and just two related to energy project, both contingent valuation studies on the Kárahnjúkar Hydropower Plant [13,14].

This paper has four main aims: (1) to enhance the currently scant academic literature concerning preferences and willingness to pay for the preservation of geothermal areas; (2) to provide a comparison of WTP to preserve high-temperature for geothermal areas of varying scale, environmental characteristics and impacts; (3) to begin to satisfy the OECD's oft-repeated call for the introduction of a suitable environmental accounting method for use within the cost-benefit assessments of future energy projects in Iceland; and (4) to communicate in detail a best practice case study of the CVM for future practitioners in Iceland to follow.

The structure of this paper is as follows. Section 2 of this paper begins by briefly summarising details about the regulative background and study locations for Eldvörp and Hverahlíð, before outlining the anticipated environmental and social impacts of their development. Section 3 sets out a detailed description of this paper's methodology, including the survey design and mode of statistical analysis. Section 4 outlines the results and discusses the main implications of the outcomes.

2. Legislative and regulatory background, project proposals and impacts

2.1. Legislative and regulatory background

The Iceland Master Plan for Nature Protection and Energy Utilisation began to be forged in the late 1990s. Its ambition was to provide a national strategic guide to aide decision-making concerning energy projects [15]. Closely akin to Strategic Environmental Assessment in terms of its land use planning objectives, its aim was to evaluate the suitability of various potential geothermal and hydro power projects, ranking and classifying these according to their environmental, socio-cultural and economic impacts [11,16,17]. Enshrined in law in 2013,[2] the Master Plan approved by the Icelandic Parliament segregated sixteen projects (2 hydro power, 14 geothermal) into the category of 'suitable for development', twenty (11 hydro power, 9 geothermal) as 'protected', and the remaining thirty-one (22 hydro power, 9 geothermal) as 'under consideration' pending further data and review [15]. The geothermal areas of Eldvörp and Hverahlíð were bracketed within the fourteen geothermal projects deemed 'suitable for development'.

2.2. Study site background and project proposals – Eldvörp and Hverahlíð

Eldvörp is a high-temperature field of 1007 ha, located on the Reykjanes peninsula, approximately 50 km south-west of the capital city of Reykjavík. Eldvörp is currently owned by the energy company, HS Orka, who have estimated the productive capacity of the area to be in the region of 50 MW_e [15]. Base on the results from a test well in 1983, HS Orka consider the field to have a productive capacity in the region of 50 MW_e. HS Orka have planning permission to carry out further exploratory research, involving the drilling of shallow and deep test wells. They intend to conduct shallow and deep drill testing on up to five further boreholes [18].

Hverahlíð is a high-temperature field of 320 ha, located approximately 25 km to the east of Reykjavík and 2 km south-east of the existing 303 MW Hellisheiði Power Plant. Owned by Reykjavík Energy, Hverahlíð is estimated to have a productive capacity in the region of 90 MW_e [15]. Reykjavík Energy currently holds a fifteen-year exploration license for the Hverahlíð area. Their project proposals include two 45 MW turbines, 18 production wells, with estimated steam consumption of around 80–85 kg/s each, and 9 re-injection wells. The main project components would also include the steam utility, freshwater utility, power plant, cooling towers, drainage utility, roads and tracks to connect to the nearby main highway, quarrying of material, facilities for contractors, and a connection with the transmission system [19].

2.3. Summary of environmental and social impacts – Eldvörp and Hverahlíð

An Environmental Impact Assessment, based on HS Orka's proposals for further exploratory research, was completed by VSO Consulting in 2013. A brief summary of the likely environmental impacts is provided as follows:

[1] Also referred to as the *Master Plan for Hydro and Geothermal Energy Resources* in Refs. [11,12].

[2] Law number 48/2011: http://www.althingi.is/lagas/141b/2011048.html.