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Energy projects in Iceland – Advancing the case for the use of economic valuation techniques to evaluate environmental impacts

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HIGHLIGHTS

- Current risk of sub-optimal decision-making by licensing body, Orkustofnun.
- OECD call for monetary valuations of environmental impacts linked to Icelandic energy projects.
- Lessons to be learned from US regulatory approach to advance cost-benefit assessment practice in Iceland.
- Practice of conducting non-market valuation techniques limited in Iceland, but now growing.

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ABSTRACT

Decision-making in Iceland has occurred without reference to economic valuations of the environmental impacts of energy projects. Environmental Impact Assessments, a legal requirement for nearly all energy projects in Iceland since 1994, have played an important role in identifying the environmental impacts of energy projects, and proposing mitigation measures. However, a purely qualitative description of environmental impacts is insufficient to ensure that they are accounted for equivalently with all of the other costs and benefits of a proposed project. Instead, as monetary information concerning the welfare gains or losses of proposed projects is not currently required to be provided to the licensing body, Orkustofnun, there is the potential for sub-optimal decision-making to occur. As this paper sets out, a broad variety of non-market valuation techniques already exist and could be applied to estimate the value of environmental benefits sacrificed to accommodate such developments. These methods and their outcomes could be incorporated within mandatory cost-benefit assessments for proposed Icelandic energy projects, communicating an estimate of the full welfare implications of approvals to decision-makers and the public alike, and fulfilling an OECD demand for the country to commence such processes.

1. Introduction

The objective of public policy is to improve or correct components of social welfare, from economic conditions to health to the quality of the environment (Lazo and McClain, 1996). Approving development projects with significant environmental impacts implies that the forgone benefits are expected to be less than a project's financial gains. A broad variety of non-market valuation techniques exist for estimating derived environmental benefits, yet in the absence of such valuations to guide decision-making, projects may be approved which result in a net loss in social welfare (Pearce, 1998; Dixon et al., 2013). This risk is evident in the case of Iceland, where neither the cost-benefit assessments (CBA) for renewable energy power plants nor industrial works reliant on their generating capacity have been required to incorporate such non-market considerations.

Iceland has become a world-leader in terms of harnessing renewable energy, with its abundant hydropower and geothermal sources together now supplying almost 100% of electricity generation and 85% of primary energy use (Orkustofnun, 2014). The availability of highly competitive energy prices and a secure supply of electricity have led to an expansion in the number of power plants and the role of energy-intensive industries, particularly aluminium smelting, which consumes 68.40% of the nation's annual electricity consumption (Orkustofnun, 2014). Unable currently to export Iceland's renewable energy abroad, this focus has been effective in drawing in foreign investment and diversifying the export industry (Kristófersson and Cosser, 2009), but has also

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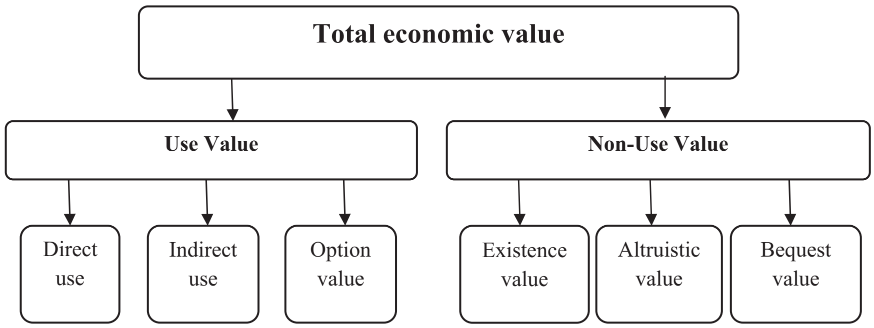

Fig. 1. Total economic value framework.

led to burgeoning environmental impacts such as a 178% increase in the leakage of sulphur hexafluoride (SF_6) emissions from electrical equipment in the period 1990–2013 (NIR, 2015). The Global Warming Potential of SF_6 emissions is around 3400 times greater than an equivalent volume of carbon dioxide.

Since 1994 the qualitative nature of environmental impacts related to proposed energy projects have been outlined within mandatory Environmental Impact Assessments, but no effort has been made to quantify these effects in monetary terms to be compared against the economic gains of projects. This is despite 'Welfare for the Future – Iceland's National Strategy for Sustainable Development 2002–2020' setting out a strategic objective for the country to *"introduce more economic instruments in the field of environmental protection and resource utilisation in the near future"* (Ministry for the Environment in Iceland, 2002, p. 13). Moreover, the OECD has repeatedly requested that Iceland commences accounting for environmental impacts within decision-making (OECD, 1993; OECD, 2001; OECD, 2014). Most recently, the OECD's (2014) assessment reiterated 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)"* (OECD, 2014, p.115).

The aims of this paper are to review the current decision-making basis in Iceland in relation to energy projects, in so doing setting out the rationale for conducting valuations of the environmental benefits sacrificed as a consequence of developing Iceland's energy resources. Section 2 begins by discussing environmental benefits in terms of the broad concept of ecosystem services. This concept is then linked to the total economic value framework, before a review is carried out concerning the strengths and weaknesses of the various non-market valuation techniques that can be applied to estimate the various value components. Section 3 provides a summary of the national policy, regulatory and legislative context in Iceland relevant to energy projects, before delineating the changes necessary to ensure that environmental impacts are properly accounted for in decision-making, as per the OECD's clarion call. Finally, Section 4 outlines the methodology pertaining to the upcoming contingent valuation studies concerning two of Iceland's geothermal areas (Hverahlíð and Eldvörp), in so doing highlighting one possible approach to valuing the environmental implications of a future Icelandic energy project.

2. Total economic value and economic valuation techniques

2.1. Introduction to ecosystem services and the concept of total economic value

2.1.1. Ecosystem services and utilitarian conceptions of value

The value of the many benefits deriving from natural resources – their ecosystem services – can be expressed in different ways according to cultural conceptions, philosophical perspectives, and schools of thought (Goulder and Kennedy, 1997). Ecosystem services are commonly classified into four categories: (1) provisioning, such as the production of food or reaping of a timber harvest; (2) regulating, such as climate control or water filtration; (3) supporting, such as pollination and nutrient recycling; and (4) cultural, such as spiritual and recreational benefits (MEA, 2005). One of the main endeavours of the Millennium Ecosystem Assessment was to evaluate the importance of ecosystem services to human welfare, so as to help promote more informed decisions concerning the management of natural resources (MEA, 2005). From a purely anthropocentric perspective, ecosystems have value because they provide services to sustain life and satisfy the consumption demands of human beings (Costanza et al., 1997). Such a perspective relies on a utilitarian conception of value, whereby human beings source utility from ecosystem services either directly or indirectly. The overall level of utility from an ecosystem service requires the aggregation of individual preferences and an indirect form of estimation using the metric of money. That is not to say that only ecosystem services generating monetary benefits are considered in economic valuation techniques. Rather, the majority of economic assessments are focused on non-market valuation techniques that estimate utility indirectly using this metric.

2.1.2. Ecosystem services and the total economic value framework

A commonly used framework for examining the utilitarian value of ecosystem services is the concept of total economic value, an all-encompassing measure of the economic value of any environmental resource. Economists have typically split the total economic value of natural resources into two main constituent parts: use and non-use value (Tietenberg, 1988; Hanley, Shogren and White, 2013), as summarised in Fig. 1.

Use value includes direct use, indirect use and option value (Bateman and Willis, 2001). In the case of direct use value, individuals undertake a planned demand for an ecosystem service. This may take the form of consumptive use, whereby individuals extract provisioning services from an ecosystem. Alternatively, direct use may be non-consumptive in character and not involve a drawing down on resource stocks, such as during the receipt of cultural, spiritual and recreational benefits. Consumptive forms can generally be traded in a market while non-consumptive cannot.

Indirect use value broadly relates to the MEA's depiction of regulating and supporting ecosystem services. Although they are frequently ignored as individuals do not receive direct benefits, these services are integral to the survival of life on the planet, including key functions such as climate regulation, waste assimilation, nutrient and water cycling, pollination, and pollution filtering (Mitchell and Carson, 1989).

Option value refers to the possibility to gain utility from a resource in the future, either directly or indirectly (Weisbrod, 1964; Hanemann, 1989). Although an individual has no immediate intention to gain utility from a particular resource, their option value relates to an opportunity to do so in the future.

Non-use value, also sometimes referred to as existence value or passive value, is derived purely from the knowledge that a resource is preserved (Krutilla, 1967; Hanley et al., 2013). The three main components are existence value, altruistic value and bequest value. Existence value describes the utility individuals gain from the existence of a resource, despite no intention to demand its ecosystem services, now or in the future. Altruistic value relates to the utility sourced from knowing that other individuals can use a resource. Bequest value is similar to altruistic, but relates to the utility acquired when individuals believe that a resource will be preserved and available for use by future generations.

2.2. Valuation methods and techniques

2.2.1. Cost benefit assessments and total economic value

The aim of this paper is not to provide a review of the theoretical foundations of CBA, however, a few very brief aspects should be pointed out with regards to its framework. CBA involve a calculation of the aggregate monetary costs and benefits of often many projects or policies, aiming to establish the option with the greatest surplus in benefits. Economic benefits are considered to be utility generating and thus increase human economic welfare, while costs have the opposite effect (Pearce and Nash, 1981). All benefits and costs are discounted according to the time value of money concept to ensure a common ‘net present value’ basis for their comparison. For projects where the aggregate discounted benefits exceed aggregated discounted costs, a welfare gain to society accrues.

In terms of decision-making, where the impacts of ecosystem management decisions are presented in purely physical, qualitative terms – such as in an Environmental Impact Assessment – a considerable layer of subjectivity can cloud the debate concerning the merits of economic utilisation versus preservation of environmental resources (Dixon et al., 2013). Although CBA can provide a standardised means of evaluating the benefits and costs of projects and policies, distorted welfare outcomes will result if studies fail to capture all of the costs or benefits of a project or policy, including environmental impacts such as the loss of or change in quality of ecosystem services (Atkinson and Mourato, 2008; Koundouri et al., 2009; Dixon et al., 2013). Failure to do so results eventually in an implied valuation of environmental resources by virtue of the outcomes arrived at by decision-makers (Navrud, 2001).

2.2.2. Non-market valuation methods and techniques

Based on the utilitarian conception of value underlying the foundations of CBA, the purpose of non-market valuation techniques is to estimate the value of ecosystem services by ascertaining individual preferences through the common, easily understood metric of money (Champ et al., 2003; Freeman, 2003; Dixon et al., 2013). The various techniques are generally split according to whether they are either revealed or stated preference methods.

Revealed preference methods involve the gathering of data concerning individual preferences for marketable goods related to the non-market good. The approaches assume that consumer behaviour is always rational and seeking to maximise utility, and that actual preferences can be revealed by the direct observation of responses to complement or substitute goods. The techniques include market pricing (Harris and Roach, 2013), avoided cost (Hanley et al., 2009; Harris and Roach, 2013), replacement cost (Hanley et al., 2009; Harris and Roach, 2013), production function approaches (Pattanayak and Kramer, 2001; Harris and Roach, 2013), hedonic pricing (HP) (Tyrväinen , 1997; Harris and Roach, 2013), and the travel cost method (TCM) (Mitchell and Carson, 1989; Fleming and Cook, 2008; Harris and Roach, 2013).

Stated preference methods rely on the use of carefully designed questionnaires to elicit individual preferences for a change in the level of provision or quality of an environmental resource. The main techniques are the contingent valuation method (CVM) and discrete choice experiments (DCE). Unlike revealed preference methods, which can be applied to estimate use value, the CVM and DCE can also be used to estimate non-use value. The CVM is an advanced survey-based technique that has been applied to a broad variety of environmental contexts to elicit valuations of non-market goods (Mitchell and Carson, 1989; Hanemann, 1994; Venkatachalam, 2004; Carson, 2012; Harris and Roach, 2013). DCE are a particular variant of the CVM and presents participants with at least two different possibilities concerning the set of future attributes of a site (Carson and Louviere, 2012).

Table 1 summarises the general strengths and limitations of the respective economic valuation methods in the context of specific ecosystem services and the total economic value framework.

2.3. Choosing methods to estimate total economic value and likely challenges in Iceland

Each of the non-market valuation methods comes attached with specific strengths and limitations, and the choice of techniques depends greatly on the ecosystem services appraised. It is clear that when estimating the total economic value of environmental resources, a number of methods may be needed, and their choice depends greatly on the services being valued, context, and the available resources – financial and time – of research teams. However, it is likely in all cases that stated preference techniques will need to be adopted as they are the only means of estimating non-use value, and a large number of studies have highlighted the potential significance of this component, especially for sites with limited recreational value (Sorg and Nelson, 1987; Lee and Han, 2002; Freeman, 2003; Hanley et al., 2009; Hoyos et al., 2012; Tentes and Damigos, 2012; Koundouri et al., 2014).

In an Icelandic context, the non-use value associated with preserving potential hydro power and geothermal sites may represent a considerable proportion of total economic value, especially for any future energy projects relying on hydro power resources located in the nation's remote and uninhabited central highland region. When carrying out stated preference methods for any potential geothermal or hydro power project located outside of Reykjavik, it will be challenging for researchers to determine the affected population to survey, as sites may have either a regional, national or even international resonance. Approximately two-thirds of the national population are located in Reykjavik, with the remainder very widely dispersed. Researchers will therefore need to make use of pre-existing online panels to ensure they gather representative samples of their deemed affected population.

For likely forthcoming geothermal power projects, such as Hverahlíð and Eldvörp (Rammaáætlun, 2011), current evidence concerning visitor numbers is perceived largely on an anecdotal basis rather than deriving from year-round data. The recreational value of these areas throughout the year is uncertain and where the time and financial resources of research teams permit, the upcoming results from continent valuation studies of these sites should ideally be bolstered through travel cost studies based on

Table 1
Economic valuation methods for different ecosystem services – main strengths and limitations.

Valuation Method	Elements of total economic value captured	Ecosystem service(s) valued	Strengths of approach	Limitations of approach
Revealed preference				
Market pricing	Direct and indirect use	Provisioning services	Market data reflects individual WTP based on observed behaviour for goods and services exchanged in markets Data is relatively easy to obtain for specific provisioning services.	Market data may not be available for the services provided by an environmental resource. Where markets do exist, the price may not reflect the service's true economic value due to market imperfections, such as externalities of production.
Replacement or avoided cost	Direct and indirect use	Regulating and supporting	Methods can convey an approximation of economic value broadly consistent with the economic concept of use value.	The method assumes that costs – either replacement or avoided – are a valid proxy for estimating benefits. The approach fails to consider social preferences for ecosystem services or individual preferences in their absence.
Production function	Indirect use	Provisioning, regulating and supporting services acting as inputs to market production	A relatively straight-forward methodology in theory, based on actual market behaviour.	The approach is limited in practice to the resources that are used as inputs to marketed goods. Biophysical links between the quality/quantity of the ecosystem services and their contribution to the price of the marketed good are poorly understood.
Hedonic pricing	Direct and indirect use	Commonly supporting and cultural services providing attributes of value to buyers	Method estimates values according to actual purchases, typically related to property markets and the vector of characteristics potentially influencing price. Data on property markets and the characteristics influencing price are generally available.	Generally a method limited to estimating values related to property markets. Method is data-intensive and takes time to analyse, involving complex statistical techniques. Not all environmental influences on housing prices are necessarily captured by the statistical model.
Travel cost method	Direct and indirect use	All ecosystem services contributing to recreational activities	Results are based on actual economic behaviour in surrogate markets. Generally straight-forward to collect a large sample size through on-site sampling.	Method is limited to capturing use components of total economic value and cannot be used alone to estimate the total economic value of an environmental resource. Method assumes that individuals respond to changes in travel costs in the same manner that they would to changes in admission prices. Many travel cost models fail to accommodate trips made with multiple purposes in mind, thus overestimating recreational benefits. The availability of substitute recreational sites affects value, as for two trips of identical cost, the one of greatest value relates to the site with most substitutes in its vicinity. The individuals that most value a site may choose to live closest, and will therefore have very low travel costs, resulting in a considerable underestimate of their true benefits.
Stated preference				
Contingent valuation method	Use and non-use	All ecosystem services	A very flexible method that can be used to measure all components of total economic value, either individual components or in aggregate. Method has been widely adopted and is very appropriate in cases where limited or no observed behaviour exists to estimate the total economic value of an environmental resource or its specific ecosystem services through other methods. Although poorly conceived surveys are very prone to bias, a number of best practice guidelines have been developed in recent years to ameliorate this risk, particularly the NOAA panel report by Arrow et al. (1993).	Criticisms in the academic literature have typically related to observations of hypothetical, starting-point and strategic sources of bias, as well as information and eliciting effects (Duffield and Patterson, 1991; Kahneman and Knetsch, 1992; Diamond and Hausman, 1994; Hausman, 2012). Method assumes that participants are able to understand the provided scenario and have an economic value for the good in question – many individuals are not be familiar with placing an economic value on environmental goods and services.

Table 1 (*continued*)

Valuation Method	Elements of total economic value captured	Ecosystem service(s) valued	Strengths of approach	Limitations of approach
Decision choice experiments	Use and non-use	All ecosystem services	Participants are required to consider trade-offs in terms of policy or project outcomes, which may be easier to contemplate than a WTP/WTA estimate in a contingent valuation study. As the prices of different alternatives are provided for participants rather than elicited, some of the information and eliciting effects commonly reported as afflicting the CVM are not so applicable. In a strategic sense, relative value estimates obtained from DCE may also be more valid than absolute monetary valuations, ensuring their usefulness in making policy decisions.	Not all of the potential trade-offs of project or policy options will necessarily be described to participants and thus participants may make choices that they would not make if these alternatives had not been presented to them. Preferences for certain trade-offs may be difficult to evaluate, particularly if bundles of characteristics are unfamiliar to participants. The hypothetical and strategic sources of bias affecting the CVM can be equally relevant in the case of DCE.

seasonal demand data. Acquiring such information may be particularly challenging given the remoteness, harsh climate and frequent inaccessibility of many areas outside of Reykjavik during the winter months. In addition, scientific research needs to be commenced in Iceland to determine the range and spatial scale of ecosystem services provisioned at undeveloped energy sites, particularly the provisioning and regulating types associated with geothermal resources. In the absence of this knowledge it will be impossible for researchers to even begin to apply revealed preference techniques to estimate the contribution that these services make to total economic value.

3. Energy projects in Iceland, planning policy and regulatory context

3.1. Energy resources and consumption in Iceland

During the course of the 20th century Iceland transitioned from a nation heavily reliant on imports of coal and kerosene for heating and cooking to a largely self-reliant energy system, one which harnesses abundant domestic renewable energy resources. In recent years the demands of power-intensive industries (particularly aluminium smelting) have led to a considerable expansion in low-cost electricity production. Iceland has become the world's largest electricity producer per capita, generation that has almost entirely derived from renewable energy sources (OECD, 2014). Renewable energy production accounted for 99.9% of the 18,116 GWh of electricity generation in 2013 – 12,863 GWh (71.0%) from hydro power and 5245 GWh (28.9%) from geothermal, with very small contributions of 3 GWh and 5 Gwh from fossil fuels and onshore wind energy respectively (Orkustofnun, 2014). In 2013, Iceland consumed a total of 251.4 Petajoules (PJ) of energy, of which 217.0 PJ (86.3%) was generated domestically from renewable energy sources – 170.7 PJ (67.9%) from geothermal energy and 46.3 PJ (18.4%) from hydro power (Statistics Iceland, 2015). The remaining 34.4 PJ (13.7%) of energy consumption derived from imported fossil fuels, predominantly for use in motorised transport and ships – 30.4 PJ from oil (12.1%) and 4.0 PJ (1.6%) from coal (Statistics Iceland, 2015).

3.2. National energy policy in Iceland

As a member of the European Economic Area (EEA) since 1994, Iceland has constructed its legislative framework and policy agenda to fulfill all relevant EU legislation common to the EEA agreement, including Directive 2009/28/EC of the European Parliament on the promotion of the use of renewable energy sources. In order to satisfy the objectives of Directive 2009/28/EC and respond to anticipated growth in gross national energy consumption of 1067 ktoe (49.3%) between 2005 and 2020 (Ministry of Industries and Innovation, 2012), the Icelandic National Renewable Energy Action Plan was formed in 2012.

Iceland has already met the main target set by Directive 2009/28/EC for at least 72% of the nation's primary energy demand to be satisfied using renewable energy generation by the year 2020. However, despite relatively limited reliance on fossil fuels compared to other European nations, in order to ensure compliance with a challenging government goal for 10% of energy demand in the transport sector to be from renewable energy sources by the year 2020 – in line with Directive 2009/28/EC's stipulations – further expansion in renewable energy generation will be required, especially in motorised transport.[1] There remain sources of

[1] In 2011 only 0.35% of energy demand in the transport sector derived from

hydro power and geothermal energy in Iceland yet to be tapped (Rammaáætlun, 2011), while early trials of onshore wind energy have been more productive than expected (Landsvirkjun, 2015).

3.3. Strategic planning – master plan for hydro and geothermal energy resources in Iceland

In the period between 1970 and 1990 there was gradual political recognition in Iceland that a range of interests need to be considered in terms of the impacts of harnessing the nation's renewable energy resources. During this time, a committee of specialists from the Ministry of Industry, National Energy Authority (Orkustofnun), National Power Company (Landsvirkjun), and the Nature Conservation Council met regularly to discuss various power plant plans, with particular attention given to their environmental impacts (Ketilsson et al., 2015). A political view began to emerge which recognised that there was merit to having a strategic guide to aide decision-making concerning energy projects, an opinion that was further reinforced following the enactment of Environmental Impact Assessment legislation in 1994.[2] In 1997, the Government proceeded to issue a white paper on sustainability in the Icelandic society (Thórhallsdóttir, 2007b). This document stressed the need for the development of a long-term Master Plan, categorising and ranking energy projects according to their likely economic, environmental and social impacts (Ketilsson et al., 2015).

Akin to a form of Strategic Environmental Assessment in terms of its land use planning objectives, the development of the Master Plan commenced in 1999 and was enshrined in Icelandic law in 2013,[3] in so doing becoming one of the world's most comprehensive national-level strategic guides for the sustainable use of energy resources. Rather than evaluating the level of detail required to complete an Environmental Impact Assessment, its aim was to provide a broad overview of the various potential hydro power and geothermal energy projects, ranking these according to their particular environmental, socio-cultural and economic impacts (Thórhallsdóttir, 2007a, 2007b). A Steering Committee was responsible for coordinating the activities of four separate working groups to assess the many impacts of energy projects – the first considered environmental impacts and cultural heritage; the second dealt with recreation and land use impacts; the third reviewed regional and economic consequences; and the fourth examined likely energy capacity and project costs. In the case of the first working group, two criteria were used as general guidelines for determining impacts: Article 1 of the Nature Conservation Act (Law 44/1999) and Article 1 of the National Heritage Act (Law 107/2001). The former stressed that Icelandic nature should be developed according to its own laws and the protection of what is unusual or historically important; the latter safeguarded Icelandic cultural heritage, placing emphasis on the retention of in-situ archaeological monuments. Values and impacts for each of five defined environmental classes were scored by Working Group 1 on a non-linear four-point numeric scale (1=insignificant impacts; 3=some; 6=large; 10=very significant) against six attributes: diversity and richness; rarity; size in area, completeness and pristineness; information (epistemological, educational, typological and scientific) and symbolic value; international responsibility; and scenic value (Ketilsson et al., 2015). The average score for each environmental class was weighted (not equally) and aggregated to arrive at an overall score for each project's environmental impact. By the end of two phases of analysis in 2011 and following the compilation of the scores from the four working groups, the eventual Master Plan approved by the Icelandic Parliament ranked 35 hydro power and 32 geothermal projects respectively – 16 (2 hydro power, 14 geothermal) were then classified as 'suitable for development' and 20 (11 hydro power, 9 geothermal) were considered to be 'protected', while the remaining 31 (22 hydro power, 9 geothermal) projects bracketed as 'under consideration' pending further data and review (Rammaáætlun, 2011). Further projects are currently being evaluated during the third phase of the Master Plan, including sites for potential onshore wind energy utilisation, and this process is due to complete in 2017.

3.4. Review of regulatory and decision-making requirements for new energy projects

Licenses for Icelandic power projects involving the utilisation or exploration of resources are granted by Orkustofnun, a legally independent government agency operating under the auspices of the Ministry of Industries and Innovation. Orkustofun's responsibilities, as set out in the Act on Orkustofnun (87/2003), also involve the provision of information and research concerning energy matters in Iceland, together with regulation of the main acts governing natural resource exploration and licensing activities.

No proposed power project can receive a license from Orkustofnun in the event that it is located in an area categorised for protection or pending further research as per the legally binding Master Plan. Secondly, assuming a project is deemed suitable for development by the Master Plan, Orkustofnun carries out decision-making concerning the award of licenses having ascertained that all survey, utilisation and power production proposals are legally compliant, particularly with respect to the Planning and Building Act (73/1997), Resources Act (57/1998), Nature Conservation Act (44/1999), Environmental Impact Assessment Act (106/2000), Electricity Act[4] (65/2003), and Water Act (20/2006).

The Resources Act establishes the legal standards with regards to the exploration, ownership and utilisation of all natural resources in the ground, bottom of rivers and lakes, and the seabed within netting limits, covering all geothermal energy resources and surveys of hydropower for the generation of electricity. While previously the Minister of Energy granted licenses for energy utilisation for periods of up to 65 years, in 2008 the Icelandic Government opted to add a clause into the Resources Act stating that this responsibility now came under the remit of Orkustofnun. The Minister continues to retain a decision-making role in the event of an appeal. The Electricity Act sets out provisions and rules with regards to electricity production and transmission, distribution and matters of trade. The Water Act has the objective of ensuring the clear ownership of water resources, as well as their efficient and sustainable use. Provisions include items with respect to property rights, priority of access, and the utilisation of hydro power and expropriation.

The Nature Conservation Act establishes the broad legislative basis for the sustainable management of the environment in Iceland, regulating interactions between man and natural resources to prevent neither harm to the bio-sphere or geo-sphere nor pollution to the air, sea or water. Article 21 of the Resources Act asserts that the Nature Conservation Act also applies with respect to geothermal areas being surveyed and utilised. The

(*footnote continued*)
renewable energy sources (Ministry of Industries and Innovation, 2012; Ketilsson et al., 2015).

[2] Iceland joined the European Economic Area in 1994 and was required to adopt the European Directive EIA85/337 on environmental impact assessment. This came into effect in 1994 and has since been amended twice, in 2000 (Law 106/2000) and 2005 (Law 74/2005).

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

[4] Licenses for electricity production are not generally required for projects of less than 1 MW.

Environmental Impact Assessment Act ensures that prior to decision-making concerning projects deemed to have the potential to cause considerable environmental and social impacts, a comprehensive qualitative assessment of their proposals is undertaken to characterise these effects. All major power project proposals and those related to power lines are required to carry out an Environmental Impact Assessment in accordance with the stipulations of the Act,[5] which must include the preparation of a list of design improvements to mitigate environmental impacts. Administration and implementation of the Act is the responsibility of the National Planning Agency (Skipulagsstofnun), who, once the final EIA is published, issues a non-binding opinion on the project.

3.5. A regulatory gap – the case for economic valuations of sacrificed environmental benefits

Reliant on a complex mix of scientific analyses by experts and public consultation, the Master Plan represents a considerable step forwards in terms of improving the strategic basis via which the suitability of potential Icelandic energy projects is determined. Furthermore, its determinations, formed using expert input sourced from multiple disciplines, help to move the country towards some sort of a consensus concerning complex energy-environment issues. However, there remain some obvious procedural and technical deficiencies that should be addressed when the next iteration of the Master Plan is published in 2017.[6] These include shortcomings connected to the lack of data for some criteria, particularly environmental aspects pertaining to the development of geothermal resources, such as wastewater and air pollutants. In addition, there is a need for greater transparency of process and outcome as it has been contended that it is too easy for projects to be shifted from one classification category to another – allegations were levied that the Master Plan's steering committees were not independent and that rankings were changed at the end of the process for reasons of political ideology (Sæþórsdóttir, 2012). Monetising the environmental impacts of energy projects could eventually provide future iterations of the Master Plan with an evidence base for a better-informed weighting system, one that moves beyond the current arbitrary system.

Irrespective of the strategic suitability of projects for development, the role of the Master Plan is limited to the overarching, policy, planning and programming level; its task is not to identify the environmental and social impacts of proposed energy projects prior to decision-making, which requires the preparation of an Environmental Impact Assessment. Recent environmental controversies concerning energy projects in Iceland have appeared to highlight the limitations of EIA's in terms of their capacity to influence decision-making (Thórhallsdóttir, 2007b) – for example, particularly heated debate ensued concerning the environmental impacts of the 690 MW Kárahnjúkar Hydropower Plant in eastern Iceland, the largest such project in Iceland and used since 2007 to generate electricity for Alcoa's Fjardaál aluminium smelter in Reyðarfjördur. These impacts were predicted to be long-lasting and severe, diminishing both the landscape value of the area and biodiversity. They included permanent negative impacts to rare wildlife populations that were inhabiting, breeding and nesting in the affected area (particularly reindeer, pink-footed geese and harbour seals); widespread soil erosion; considerable hydrological changes leading to a reduction in groundwater flows and the creation of the Hálslón reservoir, which would destroy a rare highland vegetative area with considerable conservation value; and fragmentation and disruption of one of the last remaining wilderness areas in Europe, including the loss of one of Iceland's most well-known glacial canyons, Dimmugljúfur (Landsvirkjun, 2003).

It is evident that the approval of the Kárahnjúkar Hydropower Plant was indicative of weaknesses in regulatory and decision-making processes rather than EIAs per se. The EIA for the Kárahnjúkar Hydropower Plant led to the clear depiction of the numerous irreversible environmental impacts of the project, as well as the articulation of various mitigation measures. The regulatory deficiencies are twofold. Firstly, connected to power, it is evident that Skipulagsstofnun lacks the legal authority to reject developments when it deems environmental impacts to be unacceptable, as Orkustofnun can override their published opinions during final decision-making. To many, this was an evident feature of the process leading to the eventual approval of the Kárahnjúkar Hydropower Plant, as the scheme was originally rejected by Skipulagsstofnun on the grounds of the significant and irreversible environmental impacts set out in Landsvirkjun's EIA (Del Giudice, 2008; Newson, 2010). Secondly, and more critically, the determination of the acceptability of environmental impacts deriving from energy projects has the potential to become a highly subjective affair, never more so than when political willpower provides ballast to the vested interests of developers, many of whom will have already invested considerable capital by the time that their self-prepared EIA takes place (Benson, 2003; Wathern, 2013).

Any evaluative process involving the weighing up of negative qualitative data against monetary benefits instigates the risk that impacts related to the former have insufficient arbitrage in decision-making. Failure to also quantify these impacts in monetary terms can therefore lead to project approvals that undermine social welfare. Therefore, to ensure standardisation of all costs and benefits related to projects, by utilising the total economic valuation framework discussed in this paper and the most suitable non-market techniques, the Icelandic decision-making context could be strengthened considerably. During the planning phase for the Master Plan, the use of non-market valuation techniques was considered to estimate the value of the various resources. However, these approaches were rejected due to their prohibitively high cost and the logistical complexities of ensuring that stated preference techniques targeted a representative sample of affected populations (Thórhallsdóttir, 2007b). Conducting such techniques for all of the Master Plan's potential projects would certainly have been costly, time-consuming, and, above all, unnecessary. However, once detailed power plant proposals are available, such techniques can then be used to provide economic estimates of the value of environmental impacts. These outcomes can subsequently be used within cost-benefit assessments to ensure that a project's actual welfare gains/losses are evaluated alongside the qualitative impacts detailed in an EIA.

Although seemingly radical in an Icelandic decision-making context, the use of non-market economic valuation techniques within cost-benefit assessments is fairly commonplace in countries such as the US, at least in terms of regulatory analysis. They have also been applied in cases of costing natural resources damages, perhaps most prominently in the contingent valuation study pertaining to the Alaskan oil spill by Exxon Valdez in 1989 (Carson et al., 2003). In the US, the first cost benefit assessment of environmental regulations was carried out by the Environmental Protection Agency (EPA) to estimate the social benefits of reducing various pollutants. Cost benefit assessments have since become an entrenched part of the American regulatory process following the enactment of two key Executive Orders: 12,291 by President

[5] All project types listed in Annex 2 of the Act are required to carry out an EIA, including the drilling of production and research geothermal wells in high-enthalpy fields, all hydro power projects with output of more than 100 kW and geothermal heating production of at least 2500 kW.

[6] The next iteration will include new potential projects (including related to onshore wind) and the use of new data concerning the projects currently listed as 'under consideration'.

Reagan in 1981 and 12,866 by President Clinton in 1993. The former vested the Office of Information and Regulatory Affairs with the authority to review agency regulations and required government agencies to compile regulatory impact analyses on regulations with a likely impact of $100 million or more (Shapiro, 2011). Executive Order 12,866 affirmed that agencies must assess both the costs and benefits of the intended regulation and, when choosing among alternatives with different benefits-costs ratios, opt for the one with the greatest (Polasky and Binder, 2012). The US $100 million impact threshold has enabled scarce analytical resources to be directed towards regulatory changes with the greatest economic impact. In a way, Iceland's Master Plan already acts as an equivalent strategic screening mechanism by sifting out unsuitable energy projects. Of the projects deemed by the Master Plan to be ‘suitable for development’, only a fraction of these are likely to develop into full-scale proposals, as evidenced by the fact that over the past decade only four new power projects have commenced operations in Iceland.

In recent years the US has developed and continues to update its ‘Guidelines for Preparing Economic Analyses’ to ensure that the economic evaluation of regulations is transparent and not subject to arbitrariness. The guidelines focus on multiple analytical issues such as the suitability of various non-market techniques in different circumstances; how to estimate changes in environmental quality; defining baseline conditions; locating available data sources; and how to present the results of economic analysis (EPA, 2015). The development of a standardised approach to cost-benefit assessments is vital in order to ensure the transparency and consistency of the process. In the case of proposed Icelandic energy projects, Skipulagsstofnun, as per their remit with regards to EIAs, could develop and administer this guidance, and overview its implementation. Subsequently Orkustofnun would not be allowed to grant licenses to any proposed energy project that failed to pass the benefit-cost test, and in so doing Iceland would fulfill the OECD's oft-repeated demand for the nation to conduct such accounting practices. This would require the enactment of specific cost-benefit assessment legislation necessitating such assessments to be submitted in support of project proposals and carried out according to the designated approach permitted by Skipulagsstofnun. It is anticipated that some degree of consultation between developers and Skipulagsstofnun would be required on a project-by-project basis in order to determine the most appropriate non-market valuation techniques to be utilised.

4. Economic assessments of the value of natural resources in Iceland

4.1. History of non-market valuation studies in Iceland

Although the practice is common in some countries, in Iceland a mere handful of non-market valuations of the environment have been published so far: one hedonic pricing study concerning the value of Mount Esja (Jóhannesson, 2003), five contingent valuation studies (Ásgrímsdóttir, 1998; Bothe, 2003; Lienhoop and MacMillan, 2007; Ragnarsdóttir, 2010), and an economic valuation of ecosystem services relating to Lakes Elliðavatn and Vífilsstaðavatn (Jóhannesdóttir, 2010). Of these, all have been purely academic exercises and four of the studies have related to energy projects – Ásgrímsdóttir (1998) assessed the total economic value of an area proposed for a hydropower project in Skagafjördur, Bothe (2003) evaluated willingness to pay (WTP) to prevent the environmental impacts of the Kárahnjúkar hydropower project, Lienhoop and MacMillan (2007) assessed both WTP (willingness to pay) and WTA (willingness to accept) the environmental impacts of Kárahnjúkar, and Ragnarsdóttir (2010) estimated WTP for laying underground cables to prevent the visual impact of power lines.

4.2. Upcoming contingent valuation studies of Hverahlíð and Eldvörp

In cases where an environmental resource is perceived to be associated with limited recreational value and few or zero provisioning services, there can be considerable merit to using the CVM to estimate both use and non-use value, in so doing forming a stand-alone estimate of total economic value for use in cost-benefit assessments. In response to the OECD's oft-repeated demand to value economically sacrificed environmental benefits associated with developing Icelandic power projects, the authors of this paper will shortly be issuing contingent valuation surveys seeking to estimate the value of preserving the geothermal areas of Hverahlíð and Eldvörp.

The two areas differ considerably in terms of their environmental characteristics. Hverahlíð is located to the south-east of the existing Hellisheiði Power Plant – thirty minutes drive to the east of Reykjavík – and south of the busy road Suðurlandsbraut (Route 1). A proposed 90 MW power plant would impact an area including common, well-vegetated lava formations and hot springs in its geothermal locality. In visual terms, the area of Hverahlíð is perhaps less impressive than other geothermal areas nearby, and is perceived to have low recreational value, only being frequented on an occasional basis by hikers, horsemen, cross country skiers, and some tourists en route to other destinations further afield. Eldvörp is located on the Reykjanes Peninsula, approximately 45 km to the south-west of Reykjavík, and is estimated to have a productive capacity in the region of 50 MW. The area is characterised by course lava and a visually impressive 10 km long row of craters, which are believed to have emerged during the ‘Reykjanes Fires’ of 1211–1240. In addition to being a popular area for hikers with multiple trails winding their way through the crater row, a test well drilled in 1983 discovered evidence of human settlement, suggesting the site was once used as a hideout by outlaws.

Although the CVM has been subject to criticism over the years and Table 1 considers its common limitations, these can be largely overcome if studies pay careful attention to their sampling procedures and survey design, particularly through the clear setting out of a realistic scenario, well-defined scope for the good in question, and a consequential and incentive compatible payment mechanism (Arrow et al., 1993; Kling, Phaneuf and Zhao, 2012; Haab et al., 2013). The design of the contingent valuation studies for Hverahlíð and Eldvörp has borne in mind all of the best practice guidelines discussed in these works (particularly the NOAA panel report by Arrow et al., 1993) and, as such, will represent a best practice approach for any future Icelandic study to follow.

Although contingent valuation studies typically rely on hypothetical scenarios, they need to remain as real as possible, (Cummings and Taylor, 1998). As Hverahlíð and Eldvörp are two of the fourteen geothermal projects classified by the Master Plan as ‘suitable for development’, it is conceivable that power plants will be developed at these sites in the future. Moreover, both areas have already been subject to Environmental Impact Assessments on the basis of provisional designs for power plant projects and associated infrastructure. Survey participants will be provided with a comprehensive description and photographs of the area, and will be informed about the likely environmental impacts deriving from the development of power plant projects. In addition, they will be reminded that there are no legal barriers preventing the development of these geothermal areas. As preservation of the areas via the passing of national legislation would entail forgone future economic benefits, the survey's scenario proposes that an additional lump-sum tax (paid for one year only) would be necessary to ensure their preservation. The payment vehicle was chosen due to its incentive compatibility compared to voluntary arrangements. In its design it is very similar to other lump-sum taxes in Iceland, such as the annual fixed levy paid for state radio and television production. Following the scenario description, participants will reminded about their budget constraint and answer a question concerning whether they were for or against the preservation of Hverahlíð/Eldvörp, much akin to the process in referendum voting (Kling et al., 2012).

The CVM literature is full of different ways of eliciting WTP estimates using contingent valuation studies. Over the past twenty years, the dichotomous choice method has become widely accepted as the most suitable due to its ease of use in data collection (Antony and Rao, 2010) and statistical efficiency compared to many alternative approaches (Hanemann et al., 1991). In these studies, the double bounded version of the dichotomous choice method will be used. This approach adds a second bid offer based on a participant's response to their first bid offer. For all individuals with a WTP for the preservation of Hverahlíð/ Eldvörp, if their answer to the first bid offer is 'no' then the second question will offer a lower amount; if the answer to the first bid offer is 'yes' then a higher amount will be asked (Hanemann et al., 1991). In these studies, the accuracy of the WTP distribution across the sample will be enhanced by randomly varying the bid amounts, in so doing reducing the possible influence of starting-point bias (Veronesi et al., 2011). Statistical modelling of the results will be undertaken using interval regression, a more general version of the Tobit model (Cameron and Huppert, 1989; Caudill and Long, 2010; Lu and Shon, 2012).

These studies will also follow an emerging trend in recent years for large-scale contingent valuation surveys to be conducted using the internet (Lindhjem and Navrud, 2011; Bonnichsen and Olsen, 2016). This approach has particular advantages in terms of securing a large and representative sample of the Icelandic population, provides participants with as much they need to complete the survey (unlike interview approaches), and offers the flexibility necessary to randomly vary the bid amounts.

5. Conclusion and policy implications

The OECD has repeatedly called for the Iceland to expand the role of economic analysis within cost-benefit assessments, especially related to the environmental impacts of future energy projects. Despite a policy agenda which encourages the sustainable utilisation of Iceland's renewable energy resources, the enshrining in law in 2013 of a strategic Master Plan for Hydro and Geothermal Energy Resources and a requirement since 1994 for all energy projects to carry out Environmental Impact Assessments, decision-making concerning future energy projects in Iceland remains prone, potentially at least, to a layer of discretion. Failure to value economically the environmental impacts of energy project proposals leads to the monetary gains of projects being compared against the entirely qualitative nature of their environmental impacts. This is an act of non-standardisation that potentially renders the latter insufficiently represented and the overall social welfare implications of project approvals left undetermined. The risks of distorted outcomes from cost-benefit assessments are further exacerbated when developers are in charge of the calculation process.

Key lessons can be learned from the US approach in terms of advancing the practice of conducting cost-benefit assessments for Icelandic energy projects. The imposition of legislation requiring in independent preparation and submission of a cost benefit assessment to decision-makers is of paramount importance to enforce the practice in Iceland. A legislative and policy context in which there is a standardised system for appraising the total costs and benefits of proposals would greatly limit the flexibility of decision-makers to make a decision averse to the public interest. In order to ensure that the principles of transparency and standardisation are embedded within any future process, a set of guidelines would need to be established. Skipulagsstofnun could administer and ensure the implementation of this guidance, which could be based on an adapted version of the US' 'Guidelines for Preparing Economic Analysis'. Orkustofnun would retain sole responsibility for awarding licenses, but would not be permitted to undertake projects that failed the benefit-cost test.

Utilising the total economic valuation framework delineated in this paper can be a very effective means of identifying the specific ecosystem services providing environmental benefits to society, and then the most appropriate non-market valuation technique to estimate the economic value of these. The upcoming contingent valuation studies on the geothermal areas of Hverahlíð and Eldvörp serve as an illustration of a carefully conceived methodology that could be applied to a future Icelandic energy project. Many of these are set to occur in remote areas where a significant proportion of their total economic value may derive from non-use value. In all cases, however, it is necessary for project-specific consideration to be given to identifying the most suitable non-market valuation technique(s) for estimating the environmental benefits set to be sacrificed.

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