



FINAL REPORT

Evaluating the cost of environmental impact due to geothermal utilisation (GEOCOST)

Project ID: **11-04-002**

Coordinator: Brynhildur Davidsdottir

Start date: 01.04.2014 – 31.03.2017

Duration: 3 years

Partners: University of Iceland, Reykjavik Energy and Efla

1 Project summary

The goal of the study was to develop and test a methodology that can be used to conduct an economic valuation of the environmental costs of geothermal utilisation. First project staff summarized and developed a primer on the economic assessment of environmental impact of energy development. Then an assessment was completed of an economic evaluation of a test site in Iceland (note that the academic paper from this effort is the last one to be published for the project). Second, the project staff reviewed the different environmental impacts of geothermal utilization and revealed why economic evaluation of environmental impacts is important. Third, a theoretical framework was constructed for assessing the environmental costs associated with utilization of geothermal power and different evaluation methods were reviewed illustrating the best applicable methods in the case of geothermal utilization. Fourth, project staff completed a pilot economic evaluation study on the environmental impact of geothermal utilization at two locations in Iceland in Eldvörp and Hverahlid. This research has created domestic expertise on how to assess the economic value of energy development with a particular emphasis on geothermal utilization. This research has further Iceland's status as a leader in securing sustainable energy development, in particular in the context of sustainable geothermal utilisation. **All expected and planned milestones and deliverables have been reached and no issues of concern arose throughout the duration of the project.**

Below is a summary of activities per year

Year 0 - pre activities (project initially began in 2012 – but PhD student was not hired until 2014 as noone qualified was found.

- Primer on the economic assessment of energy development written and delivered to the Ministry for Environment and natural resources

Year 1 – 2014/15

- Project initiation, including development of a research plan for the study and proposed list of five PhD articles.
- Poster presentation of the research plan for the study at GEORG open house event.
- Training in non-market valuation methods, especially focused on the practical use of the contingent valuation method in the context of the Heiðmörk ecosystem services project. One journal publication from this effort. Is part of the PhD thesis.
- Purchase of Stata statistical software and associated training with respect to economic valuation methods and practice.
- Presentation at the International Society of Ecological Economics Conference in Reykjavík, Iceland, in July 2014 entitled 'Measuring countries' environmental sustainability performance – a review and case study of Iceland'.
- Presentation at the Conference for the European Society of Ecological Economics in Leeds, UK, in July 2014 entitled 'Promoting economic efficiency through PES – scheme design to encourage additionality'.

- Review of non-market valuation techniques and ecosystem services in the context of geothermal energy.
- Review of policy changes necessary to integrate the economic valuation of environmental impacts from geothermal utilisation into Iceland's decision-making processes for energy projects. Initial preparation of journal article entitled 'Measuring countries' environmental sustainability performance—The development of a nation-specific indicator set'. Article published in Journal of Ecological Indicators, March 2017. Available here: <http://www.sciencedirect.com/science/article/pii/S1470160X16306999>

Year 2 – 2015/16

- Preparation of journal article entitled 'Energy projects in Iceland – Advancing the case for the use of economic valuation techniques to evaluate environmental impacts'. Article published with the Journal of Energy Policy, April 2016. Available here: <http://www.sciencedirect.com/science/article/pii/S030142151630146X>
- Preparation of journal article entitled 'An ecosystem services perspective for classifying and valuing the environmental impacts of geothermal power projects'. Article submitted to Journal of Energy for Sustainable Development in December 2016, accepted for publication July 2017. Available here: <http://www.sciencedirect.com/science/article/pii/S0973082616310845>
- Review of study sites for contingent valuation surveys. Eldvörp and Hverahlíð identified as being the most suitable sites for analysis.
- Design of contingent valuation surveys in conjunction with the Social Science Research Institute at the University of Iceland.
- Surveys piloted during March 2016 and officially issued to participants in April 2016.
- Presentation at the International Conference on Energy, Environment and Economics in Edinburgh, UK in August 2016 entitled 'Geothermal power – classifying and valuing impacts to ecosystem services'.

Year 3 – 2016/17

- Analysis and statistical treatment of data pertaining to the two contingent valuation surveys.
- Preparation of journal article entitled 'Willingness to pay for the preservation of geothermal areas in Iceland – the contingent valuation studies of Eldvörp and Hverahlíð'. This article is based on the results from the contingent valuation surveys and was submitted to the Journal of Renewable Energy during February 2017, revised and accepted for publication September 2017. Available here: <http://www.sciencedirect.com/science/article/pii/S0973082616310845>
- Presentation (oral and a poster) of two journal papers at GEORG's Geothermal Workshop in Reykjavik, 24-25th November 2016.
- Oral presentation at the International Conference on Environmental and Ecological Economics in Prague, July 2017. Presentation entitled 'Willingness to pay for the preservation of geothermal areas in Iceland – the contingent valuation studies of Eldvörp and Hverahlíð'.

Table 1, below summarizes all anticipated milestones as presented in the original work schedule and their status. **In sum, all milestones have been reached.**

Geocost Work plan and time schedule – contrast to progress

| Task | Subtask | Timeline (year- month) | Milestone | Status |
|--|--|------------------------------|--|--|
| Initialization – introduction- hire of PhD student | | 1-1 to 1-3 | Hire of student, project plan finalized | Complete David Cook hired; BD and DMK supervisors Poster presented at GEORG open house with project overview Additional deliverable: Journal article 1 written and published in journal Ecological Indicators – overarching assessment of how to measure environmental sustainability of Iceland/Norway, especially with focus on energy issues |
| Literature review | Review of economic evaluation methods | 1-1 to 1- 12 | Review article of economic evaluation methods in the context of energy projects | Complete Review document written in Icelandic for Icelandic stakeholders - Complete. Available at the UAR website |
| | Review of economic evaluation of energy | 1-1 to 1- 12 | | Journal article 2 written and published in |

projects

Links from LCA derived impact to economic evaluation

journal Energy Policy – examined how best to incorporate economic valuations of ecosystem service impacts into the Icelandic decision-making framework for energy projects

| | | | | |
|--|--|------------|--|--|
| Physical analysis of the affected environmental services in study area | <p>Analysis of environmental impact assessment in pilot area</p> <p>Analysis of the LCA impact in the pilot area</p> | 2-1 to 2-6 | <p>Framework for classifying and valuing environmental services affected by energy projects</p> <p>Framework for environmental impact – linked to environmental services</p> | <p>Complete</p> <p>Journal article 3 written and published in journal Energy for Sustainable Development – analysed how to value ecosystem service impacts of geothermal power using non-market valuation techniques and discussed best sources of information for impact values</p> |
| | Identification of the affected ecosystem services in the area | 2-1 to 2-6 | | |
| | Assessment of the impact of project on ecosystem services | 2-1 to 2-6 | | |
| Economic evaluation of affected environmental services | <p>Provisioning services</p> <p>Supporting services</p> <p>Regulating services</p> <p>Cultural services</p> <p>Holistic assessment</p> | 2-6 to 3-6 | <p>Assessment framework for economic evaluation of environmental impact</p> <p>Results from pilot study using contingent evaluation.</p> | <p>Journal article 4 submitted and accepted by the journal Renewable Energy – outlined the results from two contingent valuation studies focused on the economic costs of the environmental</p> |

| | | | | |
|---|------------------|-------------|--------------------|---|
| | | | | <p>impacts of potential geothermal power projects at Eldvörp and Hverahlíð</p> <p>Journal article 5 submitted and currently being revised following peer review by journal Environmental Management – applied the contingent valuation method to estimate willingness to pay to preserve the popular recreational parkland of Heiðmörk, a conservation area influenced by geothermal forces</p> |
| Completion of thesis and development of journal articles. | Thesis writing | 3-1 to 3-12 | PhD thesis | This was completed in the spring of 2017 |
| | Journal articles | 3-6 to 3-12 | 3 journal articles | <p>5 journal articles already written, 4 published with the fifth pending. In order of appearance in the thesis, these are:</p> <p>(1) Cook, D., Saviolidis, N. M., Davíðsdóttir, B., Jóhannsdóttir, L., & Ólafsson, S. (2017). Measuring countries’ environmental sustainability performance—The development of a</p> |

nation-specific
indicator
set. *Ecological
Indicators.*

(2) Energy
projects in Iceland
– Advancing the
case for the use of
economic
valuation
techniques to
evaluate
environmental
impacts.
(2016) *Energy
Policy.*

(3) An ecosystem
services
perspective for
classifying and
valuing the
environmental
impacts of
geothermal power
projects.
(2017). *Energy for
Sustainable
Development.*

(4) Willingness to
pay for the
preservation of
geothermal areas
in Iceland – The
contingent
valuation studies
of Eldvörp and
Hverahlíð. (2018).
Renewable Energy.

(5) Cook, D.,
Eiríksdóttir, K.,
Davíðsdóttir, B., &
Kristófersson, D.
M. (2018). The
contingent
valuation study of
Heiðmörk, Iceland
– willingness to
pay for its
preservation.

*Environmental
Management
(publication under
revision following
journal review).*

2 Project Management

No problems have occurred throughout the duration of the project. It has progressed as planned and finished on time. Day to day management was overseen by B. Davidsdottir.

Annual meetings were held 1x every year, and advice sought on each of the research modules from the project partners outside of those as needed. For example, the environmental manager of OR was centrally involved with designing the Contingent evaluation of Hverahlid power site and input was sought from Efla on the Contingent evaluation study as well.

3 Student involvement

PhD student David Cook has worked full time on the project. He has performed the research with the support of his supervisors and the project team. The project core team has consisted of B. Davidsdottir, D.M Kristofersson with assistance from Ruth Shortall (post doctoral researcher) and Sigridur Rós Einarsdóttir (MS student in Environment and natural resources). Ms Einarsdottir was funded by another project as well as 50% of R. Shortall's salary in 2016. Ms. Einarsdottir's thesis has been published as well as an academic paper derived from R. Shortall's work as well.

David Cook has submitted his PhD thesis for evaluation by opponents and is awaiting his defence.

4 Publications and disseminations

Academic

Cook, D., Davíðsdóttir, B., & Kristófersson, D. M. (2016). Energy projects in Iceland – Advancing the case for the use of economic valuation techniques to evaluate environmental impacts. *Energy Policy*, 94, 104-113. Available at:

<http://www.sciencedirect.com/science/article/pii/S030142151630146X>

Cook, D., Saviolidis, N. M., Davíðsdóttir, B., Jóhannsdóttir, L., & Ólafsson, S. (2017). Measuring countries' environmental sustainability performance—The development of a nation-specific indicator set. *Ecological Indicators*, 74, 463-478. Available at:

<http://www.sciencedirect.com/science/article/pii/S1470160X16306999>

Cook, D., Davíðsdóttir, B., & Kristófersson, D. M. (2017). An ecosystem services perspective for classifying and valuing the environmental impacts of geothermal power projects. *Energy for Sustainable Development*, 40, 126-138. Available at:

<http://www.sciencedirect.com/science/article/pii/S0973082616310845>

Shortall, R., Davíðsdóttir, R. (2017). How to measure national energy sustainability performance: An Icelandic case-study, *Energy for Sustainable Development*, 39:29-47. Available at: <http://www.sciencedirect.com/science/article/pii/S0973082616309760>

Cook, D., Davíðsdóttir, B., & Kristófersson, D. M. (2018). Willingness to pay for the preservation of geothermal areas in Iceland–The contingent valuation studies of Eldvörp and Hverahlíð. *Renewable Energy*, 116, 97-108. Available at: <http://www.sciencedirect.com/science/article/pii/S0973082616310845>

Cook, D., Eiríksdóttir, K., Davíðsdóttir, B., & Kristófersson, D. M. (2018). The contingent valuation study of Heiðmörk, Iceland – willingness to pay for its preservation. *Environmental Management*. (UNDER REVISION FOLLOWING JOURNAL REVIEW).

Thesis

Sigríður Rós Einarsdóttir, (2017) The Contingent Valuation of the Wind Farm Búrfellslundur: Willingness to Pay for Preservation. MS thesis Environment and Natural Resources, department of Economics, University of Iceland.

Presentations

Evaluating the cost of environmental impact due to geothermal utilization. (2015). Poster presentation at *GEORG Open House Event*, Reykjavík, Iceland.

Promoting economic efficiency through Payments for Ecosystem Services. (2015). *Proceedings of the European Society of Ecological Economics Conference*, Leeds, England.

Geothermal power – classifying and valuing impacts to ecosystem services. (2016). *Proceedings of the International Conference on Energy, Economics and Environment*, Edinburgh, Scotland.

Willingness to pay for the preservation of geothermal areas in Iceland: The Contingent Valuation Studies of Eldvörp and Hverahlíð. (2016). *Proceedings of the GEORG Geothermal Workshop*, Reykjavík, Iceland.

Willingness to Pay for the preservation of geothermal areas in Iceland: The Contingent Valuation Studies of Eldvörp and Hverahlíð. (2017). *Proceedings of the 19th International Conference on Environmental and Ecological Economics*, Prague, Czech Republic.

5 Cost statement

See attachment with explanation of each cost item. Total funding from GEORG for the project was 18,450,000. The project has currently outstanding 3,650,000 from the project that will be charged.

| | 2012-2014 | 2015 | 2016 | 2017 | Grand total 2012 - 2017 |
|--------------------------------|------------------|------------------|------------------|-------------------|----------------------------|
| Georg funding | 1.500.000 | 1.500.000 | | 11.800.000 | 14.800.000 |
| Personnel cost | 2.961.536 | 4.962.266 | 7.125.162 | 1.856.046 | |
| Operational expenses | | | | | |
| Contracted services | | | 969.700 | | |
| Travel expenses | | 157.429 | 279.595 | 265.807 | |
| Others | | | 281.120 | | |
| Total operational costs | 2.961.536 | 5.119.695 | 8.655.577 | 2.121.853 | 18.858.661 |