Hydropower Sustainability Assessment Protocol

Official Assessment

Landsvirkjun

Kárahnjúkar Hydropower Project

Iceland

Project Stage: Operation

Assessment Date: 07/09/2017 to 15/09/2017

Final

Report Date: 12/07/2017

Client: Landsvirkjun

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Project size: 690 MW

Cover page photo: Kárahnjúkar dam, with 'Vortex' art work in foreground and Snaefell mountain in background. The Hálslón reservoir is at full supply level, and the spillway is operating.

Acronyms

Acronym	Full Text
ASÍ	Icelandic Confederation of Labour
CEO	Chief Executive Officer
CSR	Corporate Social Responsibility
DMM	Dynamic Maintenance Management
EU	European Union
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPS	Global Positioning System
GRI	Global Reporting Initiative
GWh	Gigawatt-hour
HSE	Health Safety Environment
IHA	International Hydropower Association
IMF	International Monetary Fund
ISK	Icelandic Krona
ISO	International Organisation for Standardization
KAR	Kárahnjúkar project
kV	Kilovolt
LV	Landsvirkjun
m.a.s.l.	Meter above sea level
MoU	Memorandum of Understanding
MW	Megawatt
NGO	Non-Governmental Organisation
NVE	Norwegian Water Resources and Energy Directorate
OECD	Organisation for Economic Co-operation and Development
OH&S	Occupational Health and Safety
OHSAS	Occupational Health and Safety Assessment Series
SCSI	Soil Conservation Service of Iceland
UNECE	United Nations Economic Commission for Europe
WFD	Water Framework Directive

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Executive Summary

This report presents the findings of an assessment of the Kárahnjúkar project using the Operation Stage tool of the Hydropower Sustainability Assessment Protocol. Kárahnjúkar is a 690 MW hydroelectric power project, owned and operated by Landsvirkjun, located in eastern Iceland. Landsvirkjun is a strategic company for the Icelandic economy and for its owner, the Icelandic government. Kárahnjúkar is the largest power project in Iceland and accounts for about 1/3 of Landsvirkjun's and 1/4 of Iceland's electricity generation.

The assessment was carried out over the period August to November 2017, with an on-site assessment, including a visit to the project area and interviews with stakeholders, conducted from the 7th to the 15th of September, 2017. This assessment meets the requirements of an Official assessment, as described in the Terms and Conditions for the Use of the Protocol.

Kárahnjúkar, also named Fljótsdalur for the location of its power station, was commissioned in 2007. It was built primarily to supply power to Alcoa's aluminium smelter in Fjardaál, through dedicated transmission lines. This is the largest industrial facility in Iceland, producing about 350,000 tonnes of aluminium per year. At the time of construction, the hydropower project and smelter were more controversial than any other large projects in Iceland's history. Over the first ten years of operations, Landsvirkjun and Alcoa have made significant efforts to mitigate their social and environmental impacts, to create socio-economic benefits, to document changes in the region through a transparent process, and to communicate and cooperate with local communities.

Although the Kárahnjúkar project is closely connected with Landsnet's transmission lines and Alcoa's smelter, this assessment covers only the hydropower project. Its most significant impacts are related to loss of wilderness areas, caused by land inundation by several reservoirs as well as improved access to the highlands, and to changes in the flows of several rivers, all the way to the coast. At the same time, the project has led to significant socio-economic change and has enabled the smelter, which is by far the most important employer in this remote region.

These issues are reflected in the findings of this assessment, and in a range of high scores that summarise the findings. Kárahnjúkar meets proven best practice on 11 out of 17 relevant topics: Communications and Consultation; Environmental and Social Issues Management; Asset Reliability and Efficiency; Financial Viability; Labour and Working Conditions; Cultural Heritage; Public Health; Biodiversity and Invasive Species; Water Quality; Reservoir Management; and Downstream Flow Regime.

Kárahnjúkar exceeds Basic Good Practice on all six remaining topics, each of these with one significant gap against proven best practice: Governance; Hydrological Resource; Infrastructure Safety; Project Benefits; Project-Affected Communities and Livelihoods; and Erosion and Sedimentation. Two of these gaps are outside Landsvirkjun's sphere of influence, and would have to be addressed by Government; the other four could be addressed through internal corrective action.

Two topics, Resettlement and Indigenous Peoples, are Not Relevant in the Kárahnjúkar project. The scores for all topics are summarised in the following Sustainability Profile and Table of Significant Gaps.

Sustainability Profile

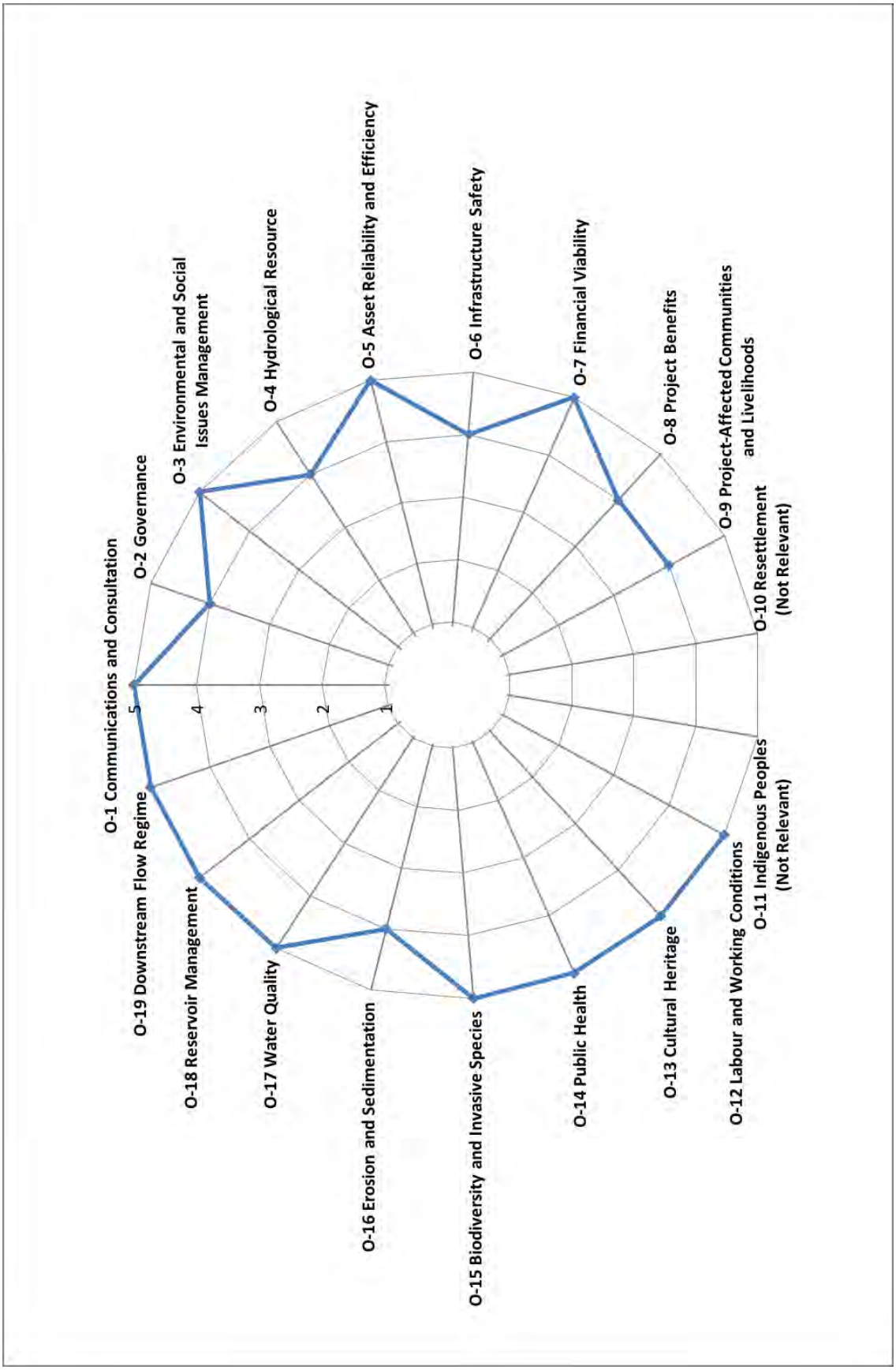


Table of Significant Gaps

	Level 3: Significant Gaps against Basic Good Practice	Level 5: Significant Gaps against Proven Best Practice
Assessment	No significant gaps	No significant gaps
Management	No significant gaps	No significant gaps
Stakeholder Engagement	No significant gaps	O-9: Feedback to individual landowners regarding bank erosion mitigation, and how it fits in within the broader program of works being undertaken by Landsvirkjun, is not thorough or timely.
Conformance/ Compliance	No significant gaps	O-6: Recent reviews have shown a number of minor non-conformances with dam safety standards and protocols; for example, some instrumentation records are incomplete, and review and analysis of monitoring data could be more systematic.
Outcomes	No significant gaps	O-2: The regulatory framework was not set up to equitably share the benefits and compensate the impacts of a project of this kind, which has left a lingering sense of unfairness and frustration among some affected communities. O-4: The constraints posed by transmission capacity gaps mean that the use of water at Kárahnjúkar (and in the broader Landsvirkjun generating system) is not fully optimized. O-8: Landsvirkjun's support for tourism in the area is seen as variable. O-16: Erosion in the Kringilsáranni area, and around Lagarfljót lake, causes ongoing environmental and social problems.

Introduction

The Hydropower Sustainability Assessment Protocol

The Hydropower Sustainability Assessment Protocol ('the Protocol') is a framework to assess the performance of hydropower projects according to a defined set of sustainability topics, encompassing environmental, social, technical, and financial issues.

Developed by the International Hydropower Association (IHA) in partnership with a range of government, civil society and private sector stakeholders, the Protocol is a product of intensive and transparent dialogue concerning the selection of sustainability topics and the definition of good and best practice in each of these topics. Important reference documents that informed the development of the Protocol include the World Bank safeguards policies, the Performance Standards of the International Finance Corporation, and the report of the World Commission on Dams. To reflect the different stages of hydropower development, the Protocol includes four assessment tools that are designed to be used separately, corresponding to the Early Stage, and Preparation, Implementation and Operation stages of a project.

Applying the Protocol delivers an evidence-based assessment of performance in each topic, with a set of scores providing an indication of performance in relation to basic good practice and proven best practice. The scoring system is as follows:

5 Meets basic good practice and proven best practice;

4 Meets basic good practice with one significant gap against proven best practice;

3 Meets basic good practice with more than one significant gap against proven best practice;

2 One significant gap against basic good practice;

1 More than one significant gap against basic good practice.

Assessments rely on objective evidence to support a score for each topic that is factual, reproducible, objective and verifiable. Key attributes of the Protocol are: (i) global applicability, i.e. it can be used on all types and sizes of hydropower projects, anywhere in the world; and (ii) consistency, i.e. the consistency of its application is carefully governed by a system of quality control encompassing accredited assessors, terms and conditions for use, and the Protocol Council.[1]

Scoring is an essential feature of the Protocol, providing an easily communicated and replicable assessment of the project's strengths, weaknesses and opportunities. The scoring system has been devised to ensure that a Protocol Assessment cannot provide an overall 'pass' or 'fail' mark for a project, nor can it be used to 'certify' a project as sustainable. The Protocol provides an effective mechanism to continuously improve sustainability performance because results identify gaps that can be addressed, and the findings provide a consistent basis for dialogue with stakeholders.

Assessment Objectives

Landsvirkjun has formulated the following objectives for the assessment:

- To review the Kárahnjúkar project after the first 10 years of operations, with an independent perspective,
- To confirm strong areas, and to identify areas for improvement of this and of other Landsvirkjun projects,

[1] Full details of the Protocol and its governance, are available on www.hydrosustainability.org.

- To facilitate an ongoing discussion within Landsvirkjun and with stakeholders about sustainability in the Icelandic context.

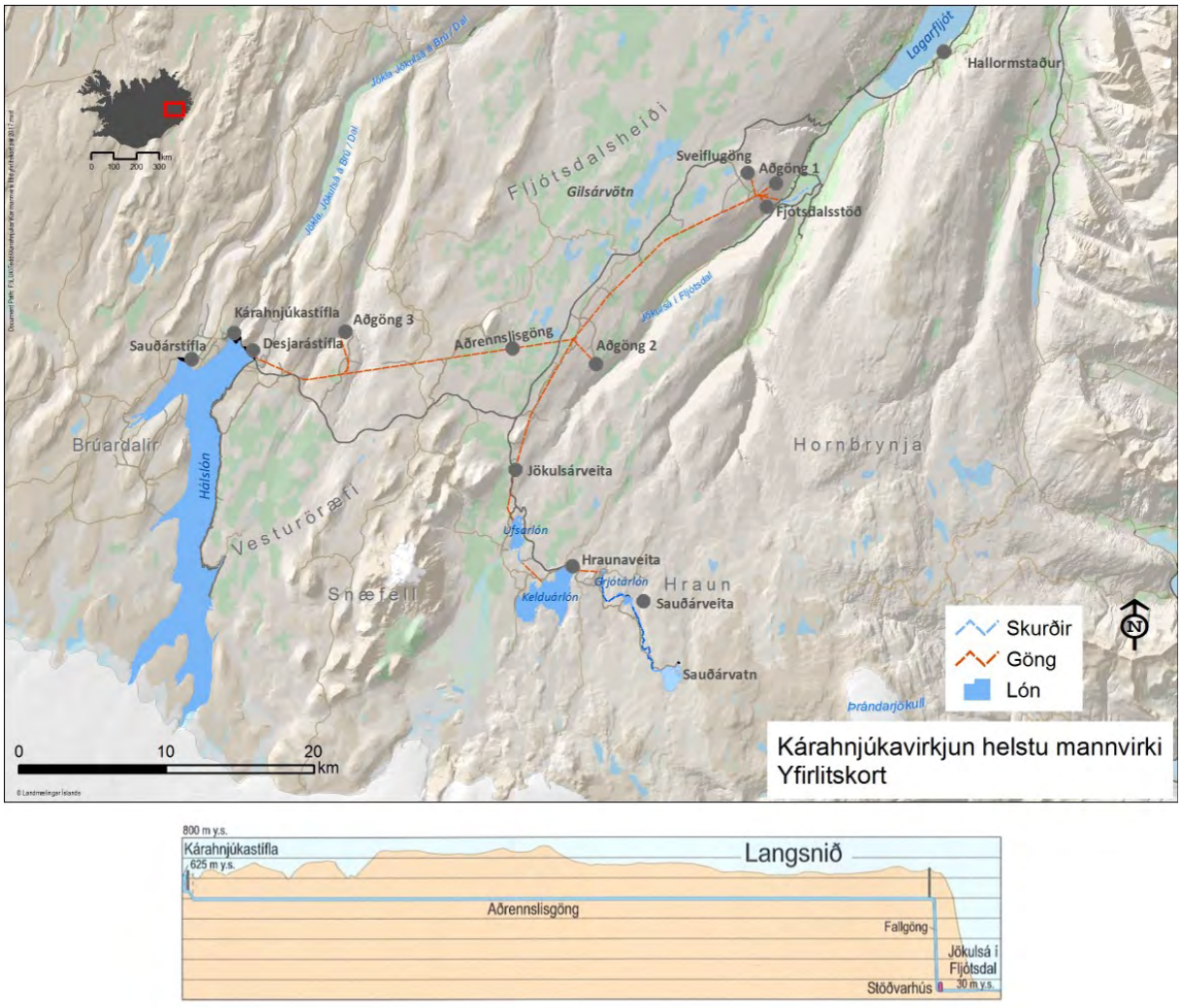
Project Description

The Kárahnjúkar project in eastern Iceland was built by Landsvirkjun, Iceland's national power company, from 2003 to 2007, when the Fljótsdalur power station reached full operational capacity. Concurrent with the construction work, Alcoa built an aluminium plant in Fjardaál on one of the eastern fjords, the Reydarfjördur. Most of the energy generated is sold to the Fjardaál smelter.

Eastern Iceland is sparsely populated, as its nine municipalities have a total of 12,500 inhabitants and cover 22,000 km^2.

Kárahnjúkar's catchment area covers over 2,200 km^2, and is largely protected by the Vatnajökull National Park. The station's reservoirs in the highlands north of the Vatnajökull ice cap, the largest glacier in western Europe, are formed by six dams that have a total length of over 5 km. Project components are linked by tunnels with a total length of 72 km. The maximum gross head is approximately 600 m.

Figure 1. Map and Profile of Project Components



The western part of the catchment, to the west of Snaefell mountain, includes the main dam (Kárahnjúkar dam) on the river Jökulsá á Dal (also called Jökla or Jökulsá á Bru, the 4th largest river in Iceland by flow). At 198 m, this is the highest concrete-faced rockfill dam (CFRD) in Europe and among the largest in the world. Its crest is at 630.5 m.a.s.l., the full supply level at 625 m.a.sl., and the minimum operating level at 575 m.a.s.l.

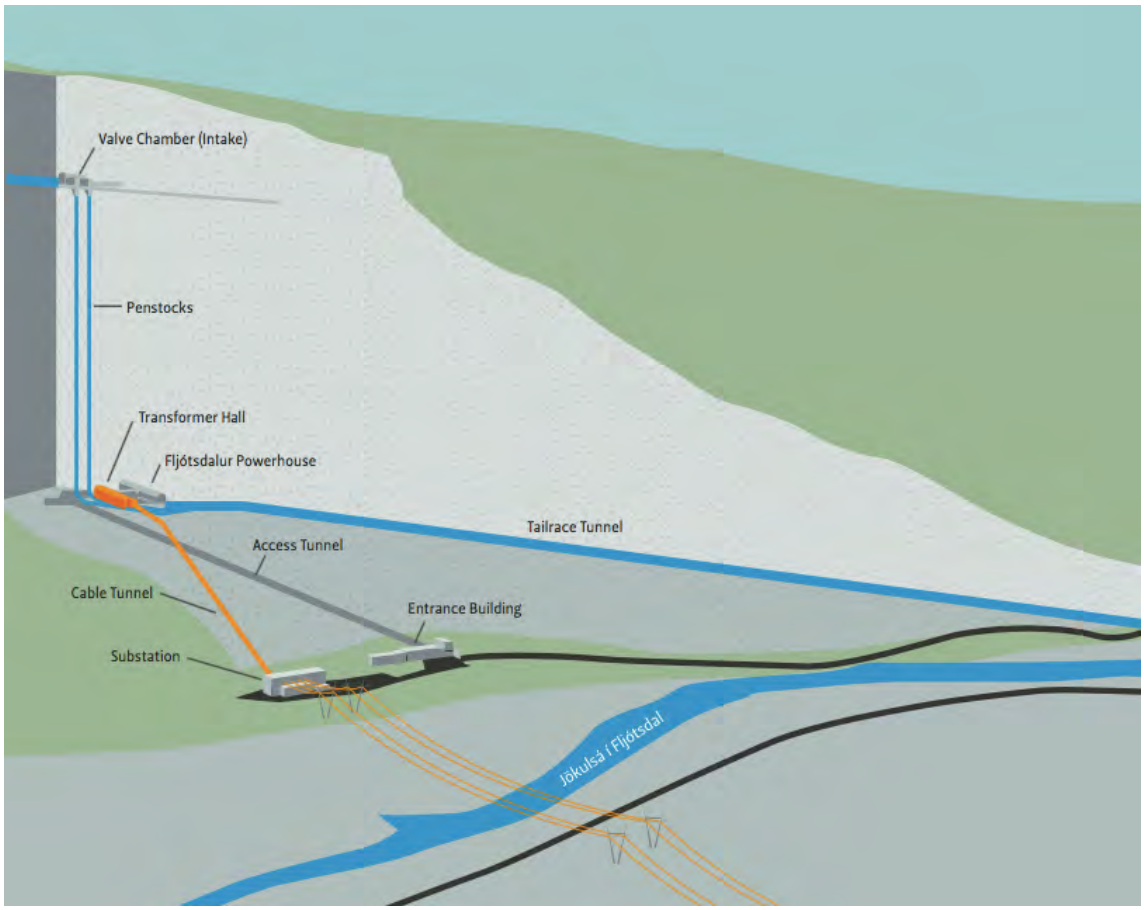
Most of the rockfill was quarried just upstream of the dam within the reservoir area. Two saddle dams were built at Kárahnjúkar, Desjará (68 m high) to the east and Saudárdalur (29 m high) to the west. Desjará is the second-highest dam in Iceland. Together, the three dams form the Hálslón Reservoir which covers an area of 57 km^2, has a volume of 2,100 million m^3, and reaches 25 km to the Brúarjökull glacier, one of the outlets of Vatnajökull. In most years, the reservoir fills up and starts spilling in late summer. It provides approximately 75% of the water used by the project.

Figure 2. Western Part of Catchment

The eastern part of the catchment, in the Hraunaveita area, provides approximately 25% of the water and includes a number of smaller dams, reservoirs and diversion tunnels. The Jökulsá í Fljótsdal river (the 7th largest river in Iceland by flow) originates from the Eyjabakkar glacier, to the east of Snaefell mountain. The river is dammed to the north of the Eyjabakkar wetland area, creating the intake reservoir Ufsarlón. Water is diverted from the Kelduár and Grjótá rivers and Saudárvatn lake into Ufsarlón. The largest reservoir on the eastern side is Kelduárlón, with a volume of 60 million m^3.

From the eastern and western intakes, water flows to the Fljótsdalur station through a 53 km long headrace tunnel system, with tunnels of 7.2-7.6 m in diameter. The headrace tunnels merge and run north under the Fljótsdalsheidi area at an average depth of 100-200 m to a valve chamber, dropping almost 200 m along the way. From the valve chamber, two 420 m long vertical pressure shafts reach the powerhouse, about 1 km inside Valthjófsstadur mountain. The effective head is lower than the physical head because of friction losses along the long tunnels. A maximum flow of approx. 144 m^3/s drives six 115 MW Francis turbines and then flows through a tailrace tunnel and canal back into the river Jökulsá í Fljótsdal, east of Valthjófsstadur mountain, at an elevation of 26 metres.

Figure 3. Fljótsdalur Power Station



Electricity is transformed from 11 kV to 220 kV by six underground transformers and transmitted from the station through a cable tunnel to the above-ground switchgear building, next to a service building for the station. From there it reaches Alcoa's aluminium plant through two 54 km transmission lines. The station is also connected to the 132 kV ring line around Iceland. Fljótsdalur is the largest power station in Iceland, operating as a baseload plant with an unusually high planned load factor of 79%, and planned generation of 4,800 GWh per year. In practice, inflows, load factor and generation have been higher than anticipated.

The water flows in the Jökulsá á Dal below Hálslón reservoir and in the Jökulsá í Fljótsdal below Ufsarlón reservoir are significantly reduced. The flow in Jökulsá í Fljótsdal below the powerhouse, through the large Lagarfljót lake, and below the lake where the river is also called Lagarfljót, is significantly increased. (In this report, where it is necessary to differentiate between lake and lower river, the terms Lagarfljót lake and Lagarfljót river are used; where the entire section including both lake and lower river are meant, the term Lagarfljót is used). The Lagarfljót river and the Jökulsá á Dal river come together in a coastal plain before discharging into the ocean. While their total flow at the mouth is unchanged, their seasonal variability is reduced. Total sediment content is also reduced as sediment settles in the reservoirs. Turbidity is decreased below the reservoirs, but increased below the powerhouse, as the diverted Jökulsá á Dal river largely consists of glacial meltwater.

The east Iceland region has been strongly influenced by the hydropower project and the aluminium smelter, which have created approximately 1,000 jobs, improved infrastructure such as roads, and increased tax revenues. The wilderness character of the area has been partially lost, and many landowners and resource users have been affected by project-induced changes. The Eastern Iceland Sustainability Initiative is an innovative and comprehensive effort to monitor these changes, jointly by the developers and the local communities.

Assessment Process

The Kárahnjúkar assessment builds on two previous official assessments of the Hvammur hydropower project (in the preparation stage) and the Blanda hydropower project (in the operation stage), as well as a trial assessment of the Theistareykir geothermal project (currently close to commissioning), with a draft Geothermal Sustainability Assessment Protocol. Landsvirkjun has developed a thorough understanding of the Protocol methodology and largely planned the assessment without support from the assessment team (identification of interviewees and documentary evidence, preparation of scoping document, electronic data room, assessment schedule, and logistical planning).

The on-site assessment was conducted between the 7th and the 15th of September, 2017, by a team of three accredited assessors. The process involved collection of verbal, visual and documentary evidence to evaluate the project's processes and performance, against the Protocol's scoring criteria. The assessment team conducted interviews in Reykjavik and in the project area, as well as through video and telephone interviews. A total of 82 individuals were interviewed, some of them several times and on a variety of topics. Site visits covered the entire Kárahnjúkar area, from its headwaters to the sea, as well as the Fjardaál aluminium smelter. Interviews covered the perspectives of the developer, employees, government institutions at central, regional and municipal level, affected communities, families and businesses, civil society groups, consultants, offtaker, contractors and academic experts. For every topic, an effort was made to ensure that those with responsibilities and direct insights into the issues were interviewed. Triangulation of evidence – visual, verbal and documentary – is an important requirement for the evidence-collection process, and was enabled through the assessment process.

Appendices B and C contain information on the interviews conducted and the documents reviewed. Both Landsvirkjun and the assessment team have done their best to ascertain the accuracy of the information provided in those appendices. Appendix D contains photos taken by the assessment team on site.

Follow-up evidence was requested by, and provided to, the assessors in the weeks following the assessment. The draft report was provided to Landsvirkjun on the 25th of October, for review of accuracy with respect to project, evidence and institutional references. Comments were received from Landsvirkjun on the 10th of November. Following editing in response to Landsvirkjun's comments, this Official Assessment report was filed on the 7th of December.

Assessment Experience

Landsvirkjun has undertaken more sustainability assessments than any other power company, and organised the assessment very professionally through staff both from the head office (LV) and the Kárahnjúkar project (KAR). The Single Point of Contact for the assessment team was Árni Ódinsson (KAR Community and Environment Manager), working with Ragnheidur Ólafsdóttir (LV Environmental Manager) and Elín Inga Knútsdóttir (LV Environmental Expert), and supported by a number of staff including Sindri Óskarsson, KAR Station Manager; Sigurdur Gudni Sigurdsson, LV Operations Manager; Sveinn Kári Valdimarsson, LV Biodiversity Project Manager; and Jóhanna Harpa Árnadóttir, LV CSR Project Manager. Landsvirkjun included internal observers in the assessment process, in order to spread capacity building benefits among its staff.

All interviewees shared their views and knowledge openly, thereby assisting the assessment team in its task of understanding the project, and being able to assess and score the 17 relevant topics in accordance with the Protocol's requirements. Much of the documentary evidence is publicly available. Translation from Icelandic to English was done with the help of professional interpreters, Landsvirkjun staff, and on-line translation tools. Requests for follow-up information were responded to rapidly and comprehensively.

Layout of this Report

This report consists of nineteen sections numbered in direct correspondence with the nineteen topics of the Protocol's Operation tool. Four appendices are provided, including the written letter of support of the project

operator (required for an official Protocol assessment), and detailing the items of visual, verbal and documentary evidence referred to under each topic.

For each topic, except for Resettlement and Indigenous Peoples which are Not Relevant, findings are provided according to the criteria used in the Protocol's methodology: Assessment, Management, Stakeholder Engagement, Stakeholder Support, Conformance / Compliance, and Outcomes. Findings are presented against a statement of 'basic good practice' and a statement of 'proven best practice' for each, with a 'Yes/No' indication of whether the scoring statement is met. A summary of the significant gaps against the scoring statements, the topic score and a brief summary are presented at the close of each topic section.

1 Communications and Consultation (O-1)

This topic addresses ongoing engagement with project stakeholders, both within the company as well as between the company and external stakeholders (e.g. affected communities, governments, key institutions, partners, contractors, catchment residents, etc). The intent is that stakeholders are identified and engaged in the issues of interest to them, and communication and consultation processes maintain good stakeholder relations throughout the project life.

1.1 Background Information

Directly affected external stakeholders of the Kárahnjúkar hydropower project include Alcoa's Fjardaál smelter, Fljótsdalshreppur and Fljótsdalshérad municipalities, landowners with highland grazing rights, landowners (who also own the water rights) along the Jökulsá á Dal, Jökulsá í Fljótsdal and Lagarfljót, and the Jökla and Lagarfljót angling clubs, who own the fishing rights.

Oher external stakeholders include Vatnajökull National Park, other municipalities in East Iceland, service providers such as local contractors and tourism operators, Austurbrú (the East Iceland Bridge; umbrella organisation for the East Iceland community and responsible for management of the Eastern Iceland Sustainability Initiative), NGO's (e.g. The Nature Conservation Association of East Iceland - *Náttúruverndarsamtök Austurlands*), regulatory agencies such as the Environmental and Cultural Heritage agencies, and the Soil Conservation Service. Internal stakeholders include Landsvirkjun's owners (the Icelandic government) and employees at Fljótsdalur power station and within Landsvirkjun generally.

Landsvirkjun manages communications and consultation at both a corporate and project level. At the corporate level, communications are managed by a dedicated team within the Deputy CEO's Office and environmental and Corporate Social Responsibility (CSR) staff, and includes establishment of corporate commitments within Landsvirkjun's Environmental Policy, external stakeholder analysis, development of communication plans for each power station, management of media relations and provision of internal training courses to all staff on external communication with stakeholders.

At the project level, communications are managed by the Fljótsdalur Station Manager and the Community and Environment Manager who are responsible for development and implementation of the station's stakeholder engagement plan, including updates and revisions as required; maintaining relationships with local stakeholders by responding to queries, listening to concerns and discussing solutions; providing information regarding Landsvirkjun's operations and programs; and attending formal and informal community meetings.

1.2 Detailed Topic Evaluation

1.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging issues relating to hydropower facility communications and consultation have been identified; requirements and approaches are determined through a periodically updated assessment process involving stakeholder mapping; and effectiveness is monitored.*

Ongoing or emerging issues relating to communications and consultation for the Kárahnjúkar project are identified by a range of processes at the corporate and project level. Identification of company-wide communication requirements is done at the corporate level by a dedicated communication team. In October 2012 Landsvirkjun first engaged Gallup to undertake a public opinion survey of the company. This survey is now undertaken annually with results analysed by age, location, income, education level and political orientation to

identify communication issues and trends in public opinions. Landsvirkjun has also undertaken a joint Gallup survey with Alcoa as part of the Sustainability Initiative since 2005 which assesses the communities' attitude to Landsvirkjun and Alcoa in the East Iceland region. Additionally, a survey of tourists at the country's main airport at Keflavik is undertaken every two years to identify trends in tourism, in particularly around renewable energy and hydropower. An annual internal Gallup survey amongst staff is also undertaken to evaluate employee satisfaction within Landsvirkjun (see topic O-12). One of the results was a high degree of satisfaction with internal communications for the Kárahnjúkar team, with a score of 4.83 on a scale of 1 to 5 regarding access to information.

An update of the stakeholder analysis at the corporate level was undertaken in 2017, which identifies stakeholders across seven groups relevant to Landsvirkjun's operations and objectives including government departments, regulatory authorities, industry organisations/unions, customers, research institutions, NGOs, banks/insurance companies and press/media. For each stakeholder, the following has been identified: who is responsible within Landsvirkjun for engagement with them, Landsvirkjun's goals for a good relationship, relevant issues, how best to communicate and, contact points and roles. Based on the 2017 stakeholder analysis, detailed stakeholder engagement plans will be developed.

At the project level, the project is located in a small community whose members interact frequently, including through local staff who are members of the community and community groups. This enables emerging issues associated with the project, including communication and consultation issues, to rapidly come to the attention of the Station Manager and Community and Environment Manager. This also assists the Community and Environment Manager to identify who key stakeholders are, and share contact details. The local staff are important conduits to Landsvirkjun's head office on any issues arising. Ongoing and emerging issues are also identified in formal and/or informal meetings with community groups e.g. Fljótsdalshreppur and Fljótsdalshérad municipalities, Austurbrú (East Iceland Bridge), and Jökla and Lagarfljót angling clubs. These meetings involve Landsvirkjun representatives from the power station and head office, depending on needs. At the annual meetings with the municipalities and Austurbrú, a review of communications over the last year and any new requirements is undertaken.

Stakeholder mapping using an Excel spreadsheet tool is undertaken by the project's Community and Environment Manager, and this identifies communication requirements and approaches for each stakeholder along with contact details. The first formal listing of stakeholders was undertaken in 2013, with the mapping now reviewed annually and updated as required during the year as changes or additions are identified. This mapping includes contact details for the stakeholders, relevant issues, plans for engagement, preferred communication methods, and notes regarding engagement undertaken.

Both formal and informal discussions with local stakeholders allow the effectiveness of communications to be monitored. As the project is located in a small community, stakeholders feel comfortable to provide feedback directly to Landsvirkjun representatives as they are part of the community. The effectiveness is also monitored through the annual Gallup surveys.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, the stakeholder mapping takes broad considerations into account.*

Stakeholder mapping at both the project and corporate level takes broad considerations into account, covering all possible groups which could be affected by or interested in the project, as well as their issues and communication needs. At both levels the stakeholder mapping/analysis has been developed in consultation with stakeholders and is comprehensive, up to date and actively used for communications.

Criteria met: Yes

1.2.2 Management

Analysis against basic good practice

Scoring statement: *Communications and consultation plans and processes, including an appropriate grievance mechanism, are in place to manage communications and engagement with stakeholders; these outline communication and consultation needs and approaches for various stakeholder groups and topics.*

A range of communication and consultation plans and processes are in place to manage engagement at both the corporate and project level including:

- Corporate stakeholder analysis and project stakeholder mapping, and associated communication and engagement plans outlining needs and approaches for various stakeholder groups and topics (as discussed above).
- Active engagement at the corporate level with Landsvirkjun's owner, regulatory agencies and research institutions.
- Corporate training of all staff in external communication and engagement and provision of corporate guidelines on how to engage with stakeholders.
- Formal meetings with Fljótsdalshreppur and Fljótsdalshérad municipalities, Alcoa Fjardaál smelter and Austurbrú involving Landsvirkjun representatives from head office as well as Fljótsdalur power station.
- Formal and informal meetings with stakeholders to discuss operation of the power station and ongoing programs e.g. with Vatnajökull National Park, Lagarfoss power station, Soil Conservation Service.
- Public meetings which are advertised via email and the local paper, e.g. annual meeting with Austurbrú.
- Contact page on Landsvirkjun's website which allows stakeholders to raise questions or concerns.
- Publication of project related information and reports via Landsvirkjun's website and the online national archive (https://leitir.is). In addition, hardcopies of project related reports are lodged with the local archive in Egilsstadir.
- Availability and participation of local Landsvirkjun employees within their communities, making it easy for local stakeholders to raise issues, which can then be escalated to the Station Manager, Community and Environment Manager or head office as required. The telephone numbers of the power station and the Station Manager are available on the internet and most local/regional stakeholders also have the number for the Community and Environment Manager. There is also a contact function on the website for the Eastern Iceland Sustainability Initiative.
- Email and phone list of stakeholders by common issues e.g. for notification of spills from Ufsarlón or Hálslón reservoirs; search and rescue organisations; tourism operators.
- Participation in community or organisational meetings, e.g. angling club meetings.
- Presentations to community regarding the project, its operation and ongoing programs, e.g. hydrological presentation at the Jökla angling club's 2015 annual general meeting.
- Documentation of all informal meetings with stakeholders including people present, concerns or issues raised, documentation of the issue and of the discussion with the stakeholder, including photos where relevant. These memos are shared with the relevant stakeholders as well as lodged in the power station's incident management system if follow up is required (DMM, see topic O-4), and the file share system (GoPro).
- Follow-up with local stakeholders regarding issues via email, phone calls or additional meetings.
- Sustainability Initiative website (http://en.sjalfbaerni.is/) which outlines results against environmental, social and economic indicators and targets.
- Information signs and tour guide at Hálslón reservoir.

Grievances or concerns regarding the project and its affects are usually raised directly with local Landsvirkjun employees in person or by phone and email. Grievances can also be made in person, via phone or email to Landsvirkjun headquarters. Landsvirkjun's quality system sets out procedures to follow in the event of a grievance.

When concerns are raised, the Community and Environment Manager at Fljótsdalur station promptly arranges a meeting with the stakeholder to listen to their concerns and discuss options. The stakeholder and their concerns are registered in the project's stakeholder spreadsheet, and a memo documenting the meeting and its outcomes is shared with the stakeholder. Where further action is required, the issue is logged in the project's DMM system, and mitigation determined in consultation with the stakeholder and relevant Landsvirkjun staff. This process has been followed to address concerns raised by landowners (e.g. bank erosion, movement of the delta mouth, safety of sheep near Ufsarlón spillway). Concerns have also been raised regarding equity in compensation for water rights, which are being managed by representatives from Landsvirkjun's head office. Outcomes of these concerns are discussed further under topics O-9 and O-16.

Landsvirkjun also has multiple internal communications mechanisms, and strong internal communication has been a priority of the current management (see also topic O-12). One of the mechanisms is informal communication 'action groups' on different issues, with participants from various departments.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, communication and consultation plans and processes show a high level of sensitivity to communication and consultation needs and approaches for various stakeholder groups and topics; and processes are in place to anticipate and respond to emerging risks and opportunities.*

The plans and processes outlined above show a high level of sensitivity to communication and consultation needs and approaches for various stakeholder groups and topics. For example, the Community and Environment Manager allows stakeholders to suggest the time and location for meetings, with one to one meetings usually taking place at the stakeholder's home. In the case of issues raised regarding bank erosion, this allows the landowner to show the Community and Environment Manager the areas of concern. Staff are also conscious of where they hold public meetings such that they are accessible to all relevant stakeholders. This has required, in some cases, holding of three separate meetings in different locations to ensure maximum engagement with relevant stakeholders. They are also conscious of how they contact relevant stakeholders, recognising that not all stakeholders use the internet; contacting stakeholders via the phone and notifications in the local paper as well as by email.

The Community and Environment Manager is also familiar with all current stakeholders of the project and no special needs have been identified to date (e.g. for the deaf, blind). However, he is conscious of the need to consider such requirements should they be required.

Regular meetings with community groups and the general availability of the Fljótsdalur station staff, as described above, as well as the Gallup surveys and corporate stakeholder analysis and risk assessment, allows Landsvirkjun to anticipate and respond to emerging risks and opportunities.

Criteria met: Yes

1.2.3 Stakeholder Engagement

Analysis against basic good practice

Scoring statement: *The operation stage involves appropriately timed and scoped, and often two-way, engagement with directly affected stakeholders; engagement is undertaken in good faith; ongoing processes are in place for stakeholders to raise issues and get feedback.*

Communications and consultation associated with the project involves appropriately timed and scoped, two-way engagement with directly affected stakeholders. This includes regular meetings with key groups within the community e.g. Fljótsdalshreppur and Fljótsdalshérad municipalities and Austurbrú, to discuss the project and its effect on the community. In addition, when issues are raised such as those regarding bank erosion, the Community and Environment Manager quickly arranges a meeting to discuss the landowner's concerns and proactively follows-up the meeting via email or phone. Landsvirkjun staff emphasise the need to listen to stakeholder concerns as well as discuss potential solutions and provide information regarding programs of the project.

The municipalities, Austurbrú and landowners generally stated that engagement and negotiations were held in good faith and that Landsvirkjun were open, responsive and transparent in their communications. Whilst some landowners where not necessarily happy with the resolution of their issues e.g. around bank erosion (see topics O-9 and O-16), they did acknowledge that they were able to discuss their concerns openly with Landsvirkjun, and that local representatives maintained ongoing contact with them.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, engagement is inclusive and participatory; negotiations are undertaken in good faith; and feedback on how issues raised have been taken into consideration has been thorough and timely.*

Engagement with stakeholders is inclusive and participatory and negotiations are undertaken in good faith. Landsvirkjun is conscious of engaging with all relevant stakeholders regarding issues and seeking their feedback. For example, while the issue of the delta mouth was raised by one landowner group, Landsvirkjun ensured that it contacted and engaged with all affected landowners and groups to seek their feedback on the proposed option to relocate the delta mouth, before they referred the plans to the Environment Agency of Iceland.

As discussed above, when concerns or issues are raised with Landsvirkjun, feedback is on how issues have been taken into consideration is thorough and timely, including Landsvirkjun's position and its rationale. This feedback is provided in the form of memos, by phone and emails, and in person. While an issue was raised regarding the timeliness of feedback on bank erosion management works, as a whole, the business does have various processes in place to manage feedback on issues. Issues with the timeliness of feedback on management measures are noted under the level of proven best practice for topic O-9.

Criteria met: Yes

1.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives relating to communications and consultation have been and are on track to be met with no major non-compliances or non-conformances, and communications related commitments have been or are on track to be met.*

Landsvirkjun's Environmental Policy states the following targets for stakeholder engagement:

- Work in accordance with sustainable development protocols including active stakeholder engagement and active involvement in cooperative projects with stakeholders
- Support open and constructive discussion and account for Landsvirkjun's achievements in environmental matters

The Eastern Iceland Sustainability Initiative also includes a number of objectives regarding stakeholder engagement, namely:

- To respect and protect people – Listen to and respect the views of the workforce and the communities around the projects and preserve their dignity.
- To encourage stakeholder involvement – Work with communities, employees, customers, stakeholders, and suppliers to achieve outcomes and make decisions of mutual benefit. Report regularly to stakeholders on the sustainability performance of our operations.

Through implementation of its stakeholder engagement guidelines and its communication and consultation processes and plans as described above, Landsvirkjun actively engages with its project stakeholders and involves them in discussions regarding issues that affect them. They also support open, respectful, two-way and constructive discussions with stakeholders. Based on this, Landsvirkjun is actively ensuring that its processes and objectives relating to communications and consultation are being met with no major non-compliances or non-conformances.

Landsvirkjun maintains its commitments to stakeholders through participation in agreed meetings, e.g. annual meetings with Fljótsdalshreppur and Fljótsdalshérad municipalities, and ongoing participation in the Sustainability Initiative.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances or non-conformances.

Criteria met: Yes

1.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

1.3 Scoring Summary

Since the Protocol assessments of the Hvammur and Blanda projects, Landsvirkjun has actively improved its communication and consultation plans and processes, both at a project and corporate level. This has included ongoing stakeholder mapping and engagement plans at the project level, stakeholder analysis at a corporate level, and training for all staff on stakeholder engagement. These plans and processes take into account a wide range of stakeholders, issues and communication needs, and have been developed in consultation with stakeholders. As a result, stakeholders feel they are able to raise concerns and issues regarding the project and get feedback, especially from the local staff at Fljótsdalur station, and that engagement and negotiations are held in good faith.

There are no significant gaps at the level of proven best practice, resulting in a score of 5.

Topic Score: 5

1.4 Relevant Evidence

Interview:	3, 5, 6, 14, 15, 17, 24, 25, 26, 29, 30, 32, 37, 43, 46, 47, 48, 49, 52, 56, 57, 59, 62, 63, 64, 65
Document:	6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 39 , 144, 257, 258, 259
Photo:	2, 4, 20, 61, 62, 63, 73, 130, 137, 138

2 Governance (O-2)

This topic addresses corporate and external governance considerations for the operating hydropower facility. The intent is that the owner/operator has sound corporate business structures, policies and practices; addresses transparency, integrity and accountability issues; can manage external governance issues (e.g. institutional capacity shortfalls, political risks including transboundary issues, public sector corruption risks); and can ensure compliance.

2.1 Background Information

Landsvirkjun is a public company originally established with Act no. 59/1965 to produce and transmit high voltage electricity, and is now fully owned by the Icelandic state. The act sets out the corporate structure and responsibilities. The independent Board of Directors is appointed by the Minister of Finance. Landsvirkjun has a ~75% market share of Icelandic electricity generation. Iceland generally applies the EU Energy Market legislation, to ensure a competitive, reliable and environmentally friendly power supply. Under the Electricity Act no. 65/2003, Landsvirkjun's Transmission Division became Landsnet, an independent company and 65% subsidiary of Landsvirkjun, which owns and operates the transmission system and acts as the overall power system operator.

Iceland ratified the UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) in 2011. The environmental regulatory framework is still evolving, including the creation of an efficient and effective appeals process.

Iceland has two tiers of government, national and municipal. The nine municipalities in East Iceland range in population from 81 for Fljótsdalshreppur (where the Fljótsdalur power station is located) to 4,691 for Fjardabyggd (where the Alcoa smelter is located). All of these municipalities are directly or indirectly affected by the Kárahnjúkar project.

The regulatory framework is complex and has further evolved since the original approvals of the project:

- Parliament's Act no. 38/2002 authorized the harnessing of the rivers for the Kárahnjúkar project.
- Power Development Licences were formerly granted by the Ministry of Industry (in the case of Kárahnjúkar, in 2002). These are now granted by Orkustofnun (the National Energy Authority), which also administers licenses previously issued by other government bodies. The licence includes conditions on the monitoring of water flows and levels, as well as references to the Minister for the Environment's conditions (see below). Most power station licences do not come with such conditions; the fact that Kárahnjúkar's licence does reflects its special importance, both in terms of its size and its impacts.
- Development Permits and Building Permits are granted by municipalities and have to be consistent with municipal zoning plans. In the case of power plants, Development Permits may also define environmental conditions, on the basis of recommendations from EIA reviews by the Planning Agency. At the time of Kárahnjúkar's permit application, the Planning Agency recommended not granting the Development Permit, but after an appeal by Landsvirkjun, was overruled by the Minister for the Environment. The Minister then defined a number of environmental conditions, in 2001.
- Regional Environmental and Public Health Offices grant operating permits related to food safety, environmental quality (e.g. with relation to the gas station at the power plant) and general hygiene issues, under the supervision of the Food and Veterinary Authority and the Environment Agency. The permits for the Fljótsdalur power station were granted by the East Iceland office for 2008-2020.
- Other operating permits are issued by the Administration for Occupational Health & Safety, for work safety related to equipment such as vehicles, heavy machinery and overhead cranes. Fire safety is supervised by the regional Fire Department.

- There are also regulations regarding the acquisition of and compensation for property and water rights which are required for the project, and may be owned privately, by municipalities or the state.

As a state-owned company developing, managing and operating 16 power stations and other assets, Landsvirkjun has a complex system of processes and procedures. Its corporate governance and compliance systems are highly developed and certified against a number of standards. Annual reporting is provided for key areas (general/financial, environment including carbon footprint, and social responsibility) which are available on Landsvirkjun's external website.

2.2 Detailed Topic Evaluation

2.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging political and public sector governance issues, and corporate governance requirements and issues have been identified, and monitoring is being undertaken to assess if corporate governance measures are effective.*

Iceland generally ranks highly in international assessments of public governance, although not quite as highly as other Nordic countries (for a range of indices, see http://info.worldbank.org/governance/wgi/#reports).

As a strategic public company, Landsvirkjun is often the subject of external assessments and recommendations (for example, from the OECD and IMF) and political debates, and pays close attention to relevant government initiatives, policies and reforms. In its 'Platform of the Coalition Government', the current government has pledged

- a stability fund to manage dividends from public energy resources,
- no new concessionary investment agreements for polluting heavy industry, and
- an ownership policy for Landsvirkjun, 'the aims of which will include the maximisation of the value of generated power and having the company operate in harmony with environmental considerations and public opinion'. It is expected that Landsvirkjun as well as other stakeholders will soon have an opportunity to comment on a draft. A general ownership policy for state-owned enterprises has existed since 2012.

Through its multiple projects, Landsvirkjun is well aware of the evolving regulatory framework in Iceland. The legal department is responsible for monitoring any changes within this framework, including quality, environmental, security, electrical security, information security and document management issues. Internal directive VKL-075 describes processes, responsibilities and follow-up actions in case of changes. A number of permits and inspections that directly affect the operations of the power station are registered and monitored within the DMM system (see topic O-4).

Additionally, Landsvirkjun employs VSO Consulting for monitoring of regulations, and regular meetings are held to discuss any relevant changes. Regulatory bodies also inform Landsvirkjun of changes.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no significant opportunities for improvement in the assessment of political and public sector governance issues and corporate governance requirements and issues.*

There are no indications that Landsvirkjun is overlooking any internal or external governance issues. The unresolved external governance issues described below under Outcomes are well known, and have been discussed with various stakeholders.

2.2.2 Management

Analysis against basic good practice

Scoring statement: *Processes are in place to manage corporate, political and public sector risks, compliance, social and environmental responsibility, procurement of goods and services, grievance mechanisms, ethical business practices, and transparency; policies and processes are communicated internally and externally as appropriate; in case of capacity shortfalls, appropriate external expertise is contracted for additional support.*

Two important processes for Landsvirkjun to respond to the owner's expectations and to understand and manage political and public sector risks and opportunities, are through its Board of Directors, appointed by government, and through its direct relationships with a range of government agencies.

Within their mandates, board and management formulate corporate objectives, policies and processes, and authorize individual investments and contractual commitments. Landsvirkjun sees its role as to 'maximise the potential yield and value of the natural resources it has been entrusted with in a sustainable, responsible and efficient manner'. Key policies related to sustainability are the Corporate Social Responsibility Policy (2011), Code of Conduct (2013) and Supplier's Code of Conduct (2015), and Environmental Policy (2015). These policies are further broken down into operational guidelines and processes, which are easily available for staff and on which training is provided. Landsvirkjun's internal audit and legal units are tasked with legal and contractual compliance issues.

Programmes that are related to corporate social responsibility such as support for research and sponsoring are conducted under clear guidelines, to make Landsvirkjun's contributions as systematic, efficient and transparent as possible, and to ensure that the projects supported comply with Landsvirkjun's policies:

- The Energy Research Fund's objective is to support environmental and energy research relevant to Landsvirkjun through grants.
- The Community Fund's objective is to support projects with broad community relevance and the potential to positively impact Icelandic society.

Landsvirkjun has comprehensive internal procedures for procurement which are available to all staff via the intranet, including easy-to-read flowcharts. There are three tiers of procurement, dependent upon the size and service type required, with the most complex being a formal tender process. The Station Manager has some authority for smaller procurement decisions. Most contracts at Kárahnjúkar are with small local service companies and workshops. For larger projects, Landsvirkjun uses the Achilles Sellihca database, which is a supplier register and pre-qualification system used by the Nordic utilities to manage supplier information and risk within the supply chain as well as to procure efficiently in accordance with EU regulations, with over 4,400 qualified suppliers.

Landsvirkjun proactively releases significant corporate and project-level information, and reports on the implementation of policies and commitments. Its external website is well-designed and useful for stakeholders and the general public. Since 2016 the annual corporate and environmental reports have been integrated. An annual CSR report covers progress towards the objectives of the UN Global Compact and UN Sustainable Development Goals, and applies GRI and CDP reporting guidance.

Landsvirkjun's stakeholders can raise concerns, grievances and complaints through a number of channels. Due to close stakeholder relations, most often the station managers or community and environment managers will be contacted in person, via telephone or email.

Landsvirkjun often uses its own staff as project managers who coordinate external expertise. Independent reviews, which are typically voluntary and additional to regulatory requirements (such as this sustainability

assessment), are used in a number of areas. In the case of the Kárahnjúkar project, dam safety is supported by a panel of independent experts (see topic O-6).

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, contractors are required to meet or have consistent policies as the developer; procurement processes include anti-corruption measures as well as sustainability and anti-corruption criteria specified in pre-qualification screening; and processes are in place to anticipate and respond to emerging risks and opportunities.*

If suppliers are not already prequalified by registration in the Sellihca database (which contains information on sustainability issues, for example commitments to the Global Compact), there may be a prequalification step in the procurement process, or documentation has to be submitted with the main tender. Because of regulatory requirements, Landsvirkjun cannot easily impose its own prequalification requirements. For example, certifications comparable to ISO 14001 and ISO 9001 have to be accepted.

However, post-procurement Landsvirkjun imposes contractual requirements on its business partners that are summarized in its 'Supplier's Code of Conduct' and the detailed 'Requirements Towards Contractors and Service Providers with Regard to Environmental and Health and Safety Matters'.

These processes and requirements are being regularly reviewed and updated, for example in 2016 with respect to the responsibility of contractors for the actions of their sub-contractors and suppliers, along the value chain. Efforts are made to include these requirements retroactively in existing contracts. Landsvirkjun also became a founding member of the Green Public Procurement program in 2014, which is a forum for collaboration on green procurement, led by the Ministry for the Environment and Natural Resources; amendments were made to Landsvirkjun's procurement processes in 2015. Practices pioneered by Landsvirkjun and some other organizations like the Municipality of Reykjavik (for example, the principle of responsibility along the value chain) are often later adopted by other organizations.

Criteria met: Yes

2.2.3 Stakeholder Engagement

Analysis against basic good practice

Scoring statement: *The business interacts with a range of directly affected stakeholders to understand issues of interest to them; and the business makes significant project reports publicly available, and publicly reports on project performance, in some sustainability areas.*

Stakeholder engagement is at the top of the agenda for Landsvirkjun's management (see also topic O-1). Landsvirkjun is highly interested in maintaining a good reputation and goodwill among stakeholders. Senior management is directly involved in stakeholder engagement, particularly at the level of national and municipal governments.

Alcoa as the main offtaker has a direct interest in Kárahnjúkar's operations, and there are at least two formal coordination meetings per year, as well as other communication channels (e.g. for direct contacts in case of emergencies, through the Eastern Iceland Sustainability Initiative, and at the CEO level regarding the power contract).

Landsvirkjun makes a range of project preparation reports, background research, and project monitoring and progress reports publicly available.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, the business makes significant project reports publicly available and publicly reports on project performance in sustainability areas of high interest to its stakeholders.*

For its corporate-level reporting, Landsvirkjun does not undertake a direct materiality process to determine what is of high interest to its stakeholders. However, there are public opinion surveys (see topic O-1), the range of publicly available material is wide, and its presentation is well designed, so that very likely all stakeholder interests are satisfied.

For project-level reporting, the Eastern Iceland Sustainability Initiative represents a unique approach that deserves to be broadly recognized and emulated. Sustainability indicators have been selected with stakeholders, to reflect issues and impacts of high interest; gathering of data and management of the initiative is entrusted to a neutral organization; regular discussions with stakeholders on methods and results are held; and the focus is on the cumulative effects of regional industrial development, not just on one power generation project in isolation. The focus of the initiative is now moving towards the interpretation of results and their use for adaptive management, by Landsvirkjun and Alcoa as well as by local and regional governments, authorities and associations.

Criteria met: Yes

2.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *The project has no significant non-compliances.*

Landsvirkjun is subject to project-specific permits, specific legislation (such as the law that established the company), and general legislation that applies to all or a subset of companies (and is often derived from EU directives).

For example, procurement has to follow Directive 2014/25/EU on 'Procurement by entities operating in the water, energy, transport and postal services sectors'. While many European power companies operating in competitive markets are exempt, Landsvirkjun is not because of its large market share. Procurement practices have to be clear, fair and traceable. Procurement complaints can be directed to a committee under the Ministry of Finance, which may also be asked for guidance.

The various licences and permits listed above under Background Information are supervised by the relevant authorities. Some of these only receive occasional or regular reports, others visit the project regularly. A common impression amongst authorities was that performance at Kárahnjúkar is high, and that they trust Landsvirkjun to maintain that level of performance. Therefore, authorities tend to apply the minimum level of supervision within their discretion, and focus their resources on other companies. Information on compliance with individual licences and permits is provided under the relevant topics in this report.

Conformance with voluntary commitments is followed up through various mechanisms. Landsvirkjun's Quality Manager organises ISO certification audits. The CSR Project Manager organises reporting against the UN Global Compact and related commitments.

There are no indications for any governance-related non-compliances related to the project.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *The project has no non-compliances.*

As stated above, there are no indications for any governance-related non-compliances.

Criteria met: Yes

2.2.5 Outcomes

Analysis against basic good practice

Scoring statement: *There are no significant unresolved corporate and external governance issues identified.*

There are no governance issues that materially affect the operations of the Kárahnjúkar project. Iceland has been subject to significant economic and political instability over the past decade, but this has had limited impacts on Landsvirkjun and its largest project.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no unresolved corporate and external governance issues identified.*

The complexity of the Kárahnjúkar project is unique for Iceland, as the project transfers water on a major scale from one river basin to another, and its infrastructure components are located across two municipalities. The regulatory framework was not set up to equitably share the benefits and compensate the impacts of a project of this kind, which has left a lingering sense of unfairness and frustration among some affected communities, and is seen as a **significant gap** against proven best practice:

- In 2007, an independent commission, whose ruling was confirmed by the courts, put the compensation value for water rights holders at ISK 1.2 billion along Jökulsá á Dal, over ISK 0.3 billion along Jökulsá í Fljótsdal, and over ISK 0.1 billion along Kelduár, for a total amount of ISK 1.634 billion (USD 24 million at the time). Much of this one-time payment went to the Icelandic state as landowner. While compensating the owners of water rights along rivers with reduced flows, some of which in fact benefited from the project in certain ways (increased value of fishing), the project was not required to provide compensation for owners of water rights affected by increased flows and water levels, along Lagarfljót (see also topics O-9, O-16).
- While paying approximately ISK 100 million (USD 940,000) annually in property taxes to the municipality where the power station buildings are located (Fljótsdalshreppur), the project is not required to pay such taxes for other components. Thus the municipality of Fljótsdalshérad (with the largest project footprint) is not receiving any additional property tax (see also topic O-8).

Criteria met: No

2.2.6 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

The regulatory framework was not set up to equitably share the benefits and compensate the impacts of a project of this kind, which has left a lingering sense of unfairness and frustration among some affected communities.

1 significant gap

2.3 Scoring Summary

Corporate governance at Landsvirkjun is of a very high standard, and is setting positive examples, for example with respect to transparency, ethical business practices, and compliance. The Eastern Iceland Sustainability Initiative is a unique undertaking to enable rational and fact-based discussions about sustainability, and

adaptive management. Public sector governance and the regulatory framework are generally of a high standard, but there is some room for improvement, especially regarding improved clarity and fairness in compensation and benefit sharing arrangements. This is considered a significant gap, resulting in a score of 4.

Topic Score: 4

2.4 Relevant Evidence

Interview:	7-9, 13, 16, 19, 33, 34, 44, 57, 59
Document:	5-7, 9, 22-43, 47,49, 111, 119, 120, 125, 126, 139-141, 152, 170
Photo:	--

3 Environmental and Social Issues Management (O-3)

This topic addresses the plans and processes for environmental and social issues management. The intent is that negative environmental and social impacts associated with the hydropower facility are managed; avoided, minimised, mitigated or compensated and enhancement measures are implemented; and environmental and social commitments are fulfilled.

3.1 Background Information

The regulatory framework is described under topic O-2. The main conditions of relevance to environmental and social issues management are those stipulated by the Ministry for the Environment and Natural Resources, dated 20th of December, 2001 and the hydrological conditions set out by the National Energy Authority. Additionally, there are measures relating to commitments made as part of the work on the Environmental Impact Assessment (EIA), issues related to the developer's appeal against the ruling by the National Planning Agency, and other conditions resulting from later developments during construction and operation of the project.

Other regulatory bodies include the regional Environmental and Public Health Office in Eastern Iceland.

Key social issues for the project are: an amicable relationship with the project-affected community and various special-interest groups such as tourism operators; and attention to stakeholder-raised issues such as bank erosion along the project-affected rivers. Key environmental issues for the project are: the changes to river runoff in the two major project-affected rivers with the resulting water-level impacts in Lagarfljót lake; soil erosion and material transport from the reservoir area, especially during the draw-down period when a lot of fine sediment is exposed to wind; and revegetation efforts in highland areas in order to combat the pre-existing issues with wind-blown sand and large barren areas.

This topic concerns the general corporate approach to dealing with environmental and social issues management, while details on specific aspects are addressed by other topics. Please refer to, mainly, topics O-8 through O-19 for a fully-detailed discussion of the pertinent issues. Topic O-1 covers communications and consultation processes, and topic O-2 the regulatory and corporate governance frameworks.

The project underwent a comprehensive Environmental Impact Assessment (EIA), published in May of 2001. This was followed by the regulatory process described in topic O-2, ending with the ruling by the Ministry for the Environment and Natural Resources. The 20 conditions stipulated therein were reviewed by the Environment Agency of Iceland (*Umhverfisstofnun*) in 2010.

Landsvirkjun's management system for Corporate Social Responsibility (CSR) incorporates environmental and social issues management into a broader context and whenever "the management system" is referred to below, this covers various aspects of this overall CSR system.

3.2 Detailed Topic Evaluation

3.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Systematic processes are in place to identify any ongoing or emerging environmental and social issues associated with the operating hydropower facility, utilising appropriate expertise; and monitoring programs are in place for identified issues.*

Environmental inspections and monitoring at the power station and its ancillary structures are ongoing in accordance with a comprehensive plan which details what to monitor and with what frequency. The Station Manager and the Community and Environment Manager are the main staff responsible, but all staff are involved as part of their everyday routines. The scheduled inspections use checklists stored in the management system and are designed to identify any changes to existing issues, or the development of new socio-environmental issues of concern.

The project-specific management system includes a comprehensive tabulation of ongoing monitoring programmes with detailed information on responsible actors, frequency of monitoring, budget and reporting.

Several key monitoring programmes are implemented by senior external professionals from organisations such as: the Icelandic Institute of Natural History (*Náttúrufraedistofnun Íslands*); the Soil Conservation Service of Iceland (SCSI, *Landgraedsla ríkisins)*; the Marine and Freshwater Research Institute, (*Hafrannsóknastofnun,* which is the result of a recent merger between the two institutions Institute of Freshwater Fisheries and Marine Research Institute); and the East Iceland Nature Research Centre (*Náttúrustofa Austurlands)*. Details of these monitoring efforts are given under their respective topics below.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes to identify ongoing and emerging environmental and social issues take broad considerations into account, and both risks and opportunities.*

Risks and opportunities are identified through regular meetings at corporate level as well as through the comprehensive monitoring programmes, mainly implemented by external actors. Most of these are resident in Eastern Iceland, with personal knowledge of the social and environmental context in which risks and opportunities can be identified. The most important process to take broad considerations into account is the Eastern Iceland Sustainability Initiative launched in 2004, during the construction phase of both projects, by Alcoa and Landsvirkjun. The goal of this initiative, according to its dedicated website, is to enable residents of the Eastern Iceland region and other interested parties to follow the development over time of quantitative social, environmental and economic indicators of sustainability. The website also allows interested parties to read about the concept of sustainability and to view the history of the initiative. The initiative consists of a comprehensive set of 16 social, 24 environmental and 5 economic indicators and each indicator is described with baseline, metrics, targets, monitoring plan, progress and the rationale for selecting the indicator in question.

Other broad considerations, risk management and identification of opportunities are described in more detail under each individual topic below.

Review of changing regulatory conditions is an inherent part of the management system (see below), and is described under topic O-2.

Criteria met: Yes

3.2.2 Management

Analysis against basic good practice

Scoring statement: *An environmental and social management system is in place to manage measures to address identified environmental and social issues, and is implemented utilising appropriate expertise (internal and external).*

Landsvirkjun's CSR management approach and policies have developed over the last almost 50 years, from initial engagement with soil conservation issues in 1970, through an ISO-certification focus in the 2003-2009 period, to today's integrated comprehensive CSR-management system with its key focal areas of: corporate governance; the value chain; the environment; society; health and safety; and knowledge dissemination. These focal areas are supported by policy documents on: environment; human resources; requirements for contractors and service providers; gender equality; a code of conduct for suppliers; business integrity in the value chain; as well as an overall company code of conduct. Topic O-2 describes the organisation of the overall quality management with its various parts.

The day-to-day environmental management and quality-control system is outlined in a suite of documents describing how the system should be implemented. It documents the policies, planning, legal requirements, objectives, targets and programmes. It also details resources, roles and responsibilities, requirements for training, documentation, operational control, and monitoring needs. The Fljótsdalur power station has its own environmental management plan with actions, monitoring parameters, reporting needs and contacts listed in detail. The Station Manager has the overall responsibility for the relationships with authorities. The local management system will be fully integrated with the company-wide system in the near future. The Community and Environment Officer participates in weekly web-based meetings with CSR and environmental staff at the Landsvirkjun head office in Reykjavik.

Landsvirkjun makes use of well-trained and highly experienced internal and external expertise as it partly implements the system by outsourcing certain functions, especially monitoring. The system, its use and outcomes are audited in accordance with ISO rules and also, in its relevant parts, by the applicable authorities, including local/regional ones in Eastern Iceland.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities; and plans and processes are embedded within an internationally recognised environmental management system which is third party verified, such as ISO 14001.*

The comprehensive monitoring programmes, continuous contacts with stakeholders and the many external experts involved in monitoring and mitigation programmes provide a comprehensive approach to the identification of any emerging risks and opportunities. For Landsvirkjun's own staff, awareness and reporting of such emerging risks and opportunities is an inherent part of their responsibilities.

While the head office's social and environmental staff are on hand to support, the day-to-day operations are decentralised, and the main responsibility lies with the Community and Environment Manager stationed at the Fljótsdalur power station.

Other examples demonstrating good risk-management practices are the involvement with external reporting systems and commitments such as the UN Global Compact and Global Reporting Initiative (GRI) including on: code of conduct and code of suppliers; value chain; employees; climate change and overall environmental and social impact. The company also reports to the CDP (formerly the Carbon Disclosure Project) on "climate performance", and CDP's comments in 2016 will be internalised during 2017. Landsvirkjun also participates in the Environment Agency's Green Steps programme.

In 2016 the board approved new rules on supply-chain issues, including provisions for penalties for non-compliance. Mapping of suppliers with reference to their socio-environmental impacts is ongoing.

The company is targeting capacity development in Eastern Iceland through an intentional policy of assigning the responsibility for monitoring programmes to local and regional institutions.

Landsvirkjun is certified in accordance with ISO 9001, 14001 and 27001 as well as OHSAS 18001. These certifications are valid also for the Kárahnjúkar project. In addition, all of Landsvirkjun's energy generation has been certified as "*green electricity*" by the German certification body TÜV SÜD.

Landsvirkjun discloses up-to-date information on a great number of environmental indicators on its public website. The scope and detail of this information is of an unusually high quality, and demonstrates dedication to transparency in environmental- and social-management matters.

Criteria met: Yes

3.2.3 Stakeholder Engagement

Analysis against basic good practice

Scoring statement: *Ongoing processes are in place for stakeholders to raise issues and get feedback.*

Landsvirkjun's and the project's overall stakeholder engagement is described in detail under topic O-1.

The aspects of specific interest to the project's environmental and social issues management are guided by the project-specific communication plan. The key contact point is the Station Manager supported by the Community and Environment Manager. Regular meetings are conducted with the various representatives from municipalities, angling societies, the tourism operators, the Soil Conservation Service and individual farmers. Some aspects of special importance to stakeholders are available to the public via the internet, such as water flows and levels at several stations in the river system, as well as water levels in Lagarfljót.

The telephone numbers of the power station and the Station Manager are available on the internet and most local/regional stakeholders also have the direct number for the project's Community and Environment Manager. There is also a contact function on the dedicated website for the Eastern Iceland Sustainability Initiative.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, feedback on how issues raised have been taken into consideration has been thorough and timely.*

The interviewed stakeholders that have ongoing issues with the hydropower facility generally report thorough and immediate or next-day feedback on how the project has taken or will take their concerns into consideration. The one partial exception to the generally positive comments is bank erosion along Lagarfljót. This issue is covered under topics O-1, O-9 and O-16, and considered a significant gap under O-9, but not double-counted here.

Criteria met: No

3.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in environmental and social management plans have been and are on track to be met with no major non-compliances or non-conformances, and environmental and social commitments have been or are on track to be met.*

Regulatory requirements are recorded in the environmental management system and followed up in accordance with the procedures in place. Details on the compliance monitoring for the national-level requirements, including the national licences, are provided under topic O-2.

Regionally and locally, there are a number of agencies and entities that supervise the project's compliance, the most important ones being the municipalities and the East Iceland Environmental and Public Health Office which is also responsible for monitoring compliance with the Food Law (sanitary requirements, see also topic O-14). This office issues an operational permit; the present one is valid from the 22nd of September 2008 until that same date in 2020. Review frequency is every four years if considered necessary. A review was conducted in 2012, but none was considered necessary in 2016 due to the high level of performance. Minor incompliances have occurred, but all have been addressed and the project is now in full compliance. One issue identified concerned a contractor. This has led to an agreement that all contractors' activities will be fully internalised into, and audited as part of, the project's licence.

The project was externally audited by VSO Consulting in mid-2017, against a suite of requirements and regulations, including the operating licenses, laws and regulations, Landsvirkjun's corporate environmental management system as well as the project-specific system. Requirements of the ISO 14001: 2004 governance standard and 2015 management standards were also considered. The audit resulted in 11 comments and the auditors made the overall statement that the project is performing very well and that its document-management system could function as a model for others to follow.

All staff members have access to laws and regulations regarding CSR issues via the regularly-updated intranet. Any non-compliances or non-conformances shall be logged in the system and corrective actions identified.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

No non-compliances or non-conformances have been identified.

Criteria met: Yes

3.2.5 Outcomes

Analysis against basic good practice

Scoring statement: *Negative environmental and social impacts associated with hydropower facility operations are avoided, minimised and mitigated with no significant gaps; and land disturbance associated with development of the hydropower project is rehabilitated or mitigated.*

The main impacts identified as part of the 2001 EIA were (more detail on most of these can be found in the specialised topics below):

1. Creation of the 62 km^2 Hálslón storage reservoir, 32 km^2 of this was vegetated before the construction of the project
2. Reduction of the Kringilsáranni area by 25%
3. Increased sand encroachment in the Vesturöaefi wilderness area could damage vegetation

4. Loss of important calving areas and spring grazing land of the Snaefellshjardar reindeer herd and disturbances to their migration paths with associated negative impacts on the population
5. Reduction of the nesting areas of the Pink-footed Goose with associated negative impacts on the population
6. Many of the rivers and stream will either have changed runoff regimes or disappear completely for much of the year
7. Impacts from sediment flushing from the Ufsarlón reservoir
8. Lake levels in Lagarfljót will increase, further worsening the combined natural and human-induced (pre-existing due to the construction of the downstream Lagarfoss hydropower station in 1975) bank erosion
9. Raised groundwater levels negatively affecting a number of fields in the low-lying areas of the catchments
10. Considerable changes to the sediment-transport regimes of the two main rivers as the glacial Jökulsá á Dal will be clear for most of the year while Jökulsá í Fljótsdal will be more turbid below the tailrace of the power station.
11. The coast line will retreat by an expected 200 metres in the first 100 years of operation because the bulk of the sediments previously transported by Jökulsá á Dal will now settle in the Hálslón reservoir
12. Improved transport conditions in the highland area improving access and conditions for tourism
13. Dams, reservoirs, canals and roads will alter the physical landscape and contribute to a significant loss of wilderness conditions in the highland area close to the Vatnajökull Glacier.
14. The generated energy will create employment opportunities in the industrial sector
15. Increased income, especially in Fljótsdalshreppur, and the National Economic Institute predicted that by enabling Alcoa's Aluminium plant, GDP would increase by 8 to 15 billion ISK per year (in 2000 prices). Export revenues were predicted to increase by 14% per year and at the end of construction, the national debt was expected to be 10-12% higher than the baseline case of no project.

These predictions have proven fairly accurate in most cases. The more notable exceptions are numbers 2, 3, 4 and 5 which have not materialised in the manner predicted. The sand encroachment has been largely held at bay with minimisation efforts and the impacts to the two species of special concern have not materialised. Instead both species have seen considerably increases to their numbers in the area, albeit not mainly because of any action on the part of the project, but rather due to improved feeding conditions. The erosion in the Kringilsáranni area has been greater than predicted. This issue is covered under topic O-16. There has not been any post-project economic analysis conducted to quantify impacts under number 15 above.

The predicted impacts were internalised into the operational licence and the degree to which licence conditions were fulfilled was reviewed by the Environment Agency in 2010. That review considered 14 of the 20 conditions fulfilled in their entirety, and the other 6 fulfilled "as far as possible", a formulation relating to the long response time of some natural features to introduced changes, making it impossible to ascertain that conditions have been met after only 3 years of operation. For some of those aspects, monitoring beyond the 10 years that have now passed since the commissioning of the plant is considered necessary.

As a part of the 10-year anniversary of the plant going into operation, Landsvirkjun has reviewed licence-condition fulfilment again in 2017. In addition to the 14 fully fulfilled in 2010 (three of which considered the design and construction stages of the project), an additional two were considered fulfilled by this internal review. The remaining four are of a nature which will only lend itself to a complete evaluation over a longer time horizon. These are a) *Contingency plan for erosion and wind erosion*, due to the fact that the condition contained reference to protection against the effects of a design storm of "50-100 years' return period". There has been no such storm since the filling of the reservoir; b) *The monitoring of benthic communities in Héradsflóa*. Not enough time has passed to enable a meaningful evaluation of this condition yet; c) *Extra monitoring of reindeer.* This also requires more time to enable meaningful evaluation, but presently the reindeer herd in the project area has increased substantially since the commissioning of the project and

considerable culling is needed every year in order to control their numbers; d) *Monitoring the pink-footed goose and vegetation.* A renewed inventory of the vegetation plots is being implemented in 2017. The population of the species has exhibited a significant increase all over Iceland, including the project area. This is most probably entirely unrelated to the project, and instead dependent on improved winter feeding conditions in e.g. Scotland.

The land disturbances created as part of the project's construction has been successfully rehabilitated beyond reasonable expectations, and activities are still ongoing to address remaining aspects. The revegetation programme managed by the SCSI has been very successful and gone beyond the revegetation of project-affected areas, to addressing the pre-project lack of vegetation on other highland areas in the upper part of the project catchment as well. The ongoing monitoring of this issue is publicly disclosed through the website of the Eastern Iceland Sustainability Initiative, environmental indicator 8.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, negative environmental and social impacts associated with hydropower facility operations are avoided, minimised, mitigated and compensated with no identified gaps.*

There is one significant impact for which there is no possible avoidance, minimisation or complete mitigation. This concerns the negative impact on the farmers on Lagarfljót and their use of the lake. The cause is the increased turbidity caused by more glacial water entering the lake as a result of the inter-basin transfer from Jökulsá á Dal to Jökulsá í Fljótsdal. This aspect is addressed under topic O-15. As compensation measures are being developed at the time of the assessment, in consultation with stakeholders, this is not considered a gap against the scoring statement. If the project were to fail in developing successful compensation to address major impacts this would, however, develop into a significant gap.

Criteria met: Yes

3.2.6 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

3.3 Scoring Summary

Comprehensive procedures are in place for the ongoing identification of issues and a very extensive monitoring programme is being implemented, mainly by external experts. Landsvirkjun, as the owner, publishes much of its social and environmental monitoring on its website, and in addition there is also the Eastern Iceland Sustainability Initiative. Stakeholders generally attest to good engagement by the project, and ability to raise issues and receive timely and thorough feedback.

The company is certified in accordance with ISO 9001, 14001 and 27001 as well as OHSAS 18001. These certifications are valid also for the Kárahnjúkar project.

The impact predictions in the EIA have proven fairly accurate. The Environment Agency reviewed the project's licence conditions in 2010 and found 14 out of 20 fulfilled in their entirety, and the remaining 6 fulfilled to the extent possible. Landsvirkjun conducted an internal review of the licence conditions again in 2017. The project

was also externally audited in mid-2017 against a suite of regulations, licence conditions as well as external and internal commitments. No non-compliances or non-conformances have been identified.

There are no significant gaps against best practice, resulting in a score of 5.

Topic Score: 5

3.4 Relevant Evidence

Interview:	1, 13, 20, 23, 24, 31, 42, 55
Document:	5 – 7, 9, 22, 42 – 54, 264
Photo:	5, 6, 7, 8, 9, 13, 14, 16, 27, 29, 30, 31, 32, 33, 34, 38, 39, 40, 45, 46, 47, 48, 59, 60, 63, 64, 65, 66, 96, 97, 98, 118, 119, 120, 121, 122, 123, 124, 125, 126, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139

4 Hydrological Resource (O-4)

This topic addresses the level of understanding of the hydrological resource availability and reliability to the operating hydropower facility. The intent is that power generation planning and operations take into account a good understanding of the hydrological resource availability and reliability in the short- and long-term, taking into account other needs, issues or requirements for the inflows and outflows as well as likely future trends (including climate change) that could affect the facility.

4.1 Background Information

Iceland's electricity grid is characterized by a high dependence on hydropower, high proportion of base load, and high requirements of security of supply. These factors make management of the hydrological resource through systematic hydrological research and operational planning very important. Landsvirkjun operates all significant reservoirs in Iceland, and is the only generating company that can deliver significant balancing energy and ancillary services. The total storage in its reservoirs is equivalent to 5,000 GWh, compared to 12,800 GWh annual generation from hydropower. Generation planning is the responsibility of Landsvirkjun, while the actual dispatch of all power stations in Iceland is the responsibility of Landsnet (the transmission service operator).

The project harnesses the rivers Jökulsá á Dal and Jökulsá í Fljótsdal, which are fed by meltwaters from the Vatnajökull glacier, as well as rain and snowmelt. Runoff is very seasonal and highest in the summer months. The reservoirs are filled by late summer and are then drawn down, until next year's summer melting season. Hálslón has reached its lowest levels between May 13 and June 24. Spilling has started between July 28 (2010) and October 9 (2015), and has ended between September 16 (2011) and November 23 (2012).

The Jökulsá í Fljótsdal river and its tributaries in the eastern part of the catchment, with a higher share of snowmelt, reach their peak flow earlier in the year. Because reservoir capacity in this part of the catchment is limited, runoff is used almost continuously throughout the year, except in late summer.

The Jökulsá á Dal in the western part of the catchment depends to a greater degree on glacial meltwater and reaches its peak flow later. The glacier (which is covered with particles and has a lower albedo) starts melting rapidly after the snow layer (with a higher albedo) is melted off. As soon as operators are confident that the large Hálslón reservoir will fill up, they can run the power station completely from the Hálslón intake. At that point, the eastern reservoirs can be taken out of production, for flushing operations, to deliver environmental flows, and for refilling by the end of summer.

There are no diversions or use of water from the Kárahnjúkar catchment for any other purpose than power generation. Related aspects of reservoir management and downstream releases are also covered under topics O-18 and O-19.

Glaciers in Iceland store approximately 3,600 km^3 of ice. A majority of glaciers were advancing between the 1970s and 1990s, but they are now universally in retreat, and expected to largely disappear within ~200 years. Climate change is already affecting reservoir inflows, and will continue to do so. Significant changes to reservoir operations could also be expected if the domestic transmission system were strengthened (to allow for more integrated management of all reservoirs), if a high-voltage submarine interconnector to Europe (with substantially different market characteristics) were to be built, and/or if other electricity sources such as wind were to be expanded.

4.2 Detailed Topic Evaluation

4.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Monitoring is being undertaken of hydrological resource availability and reliability, and ongoing or emerging issues have been identified; inputs include field measurements, appropriate statistical indicators, issues which may impact on water availability or reliability, and a hydrological model.*

Significant progress has been made in recent years with regards to the understanding of Icelandic glaciers, and much of this basic research has been supported by Landsvirkjun. Surface elevation maps have been produced with LIDAR remote sensing, and now allow for more precise monitoring of the glacial mass balance over time. The influence of volcanic activity on glaciers, both through eruptions under the ice and through dust deposition which decreases the albedo, is better understood. The main source of dust on the Brúarjökull outlet glacier, which feeds Hálslón reservoir, is the Dyngjusandur plain north of Vatnajökull (see also topic O-16). In a 2012 study, it was estimated that dust deposition contributed approximately 40% of the melting on Brúarjökull, compared to a hypothetical 'clean glacier'.

Across Iceland, river runoff is projected to increase by approximately 25% between the reference period 1961-1990 and 2071-2100. The magnitude and seasonality of changes depends on the characteristics of each river basin. Total average inflows into the Kárahnjúkar reservoirs have already increased by 12%, from pre-project (2002) estimates of 135.9 m^3/s to 151.7 m^3/s (2015 estimates).

Since the 1980s, Landsvirkjun and the Icelandic MetOffice (*Vedurstofa Islands*) have jointly maintained a system of flow gauges, snowpack/glacier monitoring points, and weather stations across Iceland, including currently 17 gauges in the project area. In 2012, Landsvirkjun supported the installation of a weather radar near the power station, the second such station in Iceland, through provision of power and a fiber optic cable. Because of the natural conditions on the edge of glaciers, reservoir inflows are not directly measured but calculated from known or easily observed data (reservoir level, outflows, seepage, evaporation). Water levels in the main reservoir Hálslón are measured continuously and updated daily and are also made publicly available (http://www.landsvirkjun.com/researchdevelopment/environmentalmonitoring/halslon-water-levels/). Other data, from a total of about 40 different sensors (reservoir and lake levels, flows, groundwater levels) are accessible online for operational staff.

Landsvirkjun and their consultants produce annual reviews of monitoring results, for the water/glaciological year (defined as October 1st to September 30th), for 1) surface water inflows, storage and water levels, 2) Vatnajökull mass balance, and 3) groundwater levels. Hydrological monitoring is also a condition of the power development licence, and monitoring stations and protocols are approved by the National Energy Authority. This is partly to document changes to unregulated flows resulting from power station operations, and partly to ensure reliability of inflows and therefore, generation.

The hydrological model for Kárahnjúkar is based on high-quality, long-term (55 years) historical inflow series and has been updated several times to reflect new data and methodological advances, in particular in 2013 when new forecasts for 2015, 2025 and 2050 were developed. It has been reviewed in cooperation with several experienced consultants, in particular Vatnaskil, and its fit with observed data is considered very satisfactory. The hydrological model also covers the catchment downstream of the project, which is only relevant for calculating water rights compensation payments.

Since 2011, the MetOffice has used the HARMONIE high resolution numerical weather prediction model, which covers a much larger oceanic area than previous models and has led to a marked improvement in performance. Besides delivering forecasts to Landsvirkjun, the cooperation with the MetOffice also extends to 1) the hydro-meteorological network, as mentioned above, 2) studies on climate change and long-term implications,

3) other projects agreed on an annual basis. The MetOffice's proposals for the coming year include a re-analysis of historic data using HARMONIE, studies on flood discharge predictions, and snowpack research.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, issues that may impact on water availability or reliability have been comprehensively identified; and scenarios, uncertainties and risks are routinely and extensively evaluated over the short- and long-term.*

The Kárahnjúkar catchment experiences frequent short-term flow variations, as a result of precipitation or temperature variations around the freezing point. However, the overall annual inflows fall into a fairly predictable range and because of the large reservoir capacity, short-term variations are generally less important.

Forecasting inflows is relevant, however, during the summer and early autumn months, when the reservoirs should fill quickly within weeks, and during times when storage across Iceland is unusually low. It is during those periods that difficult decisions regarding releases from the reservoirs need to be taken, and when dispatch needs to be especially carefully managed for the Icelandic generation system, in order to meet all delivery obligations. Because of transmission constraints (see under Management below), generation needs to be planned well in advance. Also, in case curtailments of power deliveries should become a possibility, clients need to be informed as early as possible (by contract with Alcoa, at least 45 days prior to curtailment, with weekly coordination meetings during a low-flow period). During winter, when reservoirs are slowly drawn down, the value of forecasting information is low. Snowpack is measured, but since snowmelt constitutes only about 25% of total inflows, occurs at a time when reservoirs are drawn down, and its onset is particularly complex to forecast, is not forecasted separately.

The Landsvirkjun head office informs all operations managers about historic and expected inflows, storage levels and current and planned generation in weekly updates based on the Nimbus system, and staff can also access Nimbus data directly (see more under Management below).

Long-term predictions regarding climate change impacts on glaciers, hydrology and generation show more opportunities than risks. Total inflows are expected to increase, and the summer peak in inflows is expected to be less pronounced, with more rain during winter and a longer melting season. While quantitative uncertainties are considerable, the directions of change are fairly clear. Landsvirkjun's Research and Development Division is continuously working on upgrading hydrological models and simulation models for operating the existing reservoir system, and on evaluating options for upgrading the generation infrastructure, as well as options for modifying operational rules and contracts with power offtakers. One option considered is a slight raise in the maximum operating level of Hálslón reservoir.

Criteria met: Yes

4.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to guide generation operations that are based on analysis of the hydrological resource availability, a range of technical considerations, an understanding of power system opportunities and constraints, and social, environmental and economic considerations.*

The Generation Planning unit within Landsvirkjun's Energy Division is responsible for planning reservoir and power plant operations. It relies on inputs from various other units, such as the Research and Development Division for inflow forecasts, station managers for information on scheduled outages for maintenance, and agreed deliveries and orders coming in from industrial customers and wholesalers through the Marketing Division. Until 2015, the unit used a proprietary long-term reservoir simulation software named LpSim, based

on the value of water in the various reservoirs. This has been replaced by Powel's more powerful Nimbus generation planning software, with a target of increasing generation by at least 0.5% from the same resources. The software supports generation planning at various time steps, from annual plans at the beginning of the water year, to weekly and day-ahead plans with an hourly resolution. These are sent to Landsnet, the system operator, who are responsible for coordinating plans from all generating companies and the dispatch of all generating units in Iceland. Since the energy reforms of the mide-2000s, no single company or institution is responsible for overall supply security in Iceland; only recently are there steps to put a committee in place to discuss short- and long-term security (for example, in case of drought or volcanic eruptions).

Landsvirkjun has been successful in marketing its generation over the past years, and is now operating close to capacity, and makes minor purchases to fulfil its obligations. For example, in calendar week 35 of 2017 (the week before the on-site assessment), Landsvirkjun sold 40 GWh to wholesalers, 230 GWh to industrial customers, 95 GWh of which to Alcoa Fjardaál, and purchased 6 GWh on the market. The generation plan for calendar week 37 called for a total generation from Kárahnjúkar of 102 GWh.

The general approach to generation planning places a strong emphasis on limiting the risks from lower-than-expected inflows, and over the medium to longer term (several months to several years), the lower range of the adjusted 55-year historical inflow series is used for predictions.

The Hálslón reservoir is designed to fill up in almost all years, and has indeed filled up in all years since commissioning. A possible curtailment of generation and deliveries to Alcoa was announced twice, in 2013 and 2014, but in the end the curtailment was minor (2-3% of annual sales), well within the contractual limits, where 10% of the contracted energy is considered secondary, with lower probability of delivery and lower value.

Because of topographical constraints, the reservoir is generally not large enough to capture all glacial melt in the summer, and will begin spilling at the end of the summer. In fact, most of the spilling in Landsvirkjun's system occurs at the Kárahnjúkar dam. Much of the additional inflow availability at Kárahnjúkar in recent years results in additional spilling, but some of it is used to increase generation. In combination with lower than expected friction losses in the headrace tunnels, generation is higher than originally predicted. As a consequence, the contract with and sales to Alcoa have been amended by a volume of 8%.

The social and environmental aspects of generation operations, and the ways in which they affect generation operations, are described under topics O-18 and O-19.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, generation operations planning has a long-term perspective; fully optimises and maximises efficiency of water use; and has the flexibility to adapt to anticipate and adapt to future changes.*

The Nimbus reservoir simulation software optimizes operations over several years, given the current constraints of the system. There is some limited flexibility to adapt operations, as Landsvirkjun can store about 4.7 months of average inflows and can curtail deliveries to customers to some extent. Landsvirkjun is also exploring different scenarios and options to increase generation over the longer term. The most relevant of these scenarios, because plans are already in place, is a strengthening of the transmission system. Other scenarios, such as changes in the supply mix (for example, by a significant increase in wind capacity) and/or an interconnection to Europe, are more remote. In the very long term, some research has been conducted over the rate of filling of Hálslón by sediment; some research predicts that the retreat of glaciers will reduce sediment input, and significantly increase the lifespan of the reservoir, from the originally predicted 500 years perhaps up to 10,000 years (see also topic O-18).

A stronger transmission system could avoid some of the spilling, by increasing generation in regions where reservoirs are at higher than expected levels, decreasing generation in regions where reservoirs are lower than expected, and transferring energy to regions with supply deficits. It has been estimated that this could increase

annual system-level hydropower generation by an average of 400 GWh, or more than 3%. Besides the increased utilization of existing hydropower infrastructure, benefits would include 1) increased opportunities to meet needs of customers with regard to location of delivery, 2) reduced transmission losses, and 3) increased reliability of delivery in case of a power-station or transmission-line failure, for example in case of natural disasters.

It has to be recognized that running the system closer to maximum generation might reduce the reliability of supply in those regions that export power. It would be difficult, for example, to draw down Hálslón more aggressively in the spring, before the amount of glacial melt inflows during the summer is known, unless there is a large degree of confidence that in case summer inflows turn out relatively low, the lost capacity can be replaced by generation elsewhere in the system.

The constraints posed by transmission capacity gaps mean that the use of water at Kárahnjúkar (and in the broader Landsvirkjun generating system) is not fully optimized, which is a **significant gap** against proven best practice. This gap is recognized by all power sector actors. In its latest annual report, Landsnet states that "to reduce the current energy waste due to system constraints and bottlenecks, it is necessary to reinforce the grid", and has drawn up system expansion plans, which have also been approved by Orkustofnun. However, the problem has been recognized for a long time, and the implementation of these transmission line projects is significantly delayed.

Criteria met: No

4.2.3 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

The constraints posed by transmission capacity gaps mean that the use of water at Kárahnjúkar (and in the broader Landsvirkjun generating system) is not fully optimized.

1 significant gap

4.3 Scoring Summary

The management of hydrological resources in Iceland involves only a small number of competing uses and stakeholders. Landsvirkjun and Icelandic government agencies have a good sense of the availability and reliability of resources, based on long-term historic flow data as well as climate observations and modelling. They have undertaken extensive research into future water availability, which is expected to improve due to glacial retreat. Generation scheduling decisions are based on solid, state-of-the-art simulation and optimisation models and are integrated across all power stations in the country. They are however constrained in the short run, by transmission capacity gaps, which impede an optimal use of water. This is considered a significant gap against proven best practice, resulting in a score of 4.

Topic Score: 4

4.4 Relevant Evidence

Interview:	4, 8, 11, 18, 19, 22, 36, 53
Document:	5-8, 55-73, 104, 239, 240, 264
Photo:	1, 2, 5-9, 23, 27, 28, 58, 67, 111, 130

5 Asset Reliability and Efficiency (O-5)

This topic addresses the reliability and efficiency of the hydropower facility and associated network assets. The intent is that assets are maintained to deliver optimal performance in the short- and long-term in accordance with the overall electricity generation and supply strategy of the owner/operator.

5.1 Background Information

Reliable and efficient power supply from the Kárahnjúkar project is highly important, as the project makes up a significant share of Landsvirkjun's assets and revenues. Landsvirkjun's power stations were valued at USD 2.9 billion at the end of 2016 (measured at cost less accumulated depreciation and impairment). Sales to Alcoa made up 34.5% of Landsvirkjun's generation by volume in 2016. Aluminium smelters suffer significant damages from power supply outages that last beyond a few hours. Outages caused by the supplier can have financial and reputational repercussions, beyond lost sales.

The design of the power station and its interconnection with the smelter therefore placed high emphasis on reliability. Design and due diligence by joint technical committees between Landsvirkjun and Alcoa followed principles such as: the power station is able to supply the smelter under N-1 conditions (operating with 5 out of 6 units, or without the 132 kV transmission ring line); many components are redundant and/or overdesigned (for example, the transmission lines); individual generating units are separated operationally and by dividing the power station into sections to contain disturbances such as fires, explosions and flooding; key assets are protected by multiple sensors and emergency shutdown mechanisms.

While much of the project infrastructure is underground, some particular management challenges arise due to extreme weather conditions. For example, heating devices are required to ensure operability of control gates.

Together with Landsvirkjun's other generation projects (13 hydropower and two geothermal, as well as a wind demonstration project), Kárahnjúkar is operated by the Energy Division. The division has a total of 140 staff in two units for operations (hydropower and geothermal), generation planning, asset management, and major maintenance projects. The assets have been grouped into five regional operations and maintenance centres, one of which is only dedicated to Kárahnjúkar.

The monitoring and maintenance of safety-relevant assets is also covered under topics O-6 and O-12. While this topic O-5 and O-12 focus on the power station, O-6 focuses on the dams and other infrastructure.

5.2 Detailed Topic Evaluation

5.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Routine monitoring of asset condition, availability and reliability is being undertaken to identify risks and assess the effectiveness of management measures; and ongoing or emerging asset maintenance and management issues have been identified.*

Landsvirkjun's assets are classified according to the German KKS standard (Identification System for Power Plants), a hierarchical system to assign codes by plant, system, equipment, and component. This classification is the basis for asset management, which is run through an integrated software platform, the Dynamic Maintenance Management (DMM) system. The KKS and DMM systems are used by all major Icelandic power companies. DMM Solutions Ltd is an Icelandic company co-owned by the power industry, that developed the software in 1992. It has been continuously updated with input from the main users (for example, with respect to spare parts management), and made suitable for a wider range of clients. It is designed to be easy for the plant technician to use, while catering to information requirements at the corporate level. Software functions

include: asset registry, preventive maintenance schedules, work orders, condition monitoring, condition based flagging, time accounting for maintenance activities, fault reports, trending and performance reports, and version-controlled work descriptions and checklists. The DMM system is the basis of quality management systems, that have been certified to ISO 9001. It is used extensively in Kárahnjúkar, including the follow-up of licence conditions and of safety and environmental observations by staff, regulatory authorities, and stakeholders.

Among other functions, DMM guides asset condition monitoring. The system schedules routine inspections for all assets and equipment, records any monitoring results and identified issues, and schedules follow-up tasks. Tasks get rated according to priority, and then acted on accordingly. Detailed maintenance records are added so that for each component, a condition and service history can be called up. Equipment manufacturers' representatives (for example, from Andritz for the generating units) are also occasionally involved in asset condition monitoring.

Landsvirkjun has also undertaken separate systematic risk assessments at Kárahnjúkar, including for explosion and fire risk, flooding of caverns, and civil works, which have informed asset designs and maintenance plans (see also topic O-6).

Certain equipment registered with the Administration for Occupational Health & Safety is checked on an annual basis, such as forklifts, cranes, and elevators. Other external inspections are focussed on electrical safety, which is certified, and on pollution and food and water safety. For example, one inspection by the Environmental and Public Health Office identified an issue with the temperature in one of the coolers in the power station kitchen, which was promptly repaired.

Goals and performance indicators for the power station have been defined by the Energy Division and are monitored regularly through monthly, quarterly and annual reports. Reliability and availability calculations are performed through a module within DMM. A large number of performance indicators are generated.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging asset maintenance and management issues takes into account both risks and opportunities.*

Major maintenance and refurbishment projects are outside the regular operations and maintenance budget of the power station. They are identified and analysed through Copperleaf's C55, an asset management software introduced in 2013, to ensure that maintenance activities fit into the strategic corporate framework. C55 integrates finance, operational, and engineering perspectives to help plan asset investments, budgeting, and performance management over various time horizons. It supports rating and prioritising possible projects across a variety of criteria, including cost and contributions to reliability, safety, and environmental performance. The return from such projects is generally much higher than from new investments, so these types of projects are not directly compared with each other.

Maintenance routines have evolved as more experience is gained. Until 2015, for example, the turbines were drained annually for measurements and visual inspection of the mechanical parts, to get a better understanding of possible abrasion effects of glacial water in a high-head plant. As abrasion is lower than expected, this was changed from 2016, and maintenance routines for turbines are now the same as in other Landsvirkjun stations.

Landsvirkjun also identifies improvement opportunities with respect to emerging technologies, efficiencies through bulk purchases, utilisation of services across the portfolio, etc.

Criteria met: Yes

5.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to address routine monitoring and maintenance requirements of the operating facility in accordance with the overall electricity generation and supply strategy of the owner/operator.*

Landsvirkjun's quality management system is guided by a maintenance policy (STE-5), which emphasizes reliability including safety, capability, availability, longevity and economy. The maintenance strategy (VKL-91) prioritizes maintenance according to asset importance, age, condition, and role in specific processes. Internal directives define: maintenance methods (preventive, predictive, statutory inspections, corrective etc.); divergences and follow-up flagging; faults and unavailabilities.

Responsibilities of the Station Manager, Maintenance Manager, and station employees are also defined. Local power station staff are generally responsible for 1st line maintenance (incl. inspections, immediate corrective tasks, minor operating adjustments) and 2nd line maintenance (incl. preventive maintenance, minor repairs during scheduled production windows, statutory inspections), while 3rd line maintenance tasks (incl. larger preventive maintenance, repairs, rebuilds, modifications and equipment installation) are executed in cooperation with the head office's major maintenance projects unit and contractors. For example, maintenance contractors currently employed include: one carpenter who has been working on various maintenance projects and has assisted with dam monitoring; 2-3 employees from a workshop in Seydisfjördur who generally assist internal staff with various maintenance projects for 3–8 weeks during the autumn; 2-3 mechanics from a workshop in Egilsstadir who have been involved in guide vane replacement work; and an electrical company in Egilsstadir that has been responsible for maintenance of lighting in buildings.

Operational, maintenance and equipment renewal plans are prepared and reviewed regularly by the Energy Division. Head office and power station staff meet at least once a year to discuss all jobs coming up, and agree on contracts that will progress and the appropriate procurement procedures for each job. Once jobs are approved, they go into the DMM system for scheduling. An annual operational plan for the power station is prepared at the beginning of the water year, and includes scheduled outages for maintenance, generally during the high reservoir level season, when there is more operational flexibility in the system.

Since 2012, each generating unit has undergone a major condition assessment, which lasts 600-800 hours. For the medium to longer term, 3-year and 20-year investment plans for asset refurbishments are prepared through the C55 software. Kárahnjúkar has a maintenance plan until 2035, which lists for each generating unit, the years in which guide vanes, facing plates, and turbine runners are expected to be replaced. Other major recent projects that were prioritized through C55, are 1) sandblasting and painting of a bottom outlet gate at Ufsarlón, 2) rockfall protection above the Kárahnjúkar dam, 3) dam safety reviews by external consultants, following NVE standards, and 4) erosion repairs to the canyon wall below the spillway chute at the Kárahnjúkar dam (see also O-6).

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities; and asset maintenance management plans include a long-term program for efficiency improvements and asset upgrades.*

Processes to anticipate and respond to emerging risks and opportunities include the regular internal and external inspections, as well as sharing of knowledge across Landsvirkjun and with external experts. The creation of the Asset Management unit and introduction of DMM and C55 systems across the company have substantially upgraded Landsvirkjun's processes, which are now aligned with the ISO 55000 standard for asset management systems. Processes at Kárahnjúkar are designed to ensure avoidance of problems by catching any

possible emerging issues early and addressing them. The housekeeping in the power station and at all associated assets is of a very high standard, making it easy to spot any irregularities.

Regarding emerging opportunities and efficiency improvements, Landsvirkjun is continuously investing in new soft- and hardware to improve performance of its power stations. Examples for new technologies that have been identified and introduced since Kárahnjúkar became operational are

- software packages such as C55, Nimbus, and vibration measurement software
- equipment such as drones for dam monitoring, electric cars, monitoring cameras which have been increased to a total of 50, and devices for equipment assessment such as an ultrasonic measuring device, an infrared thermal imaging camera, and a borescope

Operational reliability also depends on emergency preparedness. Since 1995, Landsvirkjun has its own Emergency Committee (NLV) with detailed procedures, to prepare for, protect against, recover from and mitigate major hazards in assets and operations (see also topic O-6); one of its objectives is to minimize curtailment of power deliveries. In 2007, following deregulation of the sector, a formal cooperation body between the power companies and government agencies in Iceland (the Icelandic Power Sector Emergency Preparedness Forum or NSR) was created. There are also joint exercises with Alcoa once a year, to prepare and practice responses to scenarios that might affect the power supply to the smelter; last year's scenario was a terrorist attack.

Criteria met: Yes

5.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives relating to asset maintenance and management have been and are on track to be met with no major non-compliances or non-conformances, and any asset related commitments have been or are on track to be met.*

There are three key performance indicators (KPIs) for Kárahnjúkar asset maintenance objectives, namely the time between unscheduled stops, the proportion of maintenance projects that are on schedule, and the number of mishaps. These are all currently in the green zone (i.e. well met).

Equipment checks by the Administration for Occupational Health & Safety show that all externally certified equipment items are in compliance. According to the agency, no other workplace in the region maintains higher standards with regards to equipment than the power station.

Alcoa and Landsvirkjun maintain communications about issues that could affect reliability of supply, such as operational and maintenance plans and water inflows. There have been no issues with fulfilling the power purchase agreement with Alcoa.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

In 2016, there were two unplanned maintenance stops of a generating unit, with a total duration of two hours. These were well within the overall performance targets. There are no non-compliances or non-conformances.

Criteria met: Yes

5.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Asset reliability and efficiency performance is in line with the objectives of the owner/operator and any asset performance guarantees with only minor gaps.*

Since 2010, the annual generation at Kárahnjúkar has been consistently larger than the anticipated 4,800 GWh. In 2016, 5,049 GWh were achieved. No major engineering problems, droughts or natural disasters have affected operations.

The availability of all six units in 2016, outside of scheduled maintenance periods, was exceptionally high at 99.83% - 99.96%. The unit undergoing major preventive maintenance operated for a total of 8,185 hours, while the others operated at least 8,610 hours, or 98.29% of the year. Results for previous years were similar.

Between commissioning in 2007 and the end of 2016, there have been 40 supply interruptions to the Alcoa smelter, and 45 events where the demand of the smelter could not be fully satisfied and the number of pots in production and/or the amperage had to be reduced. After each such event, a root cause analysis is undertaken jointly between Landsvirkjun, Landsnet and Alcoa. Of the 40 interruptions, in 4 cases the cause of the problem lay with the Kárahnjúkar project, in 12 cases with Landsnet, and in 24 cases with Alcoa (including a major transformer fire in 2010). Of the 45 other events, 3 can be attributed to Kárahnjúkar, 17 to Landsnet, and 25 to Alcoa. The last event on Landsvirkjun's side was in 2014, when the electrical protection on one unit failed. The events never lasted long enough to cause serious operational problems at the smelter, and their number has trended downwards, as all three parties are gaining more operational experience.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *Asset reliability and efficiency performance is fully in line with the objectives of the owner/operator and any asset performance guarantees.*

The performance of Kárahnjúkar is fully in line with the objectives of Landsvirkjun and the main customer of the power plant, Alcoa.

Criteria met: Yes

5.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

5.3 Scoring Summary

The Kárahnjúkar project was designed and is maintained to achieve a high degree of reliability, as required by the needs of the main customer, and there have been very few supply interruptions. Landsvirkjun's operational staff at the power station and the support units in head office use state-of-the-art practices and systems to identify issues before they arise, and to prioritize and implement preventive and corrective maintenance. The load factor in 2016 was 84%, and the availability of generating units is exceptionally high. There are no identified gaps against proven best practice, resulting in a score of 5.

5.4 Relevant evidence

Interview:	7, 8, 10, 13, 16, 18, 19, 22, 27, 28, 33, 51, 53
Document:	6, 8, 19, 74-84, 115
Photo:	15, 16, 21-29, 35, 36, 68-95, 98-111, 114, 116

6 Infrastructure Safety (O-6)

This topic addresses management of dam and other infrastructure safety. The intent is that life, property and the environment are protected from the consequences of dam failure and other infrastructure safety risks.

6.1 Background Information

Iceland is prone to natural hazards including volcanic eruptions, earthquakes and extreme weather conditions. Large floods can result from eruptions under glaciers. However, the Kárahnjúkar region has no known active volcanos and low recent seismic activity.

There are no national dam safety standards and no dam safety regulator in Iceland. Landsvirkjun uses Norwegian standards for dam design and construction. An international dam safety Panel of Experts has contributed to the safety of the Kárahnjúkar dams, and a re-evaluation of the dams against current Norwegian standards is under way. All of Landsvirkjun's operating power stations are subject to periodic and continuous monitoring, and have emergency response plans and systems. In case of emergencies, the key public agency is the Icelandic Civil Protection Authority (*Almannavarnadeild*).

The project has facilitated access into the highland regions north of the Vatnajökull ice cap, has created new infrastructure and reservoirs accessible to the general public, and has changed flow conditions downstream of the dams.

6.2 Detailed Topic Evaluation

6.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Routine monitoring of dam and infrastructure safety is being undertaken to identify risks and assess the effectiveness of management measures; and ongoing or emerging dam and other infrastructure safety issues have been identified.*

During the preparation of the project, there were extensive assessments of dam safety risks including geological, geotechnical, hydrological, and engineering studies. Overtopping of the dams is the most relevant potential failure mode; others are internal erosion, and seismic or volcanic activity.

All dams except the saddle dams on the main reservoir Hálslón have free, unregulated spillways, which reduces operational uncertainties (for example, ice damage/blockage of gates). The flood design for Hálslón is determined by

- the 1-in-1000-year design flood (1,350 m^3/s, resulting from glacial melt) which could be safely passed through the Kárahnjúkar spillway without damages,
- the 'safety check' or probable maximum flood (PMF, 2,250 m^3/s, resulting from a 72-hour probable maximum precipitation event, falling as rain on frozen ground), which could also be passed through the spillway, accepting some damages,
- a catastrophic flood (6,000 m^3/s continuously over several days) resulting from a volcanic eruption under the glacier in the catchment (although no active volcanos are known), which would break a fuse plug on the Desjará saddle dam, thus lowering the water level by 11.5 m and protecting the other dams. The fuse plug is built of more erodible material, with a crest level 1 m lower than the other dams.

Shortly after the on-site visit by the assessment team, the project experienced its highest-ever inflows. At the peak on 28 September, the Kárahnjúkar spillway discharged 630 m^3/s.

With regards to seismic and volcanic activity, the project area is outside active zones, which are generally located to the west. Well-compacted concrete-faced rockfill dams on unerodible material, like the main dam at Kárahnjúkar, are inherently safe. The design was conservative, and design choices for all dams were reviewed and confirmed independently by a number of experts, including on behalf of Alcoa. During construction, a number of inactive faults and geothermal anomalies were discovered, and it is now believed that a fissure swarm from the nearest volcano extends towards the project area. The faults did not require a change in design, but additional sealing work during construction, and instrumentation.

The dams and nearby areas are equipped with a complex system of instruments which monitor seepage (incl. turbidity levels), face deflection, crest movements, settlement, strain, pore pressure, seismic activity, acceleration (in case of earthquakes), vertical and horizontal ground movement, and groundwater levels. An internal directive (VIN-172) defines monitoring protocols. Most sensors send data automatically, require little effort for data collection and maintenance, and many can be accessed online.

Several organisations cooperate in the monitoring efforts. The MetOffice operates microseismic and continuous GPS stations, the Earthquake Engineering Research Centre the accelerometer stations, and Landsvirkjun's Research and Development Division and power station staff the other instruments. No earthquakes have been associated with the reservoir impoundment, and only minor earthquakes have been recorded. All monitored parameters have been within the predicted ranges.

The frequency of visual inspections by power station staff depends on reservoir levels, and is higher on the Hálslón reservoir dams than in the eastern part of the catchment. Safety specialists from the head office and external consultants assist in monitoring. Annual monitoring reports are compiled for each dam.

There is a large number of remotely controlled cameras, some of which show areas around the reservoirs with public access. Visits to the highlands have increased considerably, because of improved road access, the attraction of the project, and a rapid increase in tourism in recent years. Usage of the project infrastructure by members of the general public is low, and primarily involves driving over the Desjará and Kárahnjúkar dams. There have been no known accidents associated with the infrastructure and its operations. The main roads have been turned over to the Road Administration, which is responsible for maintenance and safety (Landsvirkjun requests and pays for snow clearance in spring). There is some access to the rivers Jökulsá á Dal and Jökulsá í Fljótsdal below the dams, primarily to visit the canyon and waterfalls, and for fishing.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging safety issues takes into account consideration of a broad range of scenarios and both risks and opportunities.*

Recent dam safety audits and reviews and background reports (see below under Management and Conformance/Compliance) have shown that some instrumentation records are incomplete, and review and analysis of monitoring data could be more systematic. This is addressed under Conformance/Compliance below, because is it seen as a non-conformance with monitoring protocols and standards.

Landsvirkjun have limited responsibility for public safety (for example, if people decide to use boats on reservoirs, or drive on the ice, at their own risk), and has responded appropriately to emerging public safety risks. For example, after the spillway of the main dam was accessed with snowmobiles, additional fencing and signage was installed. Landsnet has similarly reacted to public safety risks, for example to people snow-kiting in the vicinity of transmission lines.

Criteria met: Yes

6.2.2 Management

Analysis against basic good practice

Scoring statement: *Dam and other infrastructure safety management plans and processes have been developed in conjunction with relevant regulatory and local authorities with no significant gaps, and provide for communication of public safety measures; emergency response plans and processes include awareness and training programs and emergency response simulations.*

Monitoring is guided by protocols and by the DMM system which schedules inspections and captures observations. Operational rules for the reservoirs and power plant are designed to ensure safe operations. Kárahnjúkar project staff includes a project manager for waterways and dam operation, who is responsible for infrastructure safety, outside the power plant. A number of safety-relevant maintenance projects are being implemented, as described under topic O-5.

Detailed emergency response plans and processes are in place at several levels. The Kárahnjúkar Action Plan (LEI-151) contains guidelines, checklists, communication procedures, inundation maps etc. The Station Manager has authority to declare different emergency levels. For larger emergencies, Landsvirkjun will activate its own Emergency Committee (NLV), also with detailed procedures (LEI-225 and a suite of other documents), to prepare for, protect against, recover from and mitigate major hazards in assets and operations (see also topic O-5). Its priorities are first to prevent injuries or loss of human life, second to protect structures, and third continuity of generation. Verkis consultants are supporting Landsvirkjun with emergency management.

There are also processes to coordinate emergency preparedness and response with the Civil Protection Authority, the fire department, police, search and rescue service, and local authorities (including a special communication group in TETRA, the national public-safety communication system); within the power sector (through the Icelandic Power Sector Emergency Preparedness Forum, NSR); and with Alcoa. Trainings and emergency simulations are conducted regularly; one evacuation exercise has been conducted. TETRA is tested annually.

Before major releases from dams, i.e. before flushing and spilling operations, local residents and other people within reach of local mobile phone stations are informed by text messages. Other warning systems (audio and visual) have been considered but found not necessary. Tourism operators and others are also informed about operational plans in advance, as described under topic O-19. In case of emergencies, information and evacuation would be coordinated by the Civil Protection Authority, which has access to emergency plans and inundation maps, and its own response plans.

Before impoundment of Hálslón reservoir, Landsvirkjun provided technical information on safety aspects of the project to the general public, to respond to public concerns. Some safety-relevant information is publicly communicated, for example reservoir and flow levels, and access restrictions.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities; and public safety measures are widely communicated in a timely and accessible manner.*

Some opportunities to improve safety monitoring have been identified by Landsvirkjun over time, for example changes in the numbers and locations of instruments and remotely controlled cameras, and use of new technologies such as drones to monitor dam face conditions, and to check for the emergence of new springs downstream of dams. Special investigations have been conducted on issues of interest, for example the quality of concrete and significance of cracks in the spillway, following recent concerns on spillways following the Oroville incident.

Reviews by an independent Panel of Experts have assisted since 2000 during dam design, construction and operations, most recently in 2017. The panel brought in international experience on specific issues, such as methods for concrete face construction and the evaluation and treatment of faults. Through visual inspections and the review of data and background documents (one of them specifically on geohazards in the Hálslón area), the panel provides updated perspectives on safety risks and management options. One recent observation of the panel was, for example, that the bottom outlet gates on the Kárahnjúkar dam have remained closed since the filling of the reservoir in 2007. They should either be tested regularly, to ensure continued functionality, or permanently plugged to stop leakage.

The dams were originally designed to comply with standards by the Norwegian regulator NVE (Norwegian Water Resources and Energy Directorate) in the early 2000's, slightly adapted to Icelandic conditions. Landsvirkjun has recently commissioned Mannvit consultants to audit all dams against current NVE standards, and make recommendations for improvements; the first report (on the Hálslón saddle dams) has been delivered.

A periodic re-calculation of design floods is foreseen under NVE standards. This is relevant because hydrology is already changing, but not of the highest importance since the dams on the Hálslón reservoir are designed to be able to pass a catastrophic flood unrelated to hydrology.

There are no concerns by local stakeholders about timely access to safety-relevant information.

Criteria met: Yes

6.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives relating to safety have been and are on track to be met with no major non-compliances or non-conformances, and safety related commitments have been or are on track to be met.*

There have been no non-compliances and no major non-conformances with regards to public safety. The safety of the dams has been assured through appropriate design, continuous monitoring, and a number of repairs. General public safety has been assured through signage, fencing, remote supervision by camera, and there are no indications from public authorities of any safety issues.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances against regulatory requirements. Landsvirkjun submits voluntarily to reviews by a Panel of Experts, and to audits of conformance with NVE standards. While the latest 2016 and 2017 reviews (see above under Assessment and Management) have confirmed the overall safety of the dams, they have resulted in a number of observations. These include some divergences from current standards, lack of follow-up of previous observations (for example, regarding the Desjará dam fuse plug), and recommendations for technical upgrades. Some instrumentation records are incomplete, and review and analysis of monitoring data could be more systematic. This is considered a **significant gap** against proven best practices.

Landsvirkjun will continue its safety audit program, have all dams at Kárahnjúkar audited against NVE standards within two years, and take action to respond to the highest-priority observations. Some of these will only require simple repairs or changes to monitoring routines; others will probably lead to significant projects, to be prioritized and budgeted through Landsvirkjun's asset management system (see topic O-5).

Criteria met: No

6.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Safety risks have been avoided, minimised and mitigated with no significant gaps.*

The objective level of public safety risks around the Kárahnjúkar project is low. Good practices for dam safety, road safety, waterway safety, and other safety aspects have been followed. It would be impossible to fence off or control access to the entire hydropower plant, including all reservoirs.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, safety risks have been avoided, minimised and mitigated with no identified gaps; and safety issues have been addressed beyond those risks caused by the operating facility itself.*

No gaps have been identified in the management of public safety around the Kárahnjúkar project. Landsvirkjun is in the process of identifying opportunities for improvements and upgrades, with the support of external advisers. Landsvirkjun is also aware of the growing public interest and access to the highlands, which brings increasing numbers of people (including some tourists with little experience of local conditions) in contact with project infrastructure. At some stage there may be a need to upgrade public safety; however this is not a current priority, and only partially a responsibility of Landsvirkjun.

There is some contribution to public safety from the project, in terms of road access and access to first aid, mobile phone coverage, snow clearing, remote cameras, and other services that would not otherwise be available in the area. Staff have occasionally assisted in search and rescue operations, and there are agreements on mutual support with the public emergency services.

Criteria met: Yes

6.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

Recent reviews have shown a number of minor non-conformances with dam safety standards and protocols; for example, some instrumentation records are incomplete, and review and analysis of monitoring data could be more systematic.

1 significant gap

6.3 Scoring Summary

The Kárahnjúkar project has several of the largest dams in Iceland. These are not subject to regulatory supervision, but Landsvirkjun (as the only owner of large dams in the country) applies international standards and expertise to ensure safe operations. There are some opportunities to improve monitoring and data analysis. There are clear processes and good cooperation with local authorities for warning the public in case of major releases from the reservoirs, and for emergency preparedness. Public access to project infrastructure is partially restricted, and otherwise at the users' own risk. There is one significant gap against proven best practices, resulting in a score of 4.

Topic Score: 4

6.4 Relevant Evidence

Interview:	4, 7, 8, 10, 13, 16, 18, 19, 27, 28, 33, 50, 53
Document:	22, 32, 37-39, 42, 47, 84-107, 155
Photo:	4, 10, 15, 16, 18, 21-31, 35, 36, 40-44, 51, 57, 59-61, 63

7 Financial Viability (O-7)

This topic addresses financial management of the operating hydropower facility, including funding of measures aimed at ensuring project sustainability, and the ability of the project to generate the required financial returns to meet funding requirements as well as to optimise its financial opportunities. The intent is that the operations of the hydropower facility are proceeding on a sound financial basis that covers all funding requirements including social and environmental measures and commitments, and that it is aware of and responding to market trends which may influence its long-term viability.

7.1 Background Information

Landsvirkjun operates in an unregulated market with respect to its power sales to industrial customers and distribution companies. Some power sales also go to the transmission service operator, for ancillary services, losses, and backup generation for outages by other generating companies. Other sources of revenue are green electricity certificates and the income from related businesses such as Landsnet (regulated transmission revenues) and Landsvirkjun Power (consulting services). Operating revenues between 2010 and 2016 averaged USD 418 million per year.

The Kárahnjúkar project was the largest single public investment in Iceland's history, with a current book value of approximately USD 2 billion, and led to a significant increase in debt and leverage. (The Fjardaál smelter was the largest private investment, with a similar order of magnitude). After the commissioning of Kárahnjúkar, Landsvirkjun reduced investments to an average of USD 110 million per year between 2010 and 2016, and focused on repaying debt. Debts decreased from USD 2,674 million at the end of 2010 to USD 1,960 million at the end of 2016. The equity ratio increased to 45%, the highest in Landsvirkjun's history. Although Landsvirkjun's debt is increasingly without government guarantee, its ratings have improved to investment grade, currently at BBB/A-2 (Standard & Poor's) and Baa3 (Moody's).

Kárahnjúkar is an integral part of Landsvirkjun's finances. It was financed through Landsvirkjun's general bond program, and its asset value, revenues, operating expenses, and other financial aspects are not reported separately. (To maintain a strong bargaining position with large customers, Landsvirkjun keeps a number of financial data and the power contracts confidential.) As a relatively new power station with an operating crew of 13, Kárahnjúkar's operational and maintenance expenses are low.

7.2 Detailed Topic Evaluation

7.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Routine monitoring of the operating hydropower facility's finances is being undertaken to identify risks and assess the effectiveness of management measures; and ongoing or emerging financial management issues have been identified.*

Landsvirkjun establishes regular annual budgets for each regional operations and maintenance centre, of which Kárahnjúkar is one. Additionally, the company assigns financial resources to individual larger maintenance or refurbishment projects. The Station Manager is responsible for requesting budgets, tracking expenditure, and quarterly as well as annual reporting to head office. The expenditures for 2016 amounted to ISK 749 million (USD 7.1 million).

Sales to Alcoa (now trading as Arconic) and other customers, payments for investment and major maintenance projects, debt service, taxes and dividends, and other financial management issues are monitored by different units in the head office, primarily by the Finance Division.

Ongoing and emerging issues are identified, as discussed below.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging financial management issues takes into account both risks and opportunities including factors and trends that might influence future demand for electricity, water and ancillary services.*

The profitability of the project was originally evaluated through a number of different analyses, drawing in several specialised consultants and academic experts who developed, for example, models of aluminium and capital markets, and performed Monte Carlo simulations for sensitivity analyses. Different project structures such as a special purpose vehicle were considered. Critics such as a conservation NGO published their own, more sceptical analyses. Government appointed a committee to examine Landsvirkjun's own models and sensitivity analyses, which reported that Landsvirkjun had used due care and diligence. Results were presented to owners, including parliamentary committees. The expected internal rate of return was 7.3%, which was 0.4% more than the weighted average cost of capital, and the return on equity was 12.8%.

The investment decision for Kárahnjúkar had to take a number of uncertainties into consideration. Some of these financial performance risks are now superseded, some have indeed occurred, and others are ongoing or may emerge at a future time:

- Constructability and construction schedule. The project was unique for Iceland in its size and complexity, and built under difficult weather conditions. Foundation works for several dams and long tunnels presented geotechnical risks, and indeed tunnelling led to some delays in delivery.
- Construction costs. The original cost estimate was approximately USD 1 billion. The final investment decision was taken once the results of the tender for the largest contract (civil works) were known. Construction costs were higher than anticipated, and were evaluated in internal studies in 2008 and 2010, but a final number has not been made public. The Minister for Industry announced cost increases by USD 264 million in 2008. The much higher current book value of the project is partly a function of the conversion into USD in 2007, when Landsvirkjun adopted the USD as its accounting currency.
- Interest rates. The project was financed through Landsvirkjun's general bond program, which at the time was largely composed of 15-year floating rate bonds. Interest rates have been very favourable.
- Exchange rates. Construction costs were incurred in a mix of currencies (mostly EUR and ISK), the project was also financed through a mix of bonds denominated in different currencies (with the largest share in EUR), and revenues are denominated in USD. Exchange rates also influence the price of aluminium, which is traded in USD.
- Aluminium prices. The power sales agreement with Alcoa links the power price directly to aluminium prices. Landsvirkjun thus shares aluminium price risks with Alcoa, and prices are highly relevant for the financial performance of the project, and quite volatile. They reached a historic high (over USD 3,000/t) at the time of commissioning of the project, fell to USD 1,300/t in the aftermath of the global financial crisis, and have since fluctuated between USD 1,500/t and USD 2,500/t. Aluminium price assumptions in Landsvirkjun's financial model were conservative, assuming a gradual decline.
- Offtaker risks. The agreement with Alcoa is a take-or-pay arrangement for at least 85% of the contracted power over 40 years. The successor company of Alcoa, Arconic, is rated at just below or above investment grade by the three major ratings agencies.
- Hydrology. 90% of contracted energy is primary or firm energy, while 10% is secondary energy. Water availability is higher than expected (see topic O-4), and only a minor curtailment of secondary energy to Alcoa occurred in one year, with no financial penalties beyond lost sales.

- Technical performance of the project. The operational performance of the project has been very satisfactory (see topic O-5). Friction losses in the headrace tunnels, and abrasion rates for hydromechanical equipment, are lower than expected.

In 2006, Landsvirkjun published a revised profitability assessment, with slightly reduced rates of return. Since then, no specific profitability analysis for Kárahnjúkar has been undertaken. In 2011, Landsvirkjun's CEO reportedly stated that the profitability was unsatisfactory. The current return on equity invested in Kárahnjúkar is considered acceptable, above the benchmarks considered at the time of the investment decision; however, this is not based on detailed calculations.

While it would not have any immediate operational implications, and is not considered a gap, it would be a useful learning opportunity for Landsvirkjun and of interest to the Icelandic public, as the ultimate owners of the project, to revisit the original assumptions and update the profitability analysis of the project, one decade after operations started.

Criteria met: Yes

7.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place for financial management of the operating hydropower facility.*

Routine financial management processes for Kárahnjúkar include annual budgeting, in the last quarter of each calendar year for the following year, based on budgeting guidelines issued by the Finance Division, and billing to Alcoa and other customers. The Finance Division continues to upgrade its operations, for example by the introduction of Reval, a new treasury and financial risk management platform in 2016.

Operational costs and staff numbers are considered low for a large facility like Kárahnjúkar, reflecting economies of scale and the good technical condition of the plant. Where necessary, for example to satisfy reliability, safety and environmental requirements, additional expenditures have been easily approved. One example is adding a position for the project manager for dams and waterways, primarily responsible for operational safety.

Nevertheless, the operating crew is continuously looking for ways to save costs and increase revenues, for example by shortening maintenance outages and outsourcing maintenance. The last offer for a 5-years cleaning and catering contract was 20% lower than before.

Landsvirkjun maintains two key insurance policies for Kárahnjúkar, all-risk as well as for up to one year of foregone revenue, in case of operational problems.

Landsvirkjun's Marketing and Business Development Division is responsible for maximising Landsvirkjun's long-term profit potential, through promotion and sale of products and services, negotiating contracts and follow up of existing contracts.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities; and financial contingency measures can be implemented for environmental and social management plans if required.*

Financial risks at the corporate level have been reduced by hedging and by decreasing the exposure to 1) commodity (especially aluminium) price risks, by de-linking sales prices from commodity prices; 2) interest rate risks, by moving towards fixed-rate bonds; and 3) foreign exchange rate risks, by moving towards refinancing in

USD, the same currency as for revenues. Risks are quantified in detail in the company's annual financial statements.

Power sales contracts are generally of long durations, and the de-linking from aluminium price risks is only possible in new and in re-negotiated sales contracts. The Kárahnjúkar contract with Alcoa Fjardaál runs over 40 years, from 2007 to 2047, and renegotiation is only possible after 20 years (in 2027) or in exceptional circumstances. Refinancing operations, on the other hand, are almost continuous, and rates are still very favourable, with an average nominal rate of 3.3% at the end of 2016.

Other risk management measures are the continued reduction of debt, and the efforts to broaden and diversify the customer base, to reduce dependence on a small number of counterparties.

Additional sales from the existing generation infrastructure could be realized if the transmission system within Iceland were strengthened, or an interconnector to Europe would be built (see topic O-4). The interconnector - provisionally called 'Icelink' - is currently undergoing studies between the Icelandic and the UK governments. Power prices in the UK are much higher than in Iceland, and average sales prices for Icelandic generation companies could increase substantially.

Alcoa has gradually increased the amperage in the operation of the smelter's potlines, and purchased correspondingly larger volumes of electricity from Landsvirkjun. It has also considered more substantial enlargements, for example by 180,000 tonnes annual capacity, if power and aluminium prices are considered favourable. No formal discussions with Landsvirkjun have yet been held.

Landsvirkjun has significant financial flexibility, should any environmental or social contingency measures be required.

Criteria met: Yes

7.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives relating to financial management have been and are on track to be met with no major non-compliances or non-conformances, and funding commitments have been or are on track to be met.*

One of the KPIs for the management of the power station is to remain within annual budgets, which is currently the case.

For the past three years, Landsvirkjun's auditors Deloitte have confirmed that the financial statements provide a true and fair view of the financial position of Landsvirkjun at year end, in accordance with International Financial Reporting Standards and additional requirements in the Icelandic Financial Statement Act, with no observations.

Debt has been serviced and refinanced without problems, as confirmed by the ratings agencies.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no indications for any non-compliances or non-conformances.

Criteria met: Yes

7.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *The operating hydropower facility or the corporate entity to which it belongs can manage financial issues under a range of scenarios, can service its debt, and can pay for all plans and commitments including social and environmental.*

Margins in Icelandic power projects are typically relatively low. The average price for industrial customers was USD 24/MWh (incl. transmission) in 2016, one of the lowest in the world, and the average wholesale price is USD 38/MWh. With increasing demand and a reduced surplus capacity, however, prices have been increasing and are expected to continue to increase.

According to the ratings agencies, the key factors for Landsvirkjun's investment grade ratings are its dominant position in the Icelandic market; its low-cost generation asset base and modest levels of capital expenditure; its ability to generate relatively stable cash flows through long-term take-or-pay power contract; and implicit support from government.

Landsvirkjun benchmarks itself financially against major Scandinavian power companies such as Statkraft, Vattenfall, Fortum and Dong. Landsvirkjun's cost structure is about average for this group, although maintenance costs are relatively small, reflecting good asset conditions, with a weighted average age of power stations of about 25 years. Landsvirkjun expects to achieve comparable financial ratings to these companies in the next 3-4 years, and to start paying substantial dividends to government, in the order of USD 100 to 200 million per year.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, the operating hydropower facility or the corporate entity to which it belongs can manage financial issues under a range of scenarios, and has optimised or is on track to optimise its market position with respect to supply and demand for electricity, water and ancillary services.*

Future costs and earnings are subject to large uncertainties, but most scenarios show a trend towards improving financial performance. For example, while the reliability of long-term aluminium price forecasts is limited, the World Bank's latest Commodity Markets Outlook (April 2017) predicts gradual price increases until 2030. Water inflows are also predicted to continue to increase.

The market position of the Kárahnjúkar project has been optimised, with increasing revenues in line with increasing water availability and increasing aluminium prices. The market position is subject to a number of constraints, such as the strong negotiating power of an industrial offtaker like Alcoa at the start of a joint project of this kind, and the limited alternatives, partially because of a weak transmission network (see topic O-4). Against a background of increasing power demand and prices, Landsvirkjun is actively following potential market developments and preparing for future opportunities, such as the renegotiations with Alcoa, in about 10 years.

Criteria met: Yes

7.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

7.3 Scoring Summary

It was not the primary objective of Landsvirkjun's owner, the Icelandic government, to maximize the short-term financial return from the investment in Kárahnjúkar, as other objectives such as regional economic development and long-term dividends played an important role. The original profitability projections have been largely met, with some assumptions turning out too positive and others too conservative, and with a strong potential for further improvements during the long remaining lifetime of the project. The financial management at the project level and at the corporate level are of a high standard. There are no significant gaps against proven best practice, resulting in a score of 5.

Topic Score: 5

7.4 Relevant Evidence

Interview:	1, 8, 11, 16, 19, 36, 44, 45, 57, 59
Document:	41, 108-124, 155, 170
Photo:	117-120

8 Project Benefits (O-8)

This topic addresses the benefits that were committed to alongside development of the hydropower facility, in cases where these commitments are well-documented against a pre-project baseline. The intent is that commitments to additional benefits and benefit sharing strategies made during development of the hydropower facility are fulfilled, and that communities affected by the hydropower development have benefitted. In the case of older projects where there is an absence of well-documented commitments to project benefits made at the time of project approval or an absence of data on the pre-project baseline against which to compare post-project, this topic is not relevant; in this case, issues in relation to project benefits should be taken into consideration under topic O-3 Environmental and Social Issues Management.

8.1 Background Information

This topic covers commitments to additional benefits and benefit sharing strategies made during the development of the hydropower facility, that are above and beyond compensation and mitigation for negative impacts (which are addressed under topic O-9). Benefits that have arisen from the project as a result of Landsvirkjun's environmental and social issues management, but that were not committed to at the time of development, are covered under topic O-3.

Based on this, the following financial commitments are associated with the development of the Kárahnjúkar project:

- property tax paid by Landsvirkjun on the power station
- local income tax paid by Landsvirkjun employees to their resident municipality
- national taxes, fees and dividends to the Icelandic government

A number of additional benefits were also committed to in agreement with Fljótsdalshreppur municipality:

- Provision of electricity and a new road and bridge to Laugafell, a highland hostel owned by the municipality.
- Agreement by Landsvirkjun to rent the Végardur community centre for use as a visitor centre during construction, including undertaking renovations to the centre. The rental agreement also included an option to loan money to Fljótsdalshreppur municipality should they wish to undertake additional renovations to the community centre.
- Provision of fibre optic cabling to the Végardur community centre and provision of any fibre optic cable purchased for the project but not used, to the municipality for their use e.g. to provide fibre optic cabling to properties in the municipality
- Investigation into the possibility of using cooling water from the station for heating.
- Provision of electrical cable purchased for the project but not used to the municipality to improve electrical supply to properties in the area. In addition, an agreement was made to discuss removal of any cabling installed for construction of the project with the municipality prior to removal, in case the municipality could use the cabling.
- Provision of summer jobs for high school and university students (up until 2010).

The Eastern Iceland Sustainability Initiative also includes a number of social commitments or objectives that were agreed to by Landsvirkjun and Alcoa, including:

- To build community experience and well-being – Contribute to improved quality of life, and build skills, knowledge, and experience in Iceland, while respecting the significance and diversity of Iceland culture and heritage.

- To deliver long-term economic benefit – Deliver economic benefits to the local communities of East Iceland and the nation of Iceland. Foster economic growth, generate wealth for the communities, provide commercial returns to shareholders, and contribute to long-term economic health.
- To meet the needs of current and future generations – Take a long-term approach to project activities and work in partnership with communities and governments to meet the needs and desires of today without compromising the ability of future generations to satisfy their own needs.

It is noted that in the eyes of many in the East Iceland region, benefits associated with the construction and operation of the Kárahnjúkar project and Alcoa's Fjardaál smelter are inherently linked and cannot be separated, as neither project would exist without the other. This is particular the case for benefits linked to the objectives included in the Sustainability Initiative.

8.2 Detailed Topic Evaluation

8.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Monitoring is being undertaken to assess if commitments to project benefits have been delivered and if management measures are effective; and ongoing or emerging issues relating to delivery of project benefits have been identified.*

Fljótsdalur station currently pays ~ISK 100 million (~USD 940,000) annually in property taxes to Fljótsdalshreppur municipality. Monitoring of this tax payment and other tax paid by Landsvirkjun is not required as the tax system is administered by the Icelandic State.

Commitments to project benefits agreed to with Fljótsdalshreppur municipality have been or are being delivered, including those regarding the community centre, Laugafell, fibre optic and electrical cables, and options for using the cooling water (found to be not feasible). No issues were identified with delivery of these commitment, and a meeting between Landsvirkjun and Fljótsdalshreppur municipality in 2007 confirmed that Landsvirkjun had met most of its commitments regarding benefits for the community with the remaining commitments ongoing, e.g. ongoing provision of electricity to Laugafell as part of Fljótsdalur power station's local distribution network.

Social commitments or objectives under the Sustainability Initiative are being monitored as part of the ongoing project managed by Austurbrú. This project has now been collecting data for ten years against a range of environmental, social and economic indicators relevant to the objectives committed to by Landsvirkjun and Alcoa. Landsvirkjun provides data to the project on its operations each year, e.g. employment and training statistics, and it funds (along with Alcoa) Austurbrú to collected additional data to support the indicators. The database generated by this project is seen as an important source of information on the socio-economic development of East Iceland. The project is now exploring the next stage of the project which is about interpreting and evaluating the data such that it can actively be used for adaptive management. The data demonstrates that the projects have contributed to economic growth in the region through employment of East Icelanders and higher than average salaries. For example, all but one new employees hired by Fljótsdalur station since 2008 were East Iceland residents, with all Fljótsdalur employees residents of East Iceland since 2011. The data also show increases in population, higher house prices, and retail sales figures. The data is further supported by observations from local stakeholders.

Landsvirkjun has provided its summer employment program each year, with participation of young people from Fljótsdalshreppur municipality prioritised over applicants from other municipalities up until 2010. This program provides employment to high school and university students between the ages of 16–20 to undertake a range of maintenance and environmental projects for Landsvirkjun and the local community. While provision of these summer jobs until 2010 was part of the original agreement with Fljótsdalshreppur municipality,

Landsvirkjun continued this program beyond 2010. In 2016, 15 young people participated in the program from both Fljótsdalshreppur and Fljótsdalshérad municipalities.

Independent studies by the University of Akureyri also monitored social impacts and benefits of the combined Kárahnjúkar project and Alcoa Fjardaál smelter project over 2004–2010. This provided an independent assessment of ongoing and emerging issues influencing project affected communities in the early stages of operation of the Kárahnjúkar project. The University of Akureyri is now on the steering committee for the Sustainability Initiative.

No issues have been identified with the provision of ongoing additional benefits such as taxes, the summer employment program, or funding and maintenance of the Sustainability Initiative.

Two emerging issues have been identified as part of the Sustainability Initiative, namely not meeting the target for employment gender balance for 2015 (see also topic O-12), and not meeting the target for increasing numbers of visitors to Fljótsdalur power station and Kárahnjúkar Dam over 2014-2015. These relate to the objectives of building community experience and well-being (gender balance) and delivering long-term economic benefit (support for tourism).

There is an additional issue associated with equity in the distribution of taxes associated with the project. Fljótsdalshreppur municipality receives annual property taxes for Fljótsdalur power station which is located in its municipality, while Fljótsdalshérad municipality receives no property taxes despite having Kárahnjúkar dam and other project infrastructure located in its municipality.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging issues relating to project benefits takes into account both risks and opportunities.*

At this stage, the trends in the data collected as part of the Sustainability Initiative have not been fully evaluated. However the next stage of the project, interpretation of the data, will evaluate risks and opportunities associated with the indicators. For the identified issues, Landsvirkjun has considered risks and opportunities associated with them including:

- Opportunities to encourage more women into the Landsvirkjun workforce to address the gender imbalance in the workforce in East Iceland, including through its summer employment program at Fljótsdalur power station.
- Opportunities to support tourism through a new visitor centre in Egilsstadir. Landsvirkjun is currently in discussion with Fljótsdalshérad municipality regarding a new visitor centre which will house a display on the Kárahnjúkar project as well as the Lagarfljót Wyrm, a local legend associated with Lagarfljót lake.

The annual public meeting for the Sustainability Initiative also provides the opportunity for risks and opportunities relating to benefits to be discussed. At each meeting there is a themed group discussion to assess issues and needs. Over the last five years, these themes have included: vision and development of the project (2017), strengths, weaknesses, threats and opportunities of the project (2016), economic indicators (2015), knowledge development (2014), and short and long-term objectives of the initiative (2013).

The issue regarding equity in the distribution of taxes is due to the national legal/regulatory framework, as discussed under topic O-2. Changes in laws and regulations and their associated risks are monitored and evaluated at the corporate level by Landsvirkjun.

The formal meetings with Fljótsdalshreppur and Fljótsdalshérad municipalities, and local tourism operators also provide a forum for the community to raise opportunities for additional project benefits. For example, artworks associated with the project area and infrastructure have been established, including at the

Kárahnjúkar dam, the power station tailrace channel, and the tunnel vent near Laugafell, to make it more interesting for tourists visiting the area.

Criteria met: Yes

8.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to deliver commitments to project benefits, and to manage any identified issues relating to these commitments; and commitments to project benefits are publicly disclosed.*

Measures are in place to deliver outstanding or ongoing commitments to additional benefits including the provision for required taxes, community funds, the summer employment program, and Sustainability Initiative, including allowances in Landsvirkjun's and Fljótsdalur power station's annual budgets to meet all financial requirements. The property taxes paid to Fljótsdalshreppur municipality (population 81) have been used to, for example: provide fibre optic cabling to all properties in the area as well as three phase power to support development of farms; upgrade of roads and walking tracks in the area; improve highland huts for the farmers; and support running the highland hostel, Laugafell.

The ongoing issue regarding gender balance will be assessed further through the next, interpretative phase of the Sustainability Initiative, and it is also being managed through Landsvirkjun's employment processes (see topic O-12). The ongoing issue associated with support for tourism will also be evaluated further in the next phase of the Sustainability Initiative. In addition, Landsvirkjun has been holding discussions with Fljótsdalshérad municipality since 2012 regarding a new visitor centre in Egilsstadir that will include a display on the Kárahnjúkar project. Landsvirkjun has budgeted ISK 70 – 80 million to support this project but is waiting on confirmation of additional support from the national government. Landsvirkjun also meets annually with tourism operators from the Wilderness Centre and Laugafell at the start of the season to discuss expected operation over summer and any concerns or issues. Landsvirkjun is also part of the local tourism operator group, sending a representative to meetings 4-5 times per year. These meetings allow issues to be discussed with local Landsvirkjun representatives with follow-up usually provided by the Landsvirkjun head office.

All commitments to project benefits have been publicly disclosed via Fljótsdalshreppur municipality and the Sustainability Initiative website (http://en.sjalfbaerni.is/). In addition, Landsvirkjun's community programs are advertised on the company's external website. In addition, all Landsvirkjun's tax payments are publicly disclosed.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to risks and opportunities.*

There are no risks associated with Landsvirkjun's ongoing commitments to Fljótsdalshreppur municipality or the national government. Annual budgeting for the project ensures that all taxes are included in the project's operating costs. The supply of electricity to Laugafell as this is managed as part of the ongoing supply for the power station.

There is an ongoing risk associated with equity in the payment of property taxes and this has been raised by Landsvirkjun with the national government. While this primarily affects Fljótsdalshérad municipality, the municipality also acknowledges that this is a legal issue for the national government, not Landsvirkjun, and have taken it up directly with the Icelandic government. As noted under O-2, changes in laws and regulations and their associated risks are monitored and evaluated at the corporate level by Landsvirkjun.

The next phase of the Sustainability Initiative to review and interpret the data that has been collected over the last ten years will assist in anticipating and responding to risks and opportunities. The intention is that this

review will be undertaken by an independent party to provide an unbiased evaluation, and that it will assist in the identification of additional management measures that can be implemented to address issues.

In addition, through Landsvirkjun's corporate community program (*Many Hands Lighten the Load* - partnerships with local projects to promote the development of tourism and environmental issues), the summer employment program, and Landsvirkjun's and Fljótsdalur power station's community funds, the Kárahnjúkar project has been able to respond to opportunities as they arise to provide additional benefits to the local communities. For example: collection of litter along roads and beaches; weed management and grounds maintenance of cemeteries and churches; funding for local sporting clubs, schools or cultural events; collection of driftwood and assistance in accessing seal hunting area for a local landowner; and skills development.

Criteria met: Yes

8.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage project benefits have been and are on track to be met with no significant non-compliances or non-conformances, and commitments have been or are on track to be met.*

As described above, Fljótsdalur power station has met its commitments regarding project benefits and is able to meet its ongoing commitments regarding taxes, community programs and provision of electricity to Laugafell with no non-compliances or non-conformances. A meeting between Landsvirkjun and Fljótsdalshreppur municipality in 2007 confirmed that Landsvirkjun had met it commitments regarding benefits for the community.

In addition, the combined projects (Kárahnjúkar and Alcoa's Fjardaál smelter) are on track to meet their broad objectives of improving community well-being and delivering long-term economic stability.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances or non-conformances.

Criteria met: Yes

8.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Communities directly affected by the development of the hydropower facility and any other identified beneficiary of the facility have received or are on track to receive benefits.*

Historically the East Iceland economy was centred around the agricultural (grazing) and fishing industries. In recent years, tourism has been increasing in the area, as for all of Iceland. Construction of the Kárahnjúkar project and Alcoa Fjardaál smelter has helped economic development in East Iceland. Through increased employment opportunities for East Icelanders, labour development, engagement of local services and contractors and improvements to roads, economic benefits have been provided to the region. These benefits helped to reduce the impact of the 2008 financial crisis in East Iceland and halt the downward trend in population, with the population of East Iceland now increasing, services improving and unemployment low. These benefits were acknowledged by a range of community stakeholders that were interviewed, including a number who had been sceptics of the projects at the time of development and construction.

More specifically, the Kárahnjúkar project has provided a number of project specific benefits for the local communities either directly or as a result of financial support via property and income taxes, as described above. This has helped improve telecommunications, roads and electricity supply in the immediate area affected by the project. In addition, it has helped improve access and facilities for tourist in the region through upgrades of roads, hiking trails and the Laugafell hostel, provision of interpretative signs at key infrastructure associated with the project, and a guide twice a week over the summer at Kárahnjúkar dam. Through its summer employment program and the *Many Hands Lighten the Load* program, Landsvirkjun also supports youth development and training, as well as small projects for local communities.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, benefits are significant and sustained for communities affected by the project.*

As described above, many of the benefits provided by the project, including those associated with the combined effects with the Alcoa Fjardaál smelter, are significant and will be sustained for communities affected by the projects. Despite this, there are a number of issues associated with providing a sustained benefit for the communities:

- The Kárahnjúkar project has improved access to the highlands and is one of the major attractions in East Iceland, and valued by tourism operators and municipalities in the area. As many visitors are asking about the project, the local community is looking for support from Landsvirkjun to help encourage tourists to come to the area and stay for additional nights. Availability of information on the project, its history and its benefits is seen as being key to this, in particular a visitor centre plus brochure or similar materials.

  There was a visitor centre associated with the project in Végardur community centre, but this was closed due to declining visitor numbers in 2013, and the displays moved into the Fljótsdalur station and shown to visitors of the station. Discussions are being held with Fljótsdalshérad municipality regarding a new visitor centre in Egilsstadir, but it is uncertain when this project will commence as it is waiting on funding from the Icelandic government. Landsvirkjun now provides a guide at Kárahnjúkar dam on Thursdays and Saturdays during summer. Interpretative signs are also provided at key infrastructure in the highlands associated with the project, including Kárahnjúkar dam. A brochure on the Kárahnjúkar project was prepared in 2015. Landsvirkjun also holds regular meetings with tourism operators in the area to discuss its operations and any concerns.

  Although Landsvirkjun supports construction of a new visitor centre in Egilsstadir, there is no clear timeline. Having a guide at the dam for two days over the summer is not seen as being enough by tourism operators who work in the area and are asked questions about the project. While there is a project brochure, it was not observed to be available at the tourist information centre in Egilsstadir or at other tourist locations during the assessment, and there is no information on the project included in the official tourist guide for East Iceland (https://www.east.is/en/travel/east-iceland-official-tourist-guide). This variability in support for tourism is seen as a **significant gap** against proven best practice.

- An issue was also raised regarding equity in the distribution property taxes between municipalities, as the smaller Fljótsdalshreppur municipality (population 81) receives significant property taxes for the location of Fljótsdalur power station within its region, while the larger Fljótsdalshérad municipality (population 3,493) receives none despite having Kárahnjúkar dam in its municipality. As the lack of fairness in the distribution of property taxes influences the sustainability of benefits received by municipalities affected by the project, this is considered a gap against proven best practice. This is part of the same gap identified under topic O-2, and not double-counted here.

Criteria met: No

8.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant against proven best practice

Landsvirkjun's support for tourism in the area is seen as variable.

1 significant gap

8.3 Scoring Summary

The Kárahnjúkar project has provided a number of additional benefits to project affected communities including financial support via taxes, community programs and the Sustainability Initiative. These have provided improvements for community groups, local facilities and infrastructure, and tourism. In addition, the project jointly with the Alcoa Fjardaál smelter, has helped improved the economy in the East Iceland region, including services and employment opportunities. Despite this, there are some issues affecting the significance and permanence of the benefits provided. The first relates to the variability in support for local tourism, in particular the lack of a visitor centre and available information on the project, and the second to the lack of fairness in the distribution of taxes between municipalities impacted by construction of infrastructure for the project (identified as a significant gap under topic O-2). The issue relating to support for local tourism is seen as a significant gap against proven best practice for this topic, resulting in a score of 4.

Topic Score: 4

8.4 Relevant Evidence

Interview:	3, 5, 6, 14, 15, 17, 24, 25, 26, 29, 30, 32, 37, 43, 46, 47, 48, 49, 52, 56, 57, 59, 63
Document:	5, 6, 7, 8,17, 18, 19, 37, 39, 42, 125, 126, 127, 128, 129, 130, 131, 140
Photo:	2, 17, 20, 30, 49, 62, 64, 65, 73, 119, 120, 124, 127, 128, 137, 138,

9 Project Affected Communities and Livelihoods (O-9)

This topic addresses how impacts of development of the hydropower facility on project affected communities have been addressed, in cases where these commitments are well-documented against a pre-project baseline. The intent is that livelihoods and living standards impacted by the project have been improved relative to pre-project conditions for project affected communities with the aim of self-sufficiency in the long-term, and that commitments to project affected communities have been fully fulfilled. In the case of older projects where there is an absence of well-documented commitments to project-affected communities made at the time of project approval or an absence of data on the pre-project baseline against which to compare post-project, this topic is not relevant; in this case, issues in relation to project affected communities should be taken into consideration under topic O-3 Environmental and Social Issues Management.

9.1 Background Information

At the time of development, the Kárahnjúkar project was a controversial project, not only locally but also across Iceland and internationally. While a majority of community members supported the project because of the expected socio-economic benefits it would bring to the region, along with the Alcoa Fjardaál smelter, others were against the project because of its impacts on the highland wilderness area, to provide power for an international company. The project was not seen as sustainable as it would significantly change one of the largest remaining wilderness areas in Iceland, impacting reindeer and pink-footed geese populations, as well as other biota and vegetation communities, and the visual amenity/natural beauty of the region. In addition, the project was predicted to exacerbate dust storms, decrease water quality downstream, increase siltation in the delta and increase greenhouse gas emissions as a result of the smelter.

The controversy over the project divided local communities and families, Iceland and the international community, and caused significant stress within the East Iceland region. While some community members who were against the project at the time of construction can now see the benefits, other members are still opposed to the project and its wilderness impact, such that some division in the community still remains.

This topic assesses commitments to project affected communities made during the development of the hydropower facility, to compensate and mitigate negative impacts. Commitments made during project development that were above and beyond compensation for impacts, are addressed under topic O-8.

Communities directly affected by the Kárahnjúkar project include:

- Fljótsdalshreppur municipality: population 81, area 1,516 km², population density 0.05/km^2, seat of administration Végardur, affected by power station, dams, diversions, transmission lines, tunnelling and roads.
- Fljótsdalshérad municipality: population 3,493, area 8,884 km², population density 0.39/km^2, seat of administration Egilsstadir, affected by dam, tunnelling and roads.

In return for the water rights and permission to develop the Kárahnjúkar project, Landsvirkjun agreed to a number of compensation measures. A number of these were consent conditions for the project while others were negotiated directly between Landsvirkjun and the project affected communities/landowners. These agreements covered compensation for changes in land use in the highlands and lowlands, and compensation for water rights in the Jökulsá á Dal and upper Jökulsá í Fljótsdal. More specifically these commitments included:

Consent conditions

- Establishment of a Land Reclamation Fund to rehabilitate land and reduce erosion in the highlands and lowlands, and compensate landowners for loss of grazing and hay-making land.
- Rehabilitation of areas disturbed by construction of the project to reduce its visual impact.
- Monitoring and bank works for Hálslón reservoir to reduce soil erosion and sand encroachment from Hálslón onto Vatnajökull National Park and highland grazing land.
- Monitoring of reindeer, geese and other birds to evaluate changes in abundance as a result of the project. These species are hunted by locals from East Iceland, as well as Icelanders in general.
- Lowering the bedrock barrier above Lagarfoss power station by 1 m to facilitate flow through Lagarfljót lake and reduce changes to water levels.
- Providing spills during the tourist season to maintain flows in the Jökulsá í Fljótsdal and Kelduár in July and August (during good water years), to ensure tourists to the area can enjoy these water courses and their waterfalls.

Direct agreements with communities/landowners

- Agreed compensation for loss of water and land rights negotiated in direct discussion with landowners, with the support of an independent commission. Compensation included a combination of financial compensation in accordance with Iceland's legal framework, purchase of new land and/or assistance in rehabilitating existing land.
- Construction and maintenance of fencing in the highlands (190 km) to maintain boundaries between grazing districts previously maintained by the rivers.
- Monitoring and stocking of salmon in the Jökulsá á Dal and Lagarfljót to improve fishing in the river for landowners.
- Provision of a local bridge in Fljótsdalshreppur municipality to allow farmers to access new grazing areas on the other side of Jökulsá í Fljótsdal.
- Construction of drainage channels in Fljótsdalshreppur municipality to help drain land impacted by higher water levels.

9.2 Detailed Topic Evaluation

9.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Monitoring is being undertaken to assess if commitments to project affected communities have been delivered and if management measures are effective; and ongoing or emerging issues that affect project affected communities have been identified.*

Landsvirkjun has maintained and monitored all of the commitments outlined above. An assessment by the Environment Agency of Iceland confirmed in 2010 that Landsvirkjun had either fulfilled its consent conditions or fulfilled them as far as possible, including those which compensate for impacts to project-affected communities. The conditions that were fulfilled as far as possible were generally in connection with environmental monitoring of impacts. Landsvirkjun completed a further review in 2017 which included additional studies undertaken since 2010 and also considered whether the management measures in place were effective. The 2017 review supported the outcomes of the 2010 assessment. The Eastern Iceland Sustainability Initiatives also monitors data associated with a number of environmental and social consent conditions.

Independent studies by the University of Akureyri have also monitored social impacts of the combined Kárahnjúkar project and Alcoa Fjardaál smelter project over 2004 – 2010. This provided an independent

assessment of ongoing and emerging issues effecting project affected communities in the early stages of operation of the Kárahnjúkar project.

Direct agreements with project-affected communities are also monitored by Landsvirkjun as well as by the communities. All agreements have been fulfilled, and there is ongoing monitoring associated with the fences in the highlands and salmon in the Jökulsá á Dal.

Ongoing or emerging issues relating to project commitments that affected communities are identified through engagement with the local communities as described under topic O-1. Ongoing issues that have been identified are bank erosion and the lack of compensation for water rights for landowners downstream of the tailrace. Other ongoing or emerging issues relevant for project affected communities, but not related to project commitments (e.g. delta mouth opening, fish in Jökulsá í Fljótsdal) are addressed under topic O-3 or the specific discipline to which they relate, e.g. topics O-15 and O-16.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging issues for project affected communities takes into consideration both risks and opportunities, and interrelationships amongst issues.*

The identification of ongoing or emerging issues takes into account both risks and opportunities, as well as interrelationships between issues. For example, bank erosion on the Jökulsá í Fljótsdal and Lagarfljót is recognised as an ongoing issue for the landowners. In principle, Landsvirkjun could debate who is responsible for the erosion, i.e. whether it is natural (thus an issue for the landowner), caused by increased water flow as a result of Kárahnjúkar project, or caused by operation of Lagarfoss power station. To accept responsibility for mitigation could be costly. Landsvirkjun has decided instead to acknowledge importance of this issue to the community and work with landowners and municipalities to identify and implement measures to address bank erosion.

The commitment to construct and maintain fences to retain grazing boundaries in the highlands shows how various issues (management of project impact, maintenance of local quarantine zones for stock, and provision of project benefits) are interrelated. This commitment provided the opportunity for Landsvirkjun to offer an additional benefit to communities, through employment of local landowners as fencing contractors. This provided an additional source of income for local landowners, with some of them engaged by Landsvirkjun since commencement of the project. Through the Land Reclamation Fund, landowners can also apply for small grants to undertake improvement works on their own land and purchase fertiliser. This allows them to rehabilitate their own land in the lowlands and improve pasture for grazing and hay making.

Criteria met: Yes

9.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to deliver commitments to project affected communities, and to manage any identified issues relating to these commitments; and if there are any formal agreements with project affected communities these are publicly disclosed.*

Measures to deliver outstanding commitments (consent conditions and direct agreements) to project affected communities, and to manage identified issues, include:

- Formation of a Land Reclamation Fund, in collaboration with local residents, to re-vegetate areas and manage erosion in the highlands and lowlands. Landsvirkjun contributes to the fund annually to maintain the ongoing program of works being undertaken in conjunction with the Soil Conservation Service. This fund has and is being used to:

    - Improve land in the highlands and lowlands for grazing and haymaking
    - Rehabilitate areas impacted by construction of the project to improve their visual amenity
    - Provide fertiliser to landowners to improve their pasture
    - Manage erosion and sand encroachment associated with Hálslón reservoir
- Ongoing monitoring of birds and reindeer in the highlands. This monitoring assists in identifying the number and sex of reindeer that can be culled as part of the annual hunt.
- Annual meetings with tourism operators at start of tourism season to discuss expected operation over the season. Notification to tourism operators to warn when spills will occur downstream of Ufsarlón or Kárahnjúkar dams.
- Annual fencing contracts with local contractors/landowner to monitor and maintain the highland fence-lines.
- Ongoing salmon monitoring program in the Jökulsá á Dal, with the contract renewed in 2017 with the Marine and Freshwater Research Institute.

The ongoing issue of bank erosion along the Jökulsá í Fljótsdal/Lagarfljót is managed through funding of an annual works programme which is prioritized in consultation with Fljótsdalshérad municipality (see topic O-16). This program of works is expected to be ongoing for a number of years.

In regards to the issue concerning lack of compensation for landowners downstream of the tailrace who have been impacted by increased water levels and changes in water quality and biota, Landsvirkjun have been involved in discussions with landowners, Lagarfoss power station and the government regarding the compensation framework for water, fishing and land rights. These discussions are ongoing and no resolution has been reached, as this is the first project in Iceland where water has been diverted from one catchment to another on a significant scale, such that this issue has not arisen previously and may require a change in regulations to resolve.

Formal agreements i.e. consent conditions and management measures were publicly displayed at the time of development and construction. These and the EIA can still be found on the internet. Direct agreements with communities are publicly known via the municipalities and/or community groups such as the angling associations. However, direct agreements regarding financial compensation for individual landowners are private.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to risks and opportunities.*

Regular meetings are held with both municipalities to discuss issues associated with operation of the project. These meetings allow issues to be identified, as well as evaluation of risks and opportunities. Informal and/or formal follow-up meetings with community groups and landowners, as per the stakeholder engagement plan for the project, also allow further discussion of issues, risks and opportunities.

Criteria met: Yes

9.2.3 Stakeholder Engagement

Analysis against basic good practice

Scoring statement: *Ongoing processes are in place for project affected communities to raise issues and get feedback.*

Fljótsdalur station's Community and Environment Manager tracks and monitors engagement with project-affected communities and landowners in accordance with the projects stakeholder engagement plan (see topic O-1 for further detail). As the project is located in a small community whose members interact frequently, emerging issues associated with the project quickly come to the attention of Fljótsdalur's Station Manager and

Community and Environment Manager. Ongoing and emerging issues are also identified through formal and/or informal meetings with community groups (e.g. Fljótsdalshreppur and Fljótsdalshérad municipalities, Jökla and Lagarfljót angling clubs) and landowners. When issues are raised, they are noted in the stakeholder engagement plan Excel workbook and the Community and Environment Manager follows them up directly, allowing discussion and feedback at the time of the meeting as well as through a follow up memo documenting the outcomes of the meeting. Depending on the outcomes of the discussion, the issue and the agreed solution is included in Fljótsdalur station DMM management system, to ensure that agreed solutions are tracked and implemented.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, feedback on how issues raised are taken into consideration is thorough and timely, and project affected communities have been involved in decision-making around relevant issues and options.*

Feedback on how issues raised are taken into consideration is usually thorough and timely, with project affected communities involved in the decision making (see topic O-1). However, concerns were raised by a number of landowners regarding how issues associated with increased bank erosion along the Jökulsá í Fljótsdal and Lagarfljót downstream of the tailrace are being managed. When issues are raised, the initial feedback is thorough and timely (direct discussion between the Community and Environment Manager and the impacted landowner), but mitigation of the issue is seen as being slow. In many cases, some initial work to mitigate the bank erosion is undertaken, but further work is required and feedback on when it may occur is limited. Where work has been undertaken, the landowners are satisfied with the outcomes of the mitigation measures.

Nine landowners, residents or municipal managers have raised concerns about bank erosion along the Jökulsá í Fljótsdal/Lagarfljót, and one landowner on the Jökulsá á Dal. As a result, a considerable mitigation program is required to mitigate this issue. While operation of Fljótsdalur station is not necessarily the only cause of the issue, Landsvirkjun has committed to provide funds each year to manage this issue (~ISK 15 million provided in 2016 and 2017). This works program has been ongoing since 2011, with priority works identified by a specialist within Landsvirkjun each year and discussed and agreed upon at the annual meeting with Fljótsdalshérad municipality. While the municipality is involved in the decision making regarding what works will be undertaken each year, the individual landowners are not. As a result, they are not fully informed on how their individual bank erosion issues are being managed within the broader bank erosion works program. Thus, feedback to individual landowners regarding mitigation of their issue, and how it fits in within the broader program of works being undertaken by Landsvirkjun, is not thorough or timely, which is seen as a **significant gap** against proven best practice.

Criteria met: No

9.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage delivery of commitments to project affected communities have been and are on track to be met with no significant non-compliances or non-conformances, and commitments have been or are on track to be met.*

Processes and objectives are in place to manage delivery of outstanding commitments to project affected communities (as described above) with no significant non-compliances or non-conformances. An assessment by the Environment Agency of Iceland in 2010, the review by Landsvirkjun in 2017, minutes from an annual meeting with Fljótsdalshreppur municipality in 2007 and discussions with Fljótsdalshreppur municipality and Jökla angling clubs, all confirm that commitments to communities have been or are on track to be met.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances or non-conformances.

Criteria met: Yes

9.2.5 Outcomes

Analysis against basic good practice

Scoring statement: *Livelihoods and living standards impacted by the project have been or are on track to be improved; and economic displacement has been fairly compensated, preferably through provision of comparable goods, property or services.*

Interviews with project affected communities indicate that while the communities and landowners have been affected by the Kárahnjúkar project, it has not negatively impacted their livelihoods or living standards. In addition, through the combined influence of the Kárahnjúkar project and Alcoa Fjardaál smelter on the economy of East Iceland, and improvements in telecommunications, roads, electrical supply and local services, the livelihoods of project affected communities have improved (see topic O-8).

Where economic displacement has occurred as a result of the project (e.g. impacts to grazing or hunting grounds, loss of land), this has been fairly compensated for. For example, individual agreements were reached in consultation with landowners in Fljótsdalshreppur municipality to compensate for loss of grazing land. Depending on the landowner this included: financial compensation, purchase of new cultivation land and/or improvements to existing land to improve its cultivation value. In addition, construction of a new bridge by Landsvirkjun in the Fljótsdalshreppur municipality in 2003 provided access to new grazing land across the river (locally referred to as 'newfoundland').

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, the measures put in place to improve livelihoods and living standards are on track to become self sustaining in the long-term.*

As described above and in topic O-8, many of the measures put in place to improve livelihoods and living standards are on track to become self sustaining in the long-term. However, the issue regarding lack of compensation for landowners downstream of the tailrace who have been impacted by increased water levels and changes in water quality and biota, remains outstanding. This provides an underlying source of frustration for owners of water, fishing and land rights downstream of the tailrace. Most landowners and community groups, but not all, acknowledge that the compensation framework for projects is a national legal issue and that the Kárahnjúkar project is the first project in Iceland that has diverted water from one river into another and such a significant scale, thus this issue has not previously been encountered. Landsvirkjun is reluctant to provide compensation outside the current legal framework, in order to avoid creating a precedent for future projects. The lack of resolve regarding this issue is see as a gap against proven best practice. As this is essentially part of the same gap identified under topic O-2, it is not double-counted here.

Criteria met: No

9.2.6 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

Feedback to individual landowners regarding bank erosion mitigation, and how it fits in within the broader program of works being undertaken by Landsvirkjun, is not thorough or timely.

1 significant gap

9.3 Scoring Summary

The Kárahnjúkar project has been controversial and caused divisions from the onset. At the time of development, a number of commitments were made to project affected communities to mitigate and manage impacts caused by the project, and to ensure that livelihoods and living standards are ultimately improved. An assessment by the Environment Agency in 2010 plus a further review by Landsvirkjun in 2017 indicates that many of these commitments have been met and for those that are outstanding, management measures are in place to ensure they can be delivered. Interviews with project affected communities indicated that while communities and landowners have been affected by the project, it has not negatively impacted their livelihoods or living standards. Through the combined influence of the Kárahnjúkar project and Alcoa Fjardaál smelter on the economy of East Iceland, and improvements in telecommunications, roads, electrical supply and local services, the livelihoods of project affected communities has improved. Despite this, a number of ongoing or emerging issues have been identified during operation of the project, the most significant being stakeholder engagement on downstream bank erosion, and lack of compensation for water, fishing and land rights that have been affected downstream of the tailrace. The issue associated with bank erosion is seen a significant gap against proven best practice for this topic, resulting in a score of 4.

Topic Score: 4

9.4 Relevant Evidence

Interview:	3, 5, 6, 14, 15, 17, 24, 25, 26, 29, 30, 32, 37, 43, 46, 47, 48, 49, 52, 56, 57, 62
Document:	1, 2, 3, 5, 6, 7, 8, 42, 129, 131, 132, 133, 134, 135, 137, 212
Photo:	48, 65, 66, 121, 122, 129, 125, 126, 131, 136, 135, 139

10 Resettlement (O-10)

This topic addresses how the physical displacement arising from development of the hydropower facility has been addressed, in cases where resettlement occurred and commitments are well- documented against a pre-project baseline. The intent is that the dignity and human rights of those physically displaced have been respected; that these matters have been dealt with in a fair and equitable manner; that livelihoods and standards of living for resettlees and host communities have been improved; and that commitments made to resettlees and host communities have been fully fulfilled.

This topic is Not Relevant in the case of the Kárahnjúkar project, because the population density in the project area is very low and the project did not cause any physical displacement of people.

11 Indigenous Peoples (O-11)

This topic addresses the rights, risks and opportunities of indigenous peoples with respect to the hydropower facility, recognising that as social groups with identities distinct from dominant groups in national societies, they are often the most marginalized and vulnerable segments of the population. The intent is that the operating facility respects the dignity, human rights, aspirations, culture, lands, knowledge, practices and natural resource-based livelihoods of indigenous peoples in an ongoing manner throughout the project life.

This topic is Not Relevant in the case of the Kárahnjúkar project, because the native Icelandic population is considered homogenous, with no ethnic minorities.

12 Labour and Working Conditions (O-12)

This topic addresses labour and working conditions, including employee and contractor opportunity, equity, diversity, health and safety. The intent is that workers are treated fairly and protected.

12.1 Background Information

Iceland's labour market is characterized by a high participation rate and high demand for labour, with an unemployment rate of less than 2%, and growing wages. There is a strong general awareness of labour rights and a high proportion of trade union membership, at around 85%. All local staff at Landsvirkjun's Kárahnjúkar unit are members of a union, according to occupational groups. These unions in turn are affiliated with the Icelandic Confederation of Labour (ASÍ).

Landsvirkjun places a high emphasis on good labour and working conditions, including ambitious targets for occupational health and safety (OH&S) and for gender equality, to remain an attractive and competitive employer. The company had 287 employees at the end of 2016, not including subsidiaries such as Landsnet which has about 100 employees.

The Kárahnjúkar unit has 13 employees, including a station manager, three project managers for maintenance, community and environment, and dam and waterways safety (added in 2012), and nine operators, most of whom have a background as electricians or marine engineers, from the fishing industry. Cleaning and canteen operations are outsourced. A number of high school and university students work at the power station each summer. The station manager reports to the head of the hydropower operations unit of Landsvirkjun's Energy Division. Support to the Kárahnjúkar unit is provided by a range of different staff at the corporate head office, and by contractors for maintenance projects.

12.2 Detailed Topic Evaluation

12.2.1 Assessment

Analysis against basic good practice

Scoring statement: *A periodically updated assessment has been undertaken of human resource and labour management requirements for the operating facility, including occupational health and safety (OH&S) issues, risks, and management measures, with no significant gaps; monitoring is being undertaken to assess if management measures are effective; and ongoing or emerging labour management issues have been identified.*

Landsvirkjun regularly evaluates its internal human resources situation through various mechanisms. For example, mechanisms at the corporate level include

- health and safety statistics (internal quarterly and annual reports, with one lost-time accident each year in 2014, 2015 and 2016)
- workplace satisfaction surveys (external by Gallup, 4.29 out of five possible points in 2014, 4.36 in 2015, 4.44 in 2016)
- gender equality reviews (external by PwC, 0.1% gender gap in fixed, non-shift pay in 2015).

Summaries of the results of these surveys are publicly available.

At the level of the work unit, regular weekly and monthly meetings are held at the Fljótsdalur station. At the individual employee level, mandatory regular performance reviews (normally three times a year) serve to identify any opportunities for improvement, and allow discussion of confidential issues.

A range of other labour-related issues are also being monitored. For example, the quality of drinking water used by staff at the main power station, as well as at the operational buildings at the reservoirs in the highlands, is regularly checked.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging labour management issues takes broad considerations into account, and both risks and opportunities.*

The monitoring mechanisms cover a broad range of labour issues. They are structured to identify specific risks and opportunities for each work unit. The work satisfaction surveys, for example, consist of some 50 questions, and have a different focus each year (for example, stress in 2016 and internal communication in 2017). Monitoring is repeated regularly, and trends are analysed.

The 2016 survey at Kárahnjúkar had a 100% response rate and had the most favourable results of any work unit in Landsvirkjun, with an overall satisfaction score of 4.51 on a scale of 1 to 5. Many questions have remained the same since 2008, and thus responses can be tracked over time, and trends identified. Results are presented to each unit and to management, to discuss options for improvements.

Criteria met: Yes

12.2.2 Management

Analysis against basic good practice

Scoring statement: *Human resource and labour management policies, plans and processes are in place to address all labour management planning components, including those of contractors, subcontractors, and intermediaries, with no significant gaps.*

Landsvirkjun has a range of relevant human resource and labour management policies, plans and processes. At the highest level are a number of policies such as the Code of Conduct, Human Resources Policy (STE-024), HSE policy (STE-002), and Gender Equality Policy (STE-006), and commitments to initiatives such as the Global Compact. A number of dedicated staff, mostly in the Human Resources unit in the Corporate Office, as well as internal directives and action plans serve to implement these policies and commitments.

For example, on work safety, the relevant policies, plans and processes include

- the overarching HSE policy
- an occupational health and safety management system certified to OHSAS 18001, an electrical safety management system (RÖSK) reviewed annually by a certified inspector, and an emergency management system
- safety directives, procedures, checklists, and other implementation documents; equipment and signage; training and emergency simulations (some of which jointly with external stakeholders, for example two trainings per year with the Fire Department)
- at the corporate level, a Safety Committee, an Emergency Committee (see topic O-6) and a safety manager (since 2014), who is responsible for an annual safety action plan, reporting, training, quarterly information updates to all staff etc.
- a coordination group of safety managers for all Icelandic power companies
- codes of conduct and requirements for contractors, which emphasize work safety
- a representative of the operators in each power station, elected for two years with responsibility for work safety, who receives training from Administration of Occupational Safety and Health, and works with the maintenance manager; safety audits every two years by this representative together with his counterpart from a different power station

- frequent talks about safety issues at staff meetings
- safety risk assessments which are conducted for all Landsvirkjun jobs and projects, and HSE plans which are prepared for all major contracts
- the DMM system, into which routine safety observations are entered for immediate follow-up
- the C55 system, which takes safety benefits into account in the prioritization of maintenance projects
- external inspections by the Administration for Administration for Occupational Health & Safety, the regional Fire Department and the regional Environmental and Public Health Office; occasionally the authorities are also invited as observers, for example recently for maintenance works at Kárahnjúkar dam, even if not required by regulations
- external OHSAS audits

Safety performance reports at the power stations are generated from DMM, while there is a separate system for the head office. Until 2015 an annual summary report was published, but now this information is integrated into Landsvirkjun's annual report. On average, 3% of work days are lost to sickness and accidents, which is low by Icelandic standards.

One of the high-profile corporate objectives in recent years has been gender equality. Partly required by Icelandic law, partly as a result of a commitment to UN Women, Landsvirkjun has its own gender equality policy, a committee led by the CEO, and a two-year action plan with 7 individual targets and 13 progress indicators. Gender equality will be the focus of the 2017 General Meeting. In 2013, 2014 and 2015, Landsvirkjun achieved PWC's Gold Standard for Wage Equality. There is, however, still a scarcity of women applying for technical jobs. All Landsvirkjun power station staff at the end of 2016 were male; the only female employees at Kárahnjúkar are with one of the contractors. The company is making efforts to encourage young women, and studies have been commissioned to identify options, also including adapting workplace conditions in the power stations.

Operators in Fljótsdalur station work on a shift system. On some shifts, they are at home but on call; during weekend shifts at the station, their families can join them. The service building contains a canteen, accommodation and a variety of recreational options. In the summers, staff are joined by student employees, who work under the coordination of the Community and Environment Manager. Summer jobs for students are seen more as a community commitment, than a recruitment instrument.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

The various mechanisms described above under Assessment and Management allow Landsvirkjun to anticipate and respond to risks and opportunities.

Employees also undergo annual medical checks, both physical and mental, and have access to an independent service provider for psycho-social assistance.

It is recognized in the Icelandic power industry in general, and at Landsvirkjun in particular, that many labour issues such as accidents occur with contractors. In 2016, Landsvirkjun's board adopted the principle of responsibility for its supply chain; among other objectives this shall ensure that everybody working indirectly for Landsvirkjun (through contractors, sub-contractors or temporary work agencies) enjoys rights and employment terms in accordance with law and collective bargaining contracts. Landsvirkjun is in the process of mapping social and environmental information on its suppliers, and has issued requirements for them to follow the Global Compact labour principles, occupational health and safety requirements, as well as other requirements not related to human resources (environmental protection, business integrity, avoidance of conflicts of interest).

Criteria met: Yes

12.2.3 Stakeholder Engagement

Analysis against basic good practice

Scoring statement: *Ongoing processes are in place for employees and contractors to raise human resources and labour management issues and get feedback.*

Despite the physical distance to the head office, employees at the power station generally feel well informed (for example, through a Facebook Workplace group and the intranet) and involved into company-wide discussions. There are various processes available to raise any issues:

- Individual meetings with managers, during performance reviews or separately
- Staff meetings, some of which are purposely held outside the workplace; staff also socialize with each other, and have gone on trips together
- Annual workplace audits and workshops with each work unit, facilitated by the Human Resources unit
- Frequent video-conferences with the head office, for example six-weekly with the CEO, and visits to and from other power stations
- Trade union representatives; the trade unions work both at the corporate level, for example for regular negotiations over pay and benefits (approximately every 3 to 4 years, directly between Landsvirkjun and four unions), and with two shop stewards at the power station, who will discuss issues like shift schedules with management
- Internal complaints raised with the Human Resources unit or with the psycho-social assistance provider
- Work satisfaction surveys

Issues raised are handled confidentially as appropriate. There are no examples of serious staff complaints at Kárahnjúkar. The most discussed issue recently is that operators would prefer to each have a personal toolbox. Turnover is low, and most staff have been at the station from the beginning of operations. The high work satisfaction scores of the Kárahnjúkar unit are explained by a positive interaction between operators and managers, who have been open to discussion and have followed up on details.

There are also no conflicts at this time, between Landsvirkjun and its employees and trade unions at the corporate level. Landsvirkjun's employees see themselves as well-treated and well-paid, although there is a perception that salary increases over the past years may have been slower than in the economy in general. The Human Resources division commissions a comparative salary study approximately every two years, to ensure that salary levels remain attractive. Non-unionized staff are offered a separate salary negotiation process.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, feedback on how issues raised have been taken into consideration has been thorough and timely.*

Employees generally confirmed that feedback has been thorough and timely. An example of a recent compromise was that pay for on-call duty on weekends was raised from 1/3 to 1/2 of base pay.

Criteria met: Yes

12.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives relating to human resource and labour management have been and are on track to be met with no major non-compliances or non-conformances, and any labour related commitments have been or are on track to be met.*

The last external inspections by the regional authorities (OH&S, fire, public health) have resulted in only minor observations that have been rectified by Landsvirkjun. There are no outstanding issues. The authorities consider the project to be high-performing, and are generally conducting their inspections with the lowest possible frequency. For example, the Administration for Occupational Health and Safety conducted its last full inspection in 2010, and has done only partial inspections, on critical equipment such as cranes, annually. In cases, the authorities are also sharing information between them. Landsvirkjun also submits to some additional inspections voluntarily, even if not required by regulations. For example, the Environmental and Public Health Office was asked to check drinking water quality at the project facilities, in line with its monitoring protocols for public water supply.

The OHSAS external audits have not revealed any non-compliances at Kárahnjúkar.

Accidents at the power station in recent years have included a fall by a contractor (with 2-3 days lost), a contractor hit by rockfall during spillway repairs, a broken finger, and several road accidents, sometimes due to collisions with geese or sheep. There were no lost-time incidents with Landsvirkjun staff, and Kárahnjúkar is generally considered within Landsvirkjun to have an excellent safety record.

No complaints from Kárahnjúkar regarding violations of the Code of Conduct and other human resources policies have been registered with the Human Resources unit.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

In 2016, Landsvirkjun achieved ten out of twelve objectives under Social Responsibility. The two objectives that were not achieved are related to human resource issues, namely

- Proportion of female managers: The target of increasing the number of female managers to more than 30% was not achieved (the value was 29.4%)
- Accidents: There was one accident related absence this year

Similarly, in 2015, the zero lost-time accident target was missed.

Gender equality is also an objective under the Eastern Iceland Sustainability Initiative, where the 2015 target for Landsvirkjun was to have 40% female participation in the overall workforce. In fact, at the end of 2016 the participation had only reached 28.8%.

These missed targets are not considered non-conformances, because they do not relate to the Kárahnjúkar project, but to the corporate level. Landsvirkjun is making extensive efforts to meet the targets.

Criteria met: Yes

12.2.5 Outcomes

Analysis against basic good practice

Scoring statement: *There are no identified inconsistencies of labour management policies, plans and practices with internationally recognised labour rights.*

Iceland has ratified all eight fundamental conventions of the International Labour Organization (ILO). These labour rights are embedded in laws, regulations, collective bargaining agreements, and individual employment contracts, and there are no indications of any inconsistencies in the Kárahnjúkar project. As for essential and emergency services in other countries, the right to strike is restricted for power station operators.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, labour management policies, plans and practices are demonstrated to be consistent with internationally recognised labour rights.*

There is no separate analysis of consistency. While this a gap, it is not significant given the high standards of labour rights in Iceland, which extend to guest workers, and the fact that the Global Compact principles, which Landsvirkjun has committed to and is reporting against, reflect the ILO fundamental conventions.

The project offers stable and well-paid employment, especially when compared with the traditional large economic sector in East Iceland, the fishing industry. Landsvirkjun in general and/or the Kárahnjúkar project in particular achieve high marks on labour satisfaction, work safety, and gender equality; have received a number of external awards and recognitions; and have contributed to improved practices in the region (see also topic O-14).

Criteria met: Yes

12.2.6 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

12.3 Scoring Summary

Landsvirkjun constantly evaluates various human resource and labour management issues, such as work safety, employee satisfaction, gender equality, and salary levels. Human resource policies and objectives are ambitious and are implemented through a variety of management measures, many of which also extend to suppliers and contractors. Employees are well-informed and engaged, and have multiple ways to raise issues. Landsvirkjun achieves high scores for workplace satisfaction, compared to other large companies in Iceland, and the Kárahnjúkar unit achieves particularly high scores. There are no gaps against proven best practices, resulting in a score of 5.

Topic Score: 5

12.4 Relevant Evidence

Interview:	13, 18, 19, 22, 27, 28, 33, 34, 50, 51, 53, 58
Document:	37-41, 43, 47, 49, 92, 94, 138-159
Photo:	51-55, 59, 68, 70, 71, 76, 78, 80-83, 86, 88, 91-92, 94, 99-110, 112, 115

13 Cultural Heritage (O-13)

This topic addresses cultural heritage, with specific reference to physical cultural resources, associated with the hydropower facility. The intent is that physical cultural resources are identified, their importance is understood, and measures are in place to address those identified to be of high importance.

13.1 Background Information

Iceland was settled by the Vikings in approximately 870 AD, and there are approximately 200,000 physical cultural heritage sites associated with early settlement. Mapping of these sites commenced in 1994 and to date approximately 34,000 have been mapped. All artefacts and sites over 100 years old are automatically protected under the Cultural Heritage Act no. 80/2012, with listing of more significant sites by the Minister. At present, there are 750 sites listed, with very few listed since 1994. The Cultural Heritage Agency (*Minjastofnun Íslands*) is responsible for protecting physical cultural resources.

Archaeological surveys undertaken as part of the EIA for the Kárahnjúkar project identified approximately 4,000 sites associated with the project area, including sites located within 100 m of the downstream rivers. Prior to this survey, no archaeological survey had been undertaken in the area, nor has there been one since. All of the approximately 80 different types of cultural heritage sites identified in Iceland were found associated with the project, due to the range of landscape types within the project area. Most of the sites identified were rambling huts but also included cairns for marking travel routes, river fords and ferry crossings; with most dating from the late 19th century. The most important find was Pálsrúst (composed of three houses) which was excavated before inundation of Hálslón Reservoir. Dating for this site indicated that the structures could be traced back to at least 1262, with some parts dating back to 1158. This site could be the famous 'Reykjasel' referred to in Hrafnkels saga of Freysgodir.

13.2 Detailed Topic Evaluation

13.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging cultural heritage issues with respect to physical cultural resources have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

An extensive archaeological survey was undertaken as part of the EIA for the project, which included surveys of all areas associated with construction and operation of the projects, including associated roads and rivers. None of the 4,000 sites recorded had been or were listed by the Minister. A total of 300 sites were located within 100 m of a river impacted by the project, or Hálslón reservoir; with 150 within 20 m. Of these sites, 25 where considered to be more at risk from the project, either due to inundation by Hálslón or as a result of bank erosion. Other potential risks to physical cultural resources assessed as part of the EIA included potential impacts from rising groundwater table, and construction of roads and other project infrastructure.

Seven of the 25 sites were excavated as part of the EIA as they would be inundated by the project. All sites excavated as part of the EIA studies, including Pálsrúst, were completely removed, with finds from the sites handed to the National Museum. The most important find was two silver coins from the Viking age.

The remaining 18 sites were identified as being at risk from bank erosion along downstream rivers based on their distance and height from the river. Although monitoring of these sites was recommended by the EIA

archaeologist, no monitoring or other management measures have been required by the Cultural Heritage Agency. While no formal monitoring is required, visual observations of these sites are being undertaken by Fljótsdalur's Community and Environment Manager. In addition, a comprehensive survey of the conditions of banks of Lagarfljót was undertaken by Landsvirkjun in 2012 (see topic O-16). One site near Hóll has been identified as being at higher risk of bank erosion than the others.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging cultural heritage issues takes broad considerations into account, and both risks and opportunities.*

The Community and Environment Manager proactively approached the Cultural Heritage Agency in 2015 to discuss monitoring requirements for the riverbank sites identified in the EIA, in recognition of the potential risk to sites associated with bank erosion. In the absence of any formal requirements, the Community and Environment Manager has continued periodic visual observations of the 18 sites.

Criteria met: Yes

13.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified cultural heritage issues.*

No formal management or monitoring measures, beyond those completed during development and construction of the project, are required by the Cultural Heritage Agency for known sites associated with the project. However, the Community and Environment Manager does undertake visual surveys of sites that may be impacted by the project due to bank erosion, to assess whether any site is at imminent risk. Landsvirkjun is in discussion with the owner of the site near Hóll, regarding risks to the site. In addition, in collaboration with landowners and Fljótsdalshérad municipality, Landsvirkjun has implemented a bank stabilisation program to manage bank erosion in Lagarfljót, with management sites prioritised annually.

Landsvirkjun is also in discussion with staff of the East Iceland office of the Cultural Heritage Agency regarding ongoing monitoring. These discussions commenced in 2015, however due to changes in staff in the East Iceland office of the agency, no final determination has been made on monitoring or management requirements, although it is felt that some monitoring should be occurring.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

In addition to undertaken the visual surveys, the Community and Environment Manager is seeking guidance from the Cultural Heritage Agency on monitoring or management requirements for the known sites along the riverbanks, to ensure that any risks to them can be identified and managed early.

Criteria met: Yes

13.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage cultural heritage issues have been and are on track to be met with no significant non-compliances or non-conformances, and cultural heritage related commitments have been or are on track to be met.*

One consent condition relating to cultural heritage was included in the project licence. This condition required regular monitoring of archaeological remains at risk from the project with any site at risk of disturbance from construction to be reported to the Cultural Heritage Agency. The Environment Agency in 2010 considered this condition to have been fulfilled through the excavation of the seven sites to be inundated by the project, with no ongoing monitoring required.

There are no formal management requirements for culture heritage sites associated with operation of the project, nor are there any cultural heritage related commitments.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances or non-conformances.

Criteria met: Yes

13.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Negative cultural heritage impacts arising from activities of the operating hydropower facility are avoided, minimised, mitigated and compensated with no significant gaps.*

There are no negative cultural heritage impacts arising from operation of the Kárahnjúkar project. Sites at potential risk from bank erosion are being monitored and Landsvirkjun is in discussion with the Cultural Heritage Agency regarding ongoing monitoring requirements for these sites.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, where opportunities have been identified, measures to address cultural heritage issues beyond those impacts caused by the facility have been or are on track to be achieved.*

Landsvirkjun is currently undertaking a three-year project to map known cultural heritage sites associated with its operations. The project has commenced with the Thjórsá and Tungnaá catchment area in southern Iceland where six hydropower projects are located, and will include the 4,000 sites recorded as part of the Kárahnjúkar project. Data from Landsvirkjun's mapping project will be provided to the Cultural Heritage Agency to inform broader mapping of cultural heritage sites across Iceland which the agency is currently compiling. This will allow public visibility of known sites and assist with management of cultural heritage sites in Iceland. Landsvirkjun has been in discussion with the agency regarding format and metadata requirements, to ensure that its mapping project is compatible with the agency's program.

Criteria met: Yes

13.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

13.3 Scoring Summary

Approximately 4,000 cultural heritage sites were recorded during the Kárahnjúkar EIA, with 18 sites identified as being potentially at risk from bank erosion during operation of the project. While there are no formal requirements to monitor these sites, Landsvirkjun has been undertaking visual observation and has evaluated the stability of banks downstream of the power station. Where one site has been identified as being more at risk (old farm building near Hóll), Landsvirkjun is in discussion with the landowners regarding management of the site. Landsvirkjun has also implemented a bank stability program to manage bank erosion along Lagarfljót. Thus, operation of the Kárahnjúkar project has had no negative impacts on cultural heritage sites, and Landsvirkjun's mapping of sites recorded during the EIA will contribute to a broader, public understanding of cultural heritage in Iceland.

There are no significant gaps at the level of proven best practice, resulting in a score of 5.

Topic Score: 5

13.4 Relevant Evidence

Interview:	17, 54, 64, 65
Document:	160, 161, 162, 163, 164, 165, 212, 260
Photo:	136

14 Public Health (O-14)

This topic addresses public health issues associated with the operating hydropower facility. The intent is that the operating facility has not created or exacerbated any public health issues; that ongoing or emerging public health issues associated with the facility are identified and addressed as required; and commitments to implement measures to address public health are fulfilled.

14.1 Background Information

The health care system in Iceland is a state-centred, publicly funded system with universal coverage for all people who have had legal residence in Iceland for more than six months. Spending on health by the Icelandic government amounted to 7.5% of GDP in 2015, and high life expectancy and low infant mortality rates testify to the advanced state of health care in Iceland. Health care services are provided mainly free of charge, although user charges are on the rise. The system is organised into seven health care regions, each of which has at least one main regional hospital and provides primary, specialist and aged care. Primary health care is provided by health clinics, and regional hospitals provide general medical care with outpatient as well as inpatient departments 24 hours a day. The availability of specialist care varies and patients may need to travel to other regional hospitals or Reykjavik to get care.

The East Iceland region has the same service set-up as other regions in Iceland and health care issues are similar to those Iceland-wide. Risk factors in Iceland are typical of other European countries with rising obesity seen as one of the main risk factors to the population. There are no particular public health issues in the region, although psychological health issues (e.g. anxiety) amongst school children is increasing, following a national trend. No public health issues have been linked to the development or operation of the Kárahnjúkar project.

There are concerns in Iceland regarding the impact of volcanic dust on human health. Volcanic dust can be easily suspended and have highly negative effects on human health. There are about 135 dust events per annum in Iceland, ranging from minor storms to >300,000 tonnes of dust emitted in single storms. Dust production is on the order of 30–40 million tonnes annually, some traveling over 1,000 km (see also topic O-16).

The closest health facilities to Fljótsdalur power station are in the town of Egilsstadir (30 minutes drive), which has a health clinic with some specialist services, four doctors, two nurses and two midwives, with four beds for minor medical problems and post-surgery recovery. The regional hospital is located in Neskaupstadur (1.5 hours drive; 23 beds) which has historically been the largest fishing port and town in East Iceland. The health clinic and hospital are further supported by visiting specialists. More major or complex issues are dealt with in the main hospitals in Akureyri (three hours drive) or Reykjavik. Patient transfer services are provided for through ambulances at the health institutions, and there is an airport in Egilsstadir for emergency situations.

Health services in Iceland were subject to cuts following the economic crisis in 2008, however due to construction of Kárahnjúkar project and Alcoa Fjardaál smelter, service levels were expanded during construction and then maintained in Egilsstadir with two of the nurses from the construction period staying on in town. As for other rural centres in Iceland, retention of doctors in the regions is difficult to the point that substitute doctors are starting to be used on a shift basis in Egilsstadir to maintain capacity.

14.2 Detailed Topic Evaluation

14.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging public health issues associated with the operating hydropower facility have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

There are no ongoing or emerging public health issues associated with the operation of the Kárahnjúkar project. The water in the lakes and rivers is reported to be of good quality. The rivers impacted by the project are not used for domestic water supply, which is sourced from springs and boreholes, and locals do not swim in Lagarfljót lake. Regular monitoring of the domestic water supply is undertaken by the East Iceland Office for Public Health and Environment. The domestic water quality is reported to be excellent with no negative impacts caused by the project.

It was noted that the controversy over the Kárahnjúkar project put stress on people within the community due to divisions over support for the project, both within the community and families. However, no increase in public health needs were identified in regards to mental health or depression.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging public health issues takes into account public health system capacities, access to health services, and health needs, risks and opportunities for different community groups.*

A regional health review was undertaken in 2011 by the Directorate of Health (*Embætti landlæknis*) for East Iceland, and statistics are compiled annually regarding public health issues/causes and resources across the seven health care regions.

As there are no ongoing or emerging public health issues associated with operation of the project, this criterion is not relevant.

Criteria met: Yes

14.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified public health issues.*

No issues have been identified thus no management measures specific to public health are required. The public health system is in place to respond to any issues identified by the Directorate of Health.

The project's management of environmental incidents would address any risks arising from pollution of river flows (see topic O-3). In addition, dust management associated with Hálslón reservoir is being undertaken by the Soil Conservation Service on behalf of Landsvirkjun (see topic O-16).

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

The public health system, Landsvirkjun's environmental management system, and the land reclamation program are in place to respond to emerging risks and opportunities for public health.

Criteria met: Yes

14.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage public health issues have been and are on track to be met with no significant non-compliances or non-conformances, and public health related commitments have been or are on track to be met.*

No specific commitments or processes are required and there are no non-compliances or non-conformances with regulatory requirements.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

There are no non-compliances or non-conformances.

Criteria met: Yes

14.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Negative public health impacts arising from activities of the operating hydropower facility are avoided, minimised and mitigated with no significant gaps.*

No particular health related issues have arisen with respect to Kárahnjúkar's operations.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, where opportunities have been identified, measures to address public health issues beyond those impacts caused by the operating hydropower facility have been or are on track to be achieved.*

The Icelandic 'Health Plan until 2010' included the prevention of workplace accidents as one of its priority projects. Through Landsvirkjun's (and Alcoa's) safety requirements and training of local contractors as part of operation of the projects, the East Iceland community has improved awareness of workplace safety and planning, which has benefited the public health system.

The project has also benefited the public health system through improvements to roads in the region, providing better access for locals to facilities as well as for emergency services.

Criteria met: Yes

14.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

14.3 Scoring Summary

Iceland has a comprehensive public health system and the water quality within rivers is generally high. The project's overall management of environmental hazards and its land reclamation program avoids impacts to public health, and the project has made a positive contribution to public health through increasing community awareness of workplace safety and planning, and improved road infrastructure to provide better access to facilities and emergency services.

There are no significant gaps at the level of proven best practice, resulting in a score of 5.

Topic Score: 5

14.4 Relevant Evidence

Interview:	13, 32, 43
Document:	148, 149, 150, 151, 166, 167, 168, 169, 170, 171, 261, 262, 263
Photo:	-

15 Biodiversity and Invasive Species (O-15)

This topic addresses ecosystem values, habitat and specific issues such as threatened species and fish passage in the catchment, reservoir and downstream areas, as well as potential impacts arising from pest and invasive species associated with the operating hydropower facility. The intent is that there are healthy, functional and viable aquatic and terrestrial ecosystems in the area that are sustainable over the long-term; that biodiversity impacts arising from the operating hydropower facility are managed responsibly; that ongoing or emerging biodiversity issues are identified and addressed as required; and that commitments to implement biodiversity and invasive species measures are fulfilled.

15.1 Background Information

Iceland's ecosystems are comparatively young, as the country was entirely covered by ice until the end of the last ice age around 10,000 years ago. Flora and fauna in the project area must also be very tolerant to environmental stress in the form of a cold and windy climate, as well as frequent ash and dust deposition resulting from volcanic eruptions, and wind storms capable of transporting dust long distances. The landscape has suffered very severe human impacts since the first settlers arrived in Iceland in the late 9th century. Sheep grazing and almost complete deforestation reduced large parts of the country to, effectively, a desert in terms of its vegetation cover.

Before the implementation of the Kárahnjúkar project, the highlands north-east of the Vatnajökull glacier were essentially a wilderness area largely unaffected by human intervention other than hunting and the introduction of reindeer from Norway in the 18th century, as well as mink. The reindeer has, in spite of its legal status as an alien species, become a symbol of the wilderness, and of Eastern Iceland as a whole, and there is a rich bird population.

The project-affected area contains four legally protected areas, the Vatnajökull national park (created in 2008) in the south, the Snaefell-Eyjabakkar area, which is a Ramsar wetland (and also a part of the national park), and two nature reserves in the southern parts of the area – Kringilsáranni and Lönsöraefum. In addition to these, a further 15 areas are entered in the Nature Conservation Register. The Hallormsstadur Forest, one of Iceland's largest and a designated National Forest, is located in the project area but is unaffected by the Kárahnjúkar project.

15.2 Detailed Topic Evaluation

15.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging biodiversity issues have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

The EIA for the project identified key biodiversity concerns as relating to, starting from the Eyjabakkarjökull and Brúarjökull outlet glaciers and moving down to the sea: loss of wilderness, both in terms of area and in terms of appreciation; impact on the Snaefell reindeer herd (the Kringilsáranni area was identified as one of the most important for grazing and breeding for the reindeer); impacts on several geese species; loss of protected area; loss and deterioration of vegetation cover (related to inundation, wind erosion and dust movement); and impact on various aspects of aquatic biodiversity in Lagarfljót lake. A total of six licence conditions and nine Sustainability Initiative environmental indicators are being monitored, as well as several additional identified issues. The Soil Conservation Service of Iceland (SCSI) monitor, oversee and take part in the implementation of

the several revegetation programmes, and monitor the effects of wind-blown sand on vegetation around the Hálslón reservoir. The consultant Laxfiskar monitor the salmon-release programme in Lagarfljót. The Marine and Freshwater Research Institute monitor fish and benthic fauna related to primary production in Jökulsá á Dal and Lagarfljót. The East Iceland Nature Research Centre monitor bird populations in the project area as well as the the reindeer population (the Engineering Research Institute of University of Iceland were responsible for aerial counting of reindeer between 1993-2013) and have also followed up vegetation plots in the Kringilsárrani, Fljótsdalsheidi and Vesturöaefi areas. The Icelandic Institute of Natural History monitor the effect of groundwater impacts on vegetation in the Úthérad area close to the coast.

The Lagarfoss hydropower station has had a fish ladder since 1975 (significant changes have been done to design since then), whose efficiency has been monitored over a long period. Evaluation of its efficiency and decision on potential improvements is still pending. Higher up in the catchment, there were pre-existing natural migration obstacles and/or too high concentrations of suspended sediment to support significant fish populations with the exception of the Kelduár and Eyvindará tributaries.

Apart from the reindeer and mink, the one alien species of interest in the area is the lupin. It is a highly controversial species in Iceland and has been used extensively in revegetation programmes.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging biodiversity issues takes into account both risks and opportunities.*

The many monitoring programmes are especially designed to capture emerging risks and opportunities for improvement to biodiversity management. The design of the monitoring programmes is purposely long-term as many of the risks identified in the EIA, and during the years since then, are of a nature that require long time series to analyse meaningfully.

The use of external monitoring agencies is a mechanism guaranteeing independence from the project owner in the follow-up of ongoing issues and identification of emerging ones, as well as an excellent source of experts' suggestions for improvement to monitoring and management.

The alien species do not constitute a problem in the area, and do not warrant any management intervention.

Criteria met: Yes

15.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified biodiversity issues.*

The main management interventions consist of the detailed monitoring programmes described above. The external experts responsible for most of the monitoring are supported by in-house biodiversity experts responsible for the project-level coordination of all efforts.

The fish-stocking programme in Lagarfljót, initiated in response to stakeholder concerns over the lack of compensation for impacts, is one example of how the project is prepared to test potential solutions even when the chances of success are limited. Stocking was also undertaken initially in Jökulsá á Dal, but was suspended when stocks began reproducing naturally.

The reindeer monitoring is partly paid for by Government-issued hunting licences; the annual hunting quota is presently 1,300 animals, a number that is determined annually with the target of limiting the density at $< 1/km^2$ in each of nine hunting zones in order to protect the vegetation from over-grazing. Landsvirkjun

contributes resources towards GPS collars and aerial monitoring. This programme, which focusses on movements to and from calving areas, will go on until 2019/20.

The road to the Hálslón reservoir is closed during the breeding season for the pink-footed goose in order to minimise disturbances.

The most important management measures, not dealing specifically with impact monitoring, are the different programmes of land reclamation and revegetation undertaken through SCSI. These are priority measures in the Icelandic context in order to re-establish a native vegetation which can support indigenous ecosystems. These programmes are: a) a Government-funded programme where approximately 50% of the cost for participating farmers, for e.g. fertilizer, is covered; b) the compensation programme for lost grazing land due to the inundation by the Hálslón reservoir paid for entirely by Landsvirkjun; and c) a voluntary programme, also funded by Landsvirkjun, focussing on land reclamation and areas of identified sand drift. This programme is Environmental Indicator 2.30 in the Eastern Iceland Sustainability Initiative and is controlled by a committee with e.g. SCSI and participation from both Fljótsdalshérad and Fljótsdalshreppur municipalities. Landsvirkjun is active in land reclamation and reforestation projects in the areas surrounding all its power stations, in close cooperation with SCSI and the Icelandic Forest Service (*Skógraektin*).

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

Some important management measures in order to respond to identified risks and minimise the expected impacts on biodiversity were implemented already during project planning, in that the layout was changed, limiting the project footprint, especially in the highland area. Important examples are the removal of a dam in the Eyjabakkar wetland as well as several diversions from the project layout.

During the preparation of the project, external stakeholders opposed to the project raised concerns to the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) regarding several developments planned in Iceland, Kárahnjúkar being one of them. Landsvirkjun responded through its owner, the Icelandic Government, which resulted in a decision by the Standing Committee of the Convention stating that no species covered by the Convention would be seriously affected by the project, see also below under Conformance/Compliance. Some of the monitoring and mitigation implemented has been identified as a part of this process, e.g. in the Eyjabakkar and Úthérad areas.

Criteria met: Yes

15.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage biodiversity issues have been and are on track to be met with no significant non-compliances or non-conformances, and biodiversity related commitments have been or are on track to be met.*

The case before the Bern Convention (a legal instrument under Icelandic law) mentioned above under Management was dealt with in a satisfactory manner with the conclusion by the Convention's Standing Committee in its recommendation 112 of 2004 that: "*Concluding that no Bern Convention species will be seriously affected by the Kárahnjúkar and Nordlingaalda projects and that there is no need to open a case file on this issue"*.

Six of the licence conditions related to this topic are: Contingency Plans for Erosion and Wind Erosion (which has a significant revegetation component); Mitigation Measures Against Erosion and the Disturbance of

Vegetation; Monitoring Bird Populations in Úthérad; Monitoring of Benthic Communities in Héradsflóa; Extra Monitoring of reindeer; and Monitoring of pink-footed goose. Out of these, the Environment Agency, in its 2010 review, judged that two were fulfilled in full and the other four fulfilled as far as possible. In all these four cases the "as far as possible" relates to the fact that not enough time has passed to ascertain the effectiveness of mitigation. Hence, all six conditions are on track to be met.

The nine relevant indicators (numbers 2.6, 2.7, 2.21, 2.22, 2.23, 2.24, 2.25, 2.26, 2.28 and 2.30), for the Eastern Iceland Sustainability Initiative are all on track to be met.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

No non-compliances or non-conformances have been identified.

Criteria met: Yes

15.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Negative biodiversity impacts arising from activities of the operating facility are avoided, minimised, mitigated, and compensated with no significant gaps.*

Out of the fifteen main impacts predicted by the EIA listed above under topic O-3, six related mainly to biodiversity, and several of the others were indirectly related to some aspect of ecosystem functioning. Irrespective of outcome, all are continuously monitored and where possible, minimised and mitigated in accordance with plans.

- Greater than expected negative impacts have only been experienced in the case of loss of protected area in Kringilsáranni, where the bank erosion in Hálslón has been more severe than expected. This unexpected extent of erosion is considered a significant gap against proven best practice under topic O-16, but as it has not led to the predicted negative impact on the reindeer herd, it is considered not significant here;
- Approximately the predicted impacts have been experienced on: improved transport conditions in the highland area will alter the physical landscape and contribute to a significant loss of wilderness conditions in the Snaefell and surrounding area;
- Significantly lower than predicted impacts have been experienced on: sand encroachment in the Vesturöaefi wilderness area with damage to the vegetation; negative impacts on the population of the reindeer; negative impacts on the population of pink-footed goose; and raised groundwater levels negatively affecting the vegetation in the low-lying areas of the catchments.

The outcome in terms of sand encroachment on vegetation is still pending as the "design storm" foreseen in the licence requirement (50-100 years, see topic O-16) has not yet occurred, hence the impact of such a storm on highland vegetation remains unclear. However, the very significant revegetation implemented, a total of >10,000 ha for the different programmes, has to be regarded as a considerable success under the harsh climatic conditions, combined with grazing pressure from sheep, present in the project area. The outcome in terms of reindeer has been quite positive, indicating that the herd is far less sensitive to the disturbances created by the project than predicted. This is one of the Environmental Indicators in the Eastern Iceland Sustainability Initiative, number 2.23. The results of around 20 years' monitoring show a considerable variation with very high numbers around the mid-1970s and a doubling from around the year 2000 until today (through the project's construction period and first 10 years of operation) from 3,000 to 6,000. The reindeer migrated away from their former areas before the project road into the highland was built, so cause-and-effect is hard to establish. Climate change has been cited as one reason the reindeer are changing their behaviour. However,

the construction of roads in traditional reindeer territory have caused a number of collisions between vehicles and reindeer, killing at least 15 animals since the project became operational, 13 of those in a single accident in 2007. The pink-footed goose is another one of the Sustainability Initiative indicators, number 2.21. The population has proven resilient to the impacts from the projects, probably because the limiting factor on their numbers is the access to winter grazing outside of Iceland. They increased considerably in numbers, but with some variation depending on site investigated. This increase is unrelated to the project, as it can be seen all over Iceland. The groundwater-related impacts on vegetation in the lowland has not materialised as the groundwater has not risen high enough to affect the vegetation.

The catches of arctic char in Lagarfljót have gone down since the commissioning of the project, but this coincides with a similar national trend, making it difficult to assess whether this is only an impact from Kárahnjúkar. The salmon stocking in Jökulsá á Dal has proven successful. Spawning is now taking place and juveniles have proven able to survive the detrimental effects of spilling from the Hálslón reservoir in late summer- early autumn. Catches of salmon were initially only recorded on the lower-most reaches of the river, but the fish have apparently moved upstream and are populating longer stretches of the river.

The usefulness of the fish ladder at Lagarfoss station is questioned by some experts on the grounds that suitable habitat is not present upstream of the power station due to the high turbidity, exacerbated by the Kárahnjúkar project. The salmon stocking in Lagarfljót should be able to shed some light on this, but the programme has still not had enough time to be evaluated with any degree of certainty; indications and expert opinion are not encouraging. The programme produced 48,000 smolt in 2017, with every fish tagged for monitoring purposes. If this programme does not succeed in establishing a workable compensation for those landowners negatively affected on Lagarfljót, other mitigation or outright compensation will have to be developed. One possibility would be to stock the high-altitude lakes and reservoirs with fish, to replace the reduced fishing resource on Lagarfljót.

A positive outcome has been the extreme reduction of suspended sediment content in Jökulsá à Dal. Except for the few months or weeks when the Hálslón reservoir spills, this river is fed entirely by snowmelt, groundwater and surface runoff. It has proven to be productive and fish stocks are increasing and apparently coping with the short periods of turbid water occurring during the spilling period. Long-tailed duck is establishing itself, together with cormorants and pink-footed geese. A salmon population has established itself in the river, and catches are trending upwards.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are healthy, functional and viable aquatic and terrestrial ecosystems in the area affected by the hydropower facility that are sustained over the long-term; or the facility has contributed or is on track to contribute to addressing biodiversity issues beyond those impacts caused by the operating hydropower facility.*

Both the aquatic and terrestrial ecosystems in the project area have been affected to a great extent by the project; some impacts have been negative and some positive. The strongest negative impact is, arguably, felt in Lagarfljót with its considerably increased levels of turbidity, reducing primary production, hence the entire food chain. This is essentially an unmitigable impact, as it is impossible to avoid the cause of it without dismantling the project. Positive biodiversity impacts have, conversely, been experienced in the Jökulsá á Dal, where the water is now mainly free from suspended sediment. Lagarfljót has experienced a gradual, as yet unquantified, reduction in biological productivity but overall the ecosystems in the area should be able to remain healthy, functional and viable.

The project has made one significant contribution beyond its own impacts. The revegetation efforts realised go well beyond mitigating the project's own impacts, and have contributed to the establishment of a healthy indigenous flora over large previously severely degraded highland areas.

Criteria met: Yes

15.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

15.3 Scoring Summary

The EIA identified a number of biodiversity-related risks, and six of these were made into licence conditions for the project. Nine of the environmental indicators in the Eastern Iceland Sustainability Initiative also relate to biodiversity. Several additional issues are monitored. External independent monitoring agencies are used to provide a robust process for the identification of risks and opportunities.

Salmon is bred and stocked in Lagarfljót as an attempt to mitigate the negative impacts on fisheries there. Management of the reindeer herd is mainly carried out by Government agencies, but Landsvirkjun supports the monitoring efforts. The revegetation efforts are both extensive and successful.

There are no non-compliances or non-conformances. The negative impacts to the populations of reindeer and pink-footed geese predicted by the EIA have not been realised. The populations have increased significantly, for reasons unrelated to the project. There have been positive impacts on fisheries in Jökulsá à Dal. The ecosystems in the project's area of operation should generally be able to remain healthy, functional and viable.

There are no significant gaps against proven best practice, resulting in a score of 5.

Topic Score: 5

15.4 Relevant Evidence

Interview:	1, 12, 13, 21, 23, 26, 31, 38, 39, 40, 41, 42, 60
Document:	6, 7, 172 – 202, 235, 242, 244, 245, 247, 248, 253, 254, 256
Photo:	8, 13, 14, 19, 32, 33, 38, 46, 47, 48, 97, 121, 123, 130, 131, 132, 133, 134. 137, 138

16 Erosion and Sedimentation (O-16)

This topic addresses the management of erosion and sedimentation issues associated with the operating hydropower facility. The intent is that erosion and sedimentation caused by the operating hydropower facility is managed responsibly and does not present problems with respect to other social, environmental and economic objectives; that external erosion or sedimentation occurrences which may have impacts on the operating hydropower facility are recognised and managed; and that commitments to implement measures to address erosion and sedimentation are fulfilled.

16.1 Background Information

Before construction of the Kárahnjúkar project, the two main rivers utilised – Jökulsá á Dal and Jökulsá í Fljótsdal – exhibited quite different characteristics in terms of their sediment load. Jökulsá á Dal, mainly receiving runoff from the Brúarjökull outlet glacier from Vatnajökull, had a very high sediment content varying between 5,000 and 8,000 mg/l. Jökulsá í Fljótsdal was also a very turbid river, but with around 600 and 800 mg/l had an average concentration of only about 10% of that of Jökulsá á Dal. This difference was mainly caused by the fact that much of Jökulsá í Fljótsdal's runoff, originating from the Eyjabakkar outlet glacier, passes through the Eyjabakkar wetlands, where much of the sediment was deposited. Before the project was constructed, the two rivers transported around 8-9 million t/year to their common mouth on Héradsflóa bay. The river mouth had been moving towards the north starting in the 1990s. By 2014 it had moved 3 km from the its 1965 location; 1.3 km of this had occurred since the commissioning of the project.

While Iceland's rivers carry huge amounts of sediment, these are largely glacial in origin, not from channel or sheet erosion, and thus fluvial erosion is not seen as a major issue on a national scale. Before the project, the two main rivers were quite different also in the case of river morphology. Due to its very high suspended load and bedload, Jökulsá á Dal's lower reaches were essentially a braided-river system with constantly changing channels in a sandy, gravelly bed. Jökulsá í Fljótsdal and Lagarfljót river, on the other hand, with lower sediment load as well as the very deep Lagarfljót lake (morphologically speaking a fjord, just lacking access to the sea) acting as an effective sediment trap, behaved quite differently in the lower reaches, below the Lagarfoss power station. The river essentially eroded through lateral bank erosion into old glacio-fluvial sediments, much of it probably deposited by the catastrophic flow (resulting from the emptying of an ice-dammed lake) that created the Hafrahvammagljúfur canyon, in which the Kárahnjúkar dam is built.

Wind erosion is a significant problem on Iceland, an issue of major national concern. As mentioned under topic O-15, large areas of Iceland were effectively reduced to desert-like conditions by the early settlers, over 1,000 years ago. The present situation is that Iceland has the world's largest national area of so called volcanoclastic sandy desert, 22,000 km^2 out of Iceland's 103,000 km^2 total area, or just over one fifth. Almost twice that, approximately 40,000 km^2, is classified as desert of some kind. In combination with the nature of the soils, fine-grained but non-cohesive, these areas then become very susceptible to wind erosion. Due to the sheer scale of the problem, much of the focus of the Soil Conservation Service of Iceland (SCSI) is on revegetation programmes in order to bind the highly erodible, bare soils of these degrade areas. Extensive areas have been revegetated all over the country and the SCSI also cooperates with sheep farmers in order to keep the stock of grazing animals at a sustainable level.

This topic has some overlaps with other topics, mainly O-15 and O-17. Aspects related to the revegetation programme in the highland areas are mainly covered under O-15 but referred to when important here in O-16. All suspended transport of sediments in the rivers (including increased turbidity in Lagarfljót) and aspects of monitoring and management of dust and wind-driven deposition of material will be covered under this topic, while all material transport in dissolved form are covered under O-17. Reservoir sedimentation is covered under O-18.

16.2 Detailed Topic Evaluation

16.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging erosion and sedimentation issues have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

Extensive work went into the erosion and sedimentation aspects of the project area during the EIA. This work focussed mainly on wind erosion and particle movement of fine sediments exposed in the Hálslón reservoir's draw-down zone during times when the reservoir is not full. This leads to a risk of migrating wind-blown sand (the phenomenon is called sandification) constituting a risk to the local vegetation cover, which has a very low resilience to sand encroachment. In approximately early June each year, when the reservoir is fully drawn down, 16 km^2 of reservoir bed are exposed. By August of an average year, this area has been reduced to 4 km^2. Monitoring takes place through visual inspection twice annually, in spring and autumn. Areas where wind-blown sand is identified are recorded and measured together with the thickness of the deposition. From 2014 the national arm of SCSI has been carrying out additional monitoring based on GPS-fixed photographed plots, every 200 metres along the shoreline in July every year. Ground sensors and permanent cameras have been added to assist in timely identification of sand movement.

Extensive areas north of the Vatnajökull glacier, immediately west of the project area, belong to some of the most degraded land areas in the country. The Dyngjusandur area is the largest dust source on Iceland, producing in excess of one million t/year of very small particles, < 1µm, with an asbestos-like star shape, with potential health repercussions. This is a pre-project condition. Due to the risk that the project would exacerbate the situation, monitoring of monthly dust deposition was implemented, starting in 2005, initially with 18 monitoring station. Most of these stations were located in the highland area near the Hálslón reservoir, but four were located in populated lowland areas. This setup was changed following evaluation in 2013, see below under proven best practice.

The EIA predicted that the turbidity in Lagarfljót would increase by about 3-5 times as a result of receiving the diverted runoff from Jökulsá a Dal. Monitoring of the concentration of suspended sediments and Secchi depth (converted to actual light transparency through an established correlation) was conducted for approximately 4 times/year, 5 years before and 5 years after commissioning of the project. Monitoring of the suspended-sediment concentration is carried out 4 times/year in Jökulsá á Dal and 10 times/year in Jökulsá í Fljótsdal.

With the harnessing of Jökulsá á Dal river, the EIA predicted that the bulk of the sediment previously transported by the two main rivers, or around 6 million tonnes on average per year (around 70% of the pre-project annual load), would settle in the Hálslón reservoir. With this significant reduction in sediment yield, the sediment budget of the coastline in Héradsflóa bay is affected, and it was projected that the shoreline would retreat by approximately 200 metres in the first 100 years of operation as a result of this reduced sediment yield. Sea-level rise due to climate change was predicted to have an incremental effect, exacerbating the erosion of the shoreline. The modelling conducted predicted a combined effect of 280 metres in the first 100 years. A comprehensive baseline was established and monitoring was put in place, utilising bathymetric surveys and aerial photographs. They are evaluated with an interval of approximately 10 years to follow the development of the shoreline.

The licence stipulated a condition in relation to the sediment flushing from the Ufsarlón reservoir. The target was to avoid sediment accumulation in the water course just downstream of the Ufsar dam.

Riverbank erosion was discussed as part of the EIA. Such erosion is a natural geomorphological process which demonstrates a pronounced high-magnitude, low-frequency nature. This effectively means that almost all the

erosion will occur at the very highest flows in the river. During such events the impact of the project is almost negligible, and the project has reduced the extremes in runoff considerably overall. Considerable bank erosion occurred before the project, particularly in some areas downstream of the Lagarfoss power station, but also in other reaches of Jökulsá í Fljótsdal. Bank erosion due to ice formation resulting from increased water levels during winter was identified as a potential issue in the area downriver from Lagarfoss. The monitoring is based on vegetation plots and erosion pegs and the establishment of river profiles have been added later to supplement the other indicators.

The risk of erosion of the shoreline of Lagarfljót lake was not expected to be a major issue as the water level was not supposed to increase appreciably, and the short-term lake-level variations were predicted to be reduced as a result of the project.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging erosion and sedimentation issues takes into account both risks and opportunities.*

Risks are captured through the many monitoring programmes. One example is the finding that the spread of the grain sizes of wind-blown sand is much greater than expected, creating a risk that bouncing sand particles will cause even more sand to dislodge from the ground and be carried away by the wind, accelerating the impacts.

An evaluation of the dust-monitoring programme led to a change of setup in 2013. The number of dust meters was reduced and monitoring by a web camera positioned at the northern end of the Hálslón reservoir was initiated. This is used for visual evaluation where frequency, density and magnitude of wind-blown dust is classified into five categories.

An opportunity taken is the presentation of several erosion and sedimentation-related monitoring results on the Eastern Iceland Sustainability Initiative's website in order to be as transparent as possible about this issue of public concern. Relevant issues publicly disclosed there are environmental indicators 4, 6, 12 and 29, *Erosion of the River Banks*, *Changes in Coastline*, *Dust Pollution* and *Sand Encroachment by Hálslón Reservoir*.

Criteria met: Yes

16.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified erosion and sedimentation issues.*

Management measures addressing all identified erosion and sedimentation-related issues are in place. Examples are:

- Sediment traps to capture wind-driven sediment on the eastern shore of the Hálslón reservoir. Also, the various revegetation programmes improve the resilience of the highland area to windblown sediments and reduces the risk of negative impacts from dust storms. This is also covered under topic O-15.
- When the northwards migration of the river mouth at Héradsflóa bay became a concern to local stakeholders, Landsvirkjun consulted with all relevant parties and the decision was taken in 2014 to break through the outer sand bank, thereby creating a straighter outflow for the two rivers some distance to the south-east. The first attempt failed, but when repeated it was successful. This will reduce upstream damming effects somewhat but the main benefit is to protect the lower reaches of a small river which has its mouth at the extreme northern end of Héradsflóa from the turbid water

originating from Jökulsá í Fljótsdal, and during spilling also from Jökulsá á Dal. This small river has a salmon stock which is of high value to local stakeholders.

- The management measure implemented for the Ufsarlón flushing operation is that the maximum runoff used in the flushing process has to be maintained over a minimum of 4 hours, in order to rinse the sediment out and propel it downstream to avoid accumulation immediately downstream from the Ufsar dam. The Community and Environment Manager maintains a stakeholder list in order to be able to inform all concerned when flushing is to take place.
- One of the licence conditions was the requirement to remove a rock constriction in the river in order to lower the water level on Lagarfljót lake, contributing to a reduction of the negative impacts of increased runoff in Jökulsá í Fljótsdal in general, but in in particular around the lake. This has been implemented to the satisfaction of the Environment Agency.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

The comprehensive monitoring programmes in place are effective processes for the anticipation of emerging risks and opportunities. The close cooperation with several regional environmental institutions, such as the local arm of SCSI, the Icelandic Institute of Natural History and the East Iceland Nature Research Centre constitutes a strong mechanism for the identification of emerging issues and opportunities and responding to risks.

The project's Community and Environment Manager communicates regularly with concerned stakeholders and has received complaints about river-bank and lake-shoreline erosion. A list has been established containing around a dozen sites, most of those on Jökulsá í Fljótsdal/Lagarfljót above the Lagarfoss power station, a few below the station, and one in Jökulsá á Dal. In response to these stakeholder concerns the project is implementing an ISK 15 million/year (approximately USD 140,000) programme to implement bank protection and other mitigating measures. Starting in 2012, several km of bank protection have been constructed along Jökulsá í Fljótsdal and on the banks of Lagarfljót. This was assisted by a study, conducted by the SCSI, of the shorelines on Lagarfljót. This programme is intended to be permanent, and ongoing consultations will continue to identify needs and countermeasures.

An opportunity not taken is the possibility to address the cumulative impacts caused by the Lagarfoss and Kárahnjúkar projects on raised water levels on Lagarfljót lake, by investigating additional technical measures such as: lowering the threshold at Lagarfoss further in addition to what has already been implemented, or widening/deepening the river channel in critical sections. These options were considered in the EIA, but were not seen as necessary at the time. This is seen as a non-significant gap, as the impacts are managed to a certain extent by the bank-protection initiatives mentioned above.

In response to the monitoring findings concerning the unexpected rates of erosion in the Kringilsáranni area, which is located in the Vatnajökull National Park, a draft management plan for the 2017-2026 period has been drawn up by the Environment Agency. Landsvirkjun will cooperate with this and implement some of the measures. The plan essentially focusses on limiting the future erosion by constructing bank protection above the high-water line of the reservoir.

Criteria met: Yes

16.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage erosion and sedimentation issues have been and are on track to be met with no significant non-compliances or non-conformances, and erosion and sedimentation related commitments have been or are on track to be met.*

The project is in compliance with all licence conditions. All processes and objectives, as well commitments, to addressing erosion and sedimentation-related issues have been and are on track to be met with no non-conformances.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

No non-compliances or non-conformances were identified.

Criteria met: Yes

16.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Erosion and sedimentation issues are avoided, minimised and mitigated with no significant gaps.*

An impact that was not predicted at the level it has occurred is the erosion of the Kringilsáranni nature reserve. The loss of about one fourth of the area was caused by creation of the Hálslón reservoir, and bank erosion on the reservoir has continued eating away at the shore line. It appears that the Gleyic Andosols constituting the soil cover at Kringilsáranni, with their coarse-grained structure and absence of cohesion, are even more susceptible to reservoir-bank erosion than predicted in the EIA. This impact, the effects of which are described under topic O-15, will be addressed through a management plan developed especially for this purpose; see above under Management.

Apart from the reservoir-bank erosion at Kringilsáranni, the impacts around Hálslón have been less severe than predicted in the EIA. The revegetation programme in conjunction with other mitigation, mainly the sediment traps constructed along the reservoir's eastern shore, have proven effective. However, the mitigation for this aspect is one of the licence conditions which remains unproven, as the target in the condition was to protect against "a design storm with 50-100 years' return period", and such a storm has not yet occurred after the commissioning of the project. This is not regarded as a gap against the scoring statement as only time will prove whether the mitigation is effective or not.

The dust monitoring relates to the existing air-quality-related dust-deposition limits where good represents <5 g/m^2/month; acceptable is between 5 and 10 g/m^2/month; and unacceptable is >10 g/m^2/month. The monitoring has resulted in 548 measurements, out of which three exceeded 10 g/m^2/month. In all three cases the cause was unrelated to the Hálslón reservoir. 542 of the measurements had results <5 g/m^2/month. The new web-cam monitoring has resulted in very low figures. There have been no records for the three higher categories, and only very short time periods recorded in category 2.

River-bank erosion in the Úthérad area, below the Lagarfoss power station, is largely a natural phenomenon and is not expected to be significantly exacerbated by the project as the extreme high flows are not much affected by the project. Irrespective of this, monitoring will continue. The shoreline erosion on Lagarfljót lake has been significantly greater than predicted. This is partially the result of higher lake levels caused by more runoff, in turn caused by the higher runoff from more intense glacial melting than expected, a climate-change-

related phenomenon occurring all over Iceland. This impact was clearly initiated when the Lagarfoss station was constructed, raising the threshold of Lagarfljót lake. Monitoring has shown that the Lagarfoss plant caused the water level to rise on average about 1.88 m at Lagarfoss and about 0.28 m at the Lagarfljót bridge. The commissioning of Kárahnjúkar in 2007 changed the water levels again. At Lagarfoss, the water level dropped by 0.34 m, but at the Lagarfljót bridge it increased by 0.14 m. This means that the majority of the negative changes on Lagarfljót were caused by the Lagarfoss plant and that Kárahnjúkar contributed to mitigate some of the negative impacts close to Lagarfoss. Nevertheless, the Kárahnjúkar project has taken action to address the erosion concerns on Lagarfljót lake and downstream of Lagarfoss, see above under Management.

Sediments are flushed from the Ufsarlón reservoir on an annual basis, as long as there is enough water in the Hálslón reservoir to allow for this.

The result of the monitoring of turbidity and Secchi depth in Lagarfljót lake have shown that the suspended-sediment concentration has increased by close to three times, slightly less than predicted. The transparency is around 40 cm, which is around one third to half of pre-project conditions. The effects of this are covered under topic O-15 and also mentioned under topic O-17.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, erosion and sedimentation associated with operating facility do not present ongoing problems for environmental, social and economic objectives of the facility or the project affected areas.*

The erosion and sedimentation associated with the operating facility generally do not present any ongoing sustainability issues. There are, however, two exceptions to this. The impacts caused by the unpredicted extent of shoreline erosion at Kringilsárrani in the Vatnajökull National Park and around Lagarfljót lake, caused by the increased lake levels, together constitute **a significant gap** against the scoring statement.

Criteria met: No

16.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

Erosion in the Kringilsáranni area, and around Lagarfljót lake, causes ongoing environmental and social problems.

1 significant gap

16.3 Scoring Summary

The focus of erosion and sedimentation during the EIA was on wind erosion from the draw-down zone of the Hálslón reservoir and the sedimentation into that reservoir (dealt with under O-18). Iceland has a considerable problem with wind-blown sand and dust, and several conditions were imposed for the monitoring and mitigation of this aspect. Other important issues identified were erosion around Lagarfljót lake due to water-level increases, and shoreline retreat at the coast. Monitoring is ongoing, much of it conducted by the Soil Conservation Service, as are extensive revegetation efforts. Other mitigation efforts include sediment traps along the eastern shoreline of the main reservoir, bank protection works along Lagarfljót, and an artificial opening of a new river mouth at the coast.

The project is in full compliance and conformance with all licence conditions and commitments relating to erosion and sedimentation. However, greater than expected negative impacts have occurred at the Kringilsáranni area. A management plan has been developed by the Environment Agency and will be supported by the project, but will not be able to keep the loss of the protected area at predicted levels. The opportunity to address some of the bank-erosion issues on Lagarfljót lake, by investigating additional technical measures to lower the lake level, has not been taken.

The unpredicted level of impacts on the protected Kringilsáranni area, and the continued shoreline erosion around Lagarfljót lake caused by increased lake levels, together constitute a significant gap against proven best practice, resulting in a score of 4.

Topic Score: 4

16.4 Relevant Evidence

Interview:	1, 2, 4, 12, 26, 31, 40, 41, 60, 61
Document:	6, 7, 203 – 231, 235, 243, 252, 254, 255
Photo:	5, 9, 11, 12, 13, 14, 19, 39, 63, 96, 125, 126, 130, 135, 137, 139

17 Water Quality (O-17)

This topic addresses the management of water quality issues associated with the operating hydropower facility. The intent is that water quality in the vicinity of the operating hydropower facility is not adversely impacted by activities of the operator; that ongoing or emerging water quality issues are identified and addressed as required; and commitments to implement measures to address water quality are fulfilled.

17.1 Background Information

Iceland is a member of the European Economic Area, and as such subject to implementing the European Union's Water Framework Directive (WFD). As a part of its work on implementation of the directive, the Icelandic MetOffice (*Vedurstofa Íslands*) is looking to expand its current monitoring programme for Iceland and develop a national water-quality data base. The preparation for such a nation-wide monitoring network, ensuring the "good or very good" status sought by the WFD, has been going on for some time and is likely to be launched soon. Landsvirkjun is involved in this initiative as a major stakeholder. The Institute of Freshwater Fisheries is also involved in upgrading water-quality monitoring in Iceland.

The surface water quality of Iceland's rivers and lakes is generally very good, with the exception of extremely high content of suspended sediments in rivers draining major glaciers. Surface water is not used as domestic water supply as that is normally supplied from groundwater sources, which is of such high quality that it normally requires little or no treatment.

Some Icelandic rivers are known to have high concentrations of dissolved solids due to the weathering of young volcanic rock or geothermal activity in their watersheds. Long residence time in reservoirs would also cause an increase in chemical content.

This topic has some overlaps with other topics. Domestic water supply is covered under topics O-12 and O-14. Suspended transport of sediments in the rivers (including increased turbidity in Lagarfljót) is covered under topic O-16, while material transport in dissolved form is covered under this topic, O-17.

17.2 Detailed Topic Evaluation

17.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging water quality issues have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

The EIA predicted the impacts on Lagarfljót's transparency, but did not identify water quality in itself as a general issue.

There is one environmental indicator in the Eastern Iceland Sustainability Initiative (2.9 - Oil/chemical spills due to operation) and two licence conditions which are relevant to this topic. The latter are: preventive measures against extensive leakage caused by tunnels during the construction period; and conducting research on the geo-thermal energy in the project-affected area. The Sustainability Initiative monitoring registers any spills >20 litres and >2,000 litres. During the monitoring period, 2007-2016, the project has had one spill >20 litres (in 2010) and none above 2,000 litres. The monitoring of the geo-thermal sources has been conducted to ascertain that there are no impacts on the chemical nature of water in springs in the area; none have been identified. The impacts of leakage from tunnels are monitored.

The MetOffice was in charge of a dedicated monitoring programme of water quality running for 5 years before and 5 years after commissioning of the project (with a gap during construction). Samples were initially taken 8-

10 times/year including in several non-affected rivers as control. After commissioning the sampling frequency was set at 8/year and the number of controls limited to one, based on experience. The results show increased fluxes of dissolved solids, but not at a level which could cause negative impacts to ecology or human health. This monitoring was discontinued in 2013 as no need for further monitoring was identified. However, the MetOffice still carries out analyses of samples of suspended sediment content taken from both main rivers, and these samples are also analysed for total dissolved solids.

The tailwater from the power station (water is drawn from the draft tubes of units 2 and 5) is sampled for turbidity on a monthly basis and the control system provides information on water temperature in the tailwater as well as in Ufsarlón and Hálslón reservoirs.

The East Iceland Environmental and Public Health Office (*Heilbrigdiseftirlit Austurlands*) is responsible for food and water safety, and as part of that monitors the water quality of bore holes regularly since 1983.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging water quality issues takes into account both risks and opportunities.*

The MetOffice monitoring mentioned above has resulted in a number of scientific articles with detailed analyses of the impact of damming and climate on the transport of nutrients and trace elements. The raw data from this work have been made publicly available, enabling later generations of researchers to further analyse various aspects of the post-project environment against a well-established baseline.

As a part of the studies on fish (see topic O-15), Jökulsá á Dal, Jökulsá í Fljótsdal, Lagarfljót and a number of other water bodies in the area are continuously monitored once or twice per year (depending on site and context) for pH, electrical conductivity, temperature and Secchi depth.

Criteria met: Yes

17.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified water quality issues.*

There are no identified water-quality issues requiring management identified beyond complying with the licence conditions, which has been done to the full satisfaction of the Environment Agency. The monitoring of the reduced transparency in Lagarfljót lake is covered under topic O-16.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

The ongoing monitoring of surface water quality constitutes a satisfactory process to anticipate and respond to emerging risks and opportunities. This is, however, presently mainly dependent on the monitoring conducted as part of the fish-monitoring programmes.

The expected launching of the nationwide monitoring necessary for the implementation of the WFD will improve the ability to identify any emerging issues. The nature of the WFD as a directive (adopted into Icelandic law in 2011) will guarantee the continuity of this monitoring. However, if the WFD has not been fully implemented by 2019, and the fish-monitoring programmes' water-quality measurements are not continued beyond their present funding limit in 2019, a significant gap would develop as there would be no process in place to identify and respond to emerging risks.

Criteria met: Yes

17.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place to manage water quality issues have been and are on track to be met with no significant non-compliances or non-conformances, and water quality related commitments have been or are on track to be met.*

All processes, objectives and water-quality-related commitments are on track to be met and regulators attest that the project has not had any negative impacts.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

No non-compliances or non-conformances have been identified.

Criteria met: Yes

17.2.4 Outcomes

Analysis against basic good practice

Scoring statement: *Negative water quality impacts arising from activities of the operating hydropower facility are avoided, minimised and mitigated with no significant gaps.*

The key identified negative water-quality impact is the deteriorated water quality in Jökulsá í Fljótsdal and Lagarfljót (transparency and suspended-sediment content, dealt with under topic O-16). No other significant negative impacts on water quality have been identified.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, water quality in the area affected by the operating hydropower facility is of a high quality; or the facility has contributed or is on track to contribute to addressing water quality issues beyond those impacts caused by the operating hydropower facility.*

Surface water quality in the project area is generally high. There have been two major impacts from the project, one positive and one negative. The negative impact is described above. The positive impact is the, on average, significantly reduced suspended-sediment yield in the main rivers, as an estimated 85% of the pre-project sediment yield is now captured in Hálslón. This results in clean, clear water for much of the year in Jökulsá á Dal, contributing to improved conditions for e.g. salmon (see topic O-15).

Criteria met: Yes

17.2.5 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

17.3 Scoring Summary

Surface water quality in Iceland is generally of very good quality. The EIA did not identify any major long-term negative impacts on water quality beyond the transparency and turbidity of Lagarfljót lake, dealt with under O-16. One identified positive impact is the significant reduction of sediment content in Jökulsá á Dal, which has exceeded expectations. The positive effects of this are dealt with under O-15. No non-compliances or non-conformances have been identified.

The MetOffice conducted comprehensive monitoring during 5 years before and after the project's construction period, and there is still limited sampling going on. In addition to this, the fish studies in the project-affected rivers monitor some water-quality parameters. The EU WFD is part of the Icelandic regulatory framework for water and will result in a nation-wide comprehensive monitoring network, capable of identifying any risk and opportunities.

There are no significant gaps identified, resulting in a score of 5.

Topic Score: 5

17.4 Relevant Evidence

Interview:	1, 2, 4, 13, 21, 31, 38, 60
Document:	6, 7, 215, 226, 231 – 235, 244, 245, 264
Photo:	39, 96, 97

18 Reservoir Management (O-18)

This topic addresses management of environmental, social and economic issues within the reservoir area during hydropower facility operation. The intent is that the reservoir is well managed taking into account power generation operations, environmental and social management requirements, and multi-purpose uses where relevant.

18.1 Background Information

The Kárahnjúkar project has one main storage reservoir, Hálslón, which was designed with a surface area of 57 km^2, with a length of around 25 km and a width of around 3 km. The full supply level is 625 m.a.s.l. and the minimum drawdown level is 550 m.a.s.l., with a designed live storage of 2,100 million m^3.

Hálslón is augmented by a number of smaller diversions and reservoirs, the most important of which are the Kelduárlón, Saudárvatn lake and Ufsarlón. Kelduárlón has an area of 7.5 km^2 and a live storage of 60 million m^3. Saudárvatn and Ufsarlón are small reservoirs at about 2 and 1 km^2 respectively. They are not primarily storage reservoirs, but rather part of the diversions and intake for water harnessed from the south-east of the project's catchment. The runoff captured by and stored in Saudárvatn lake and Kelduárlón is transferred through tunnels to Ufsarlón.

During project planning and design, the average inflows were estimated as 107 m^3/s to Hálslón and 31 m^3/s to Ufsarlón for a total of around 138 m^3/s (136 m^3/s after allowing for leakages). By 2015 these numbers had increased to a total inflow of just over 154 m^3/s (152 m^3/s), an increase of around 12% in only 13 years, caused by the considerable net contribution from the melting glaciers, due to climate change.

The dams for all reservoirs are all equipped with overflow spillways, see topic O-6. Aspects related to generation optimisation based on inflow and demand forecasting are dealt with under topic O-4; issues of shoreline erosion in, and wind-transported dust from, Hálslón under topic O-16; water-quality issues under topic O-17; and the releases and spill from the reservoirs into the downstream rivers under topic O-19.

18.2 Detailed Topic Evaluation

18.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging reservoir management issues have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

Reservoir management issues have been comprehensively identified and all key aspects, such as reservoir levels, shoreline erosion, sedimentation and greenhouse gas (GHG) emissions are monitored, in order to ascertain the effectiveness of ongoing reservoir management. One issue identified as part of the EIA was the need to map and study the alluvial terraces that were to be inundated by the Hálslón reservoir, as they were thought to have a high scientific value and had not been extensively studied before. This was made into a licence condition for the project.

Sedimentation rates were assessed through detailed measurement of Hálslón's bathymetry in 2013. The results showed an increase in the area and volume of the reservoir, mainly due to the retreat of the Brúarjökull outlet glacier, resulting in an area of 62 km^2, a length of 28 km and a width of 3 km with a live storage of 2,195 million m^3. The conclusion is that the reservoir's economic life span has been underestimated.

There is very little to no other utilisation of the reservoirs than for power generation. Safety aspects for people accessing project facilities are covered under topic O-6. There are some fish, e.g. arctic char in Kelduárlón, but fishing does not seem to be a major activity in the highland areas where the reservoirs are located.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, identification of ongoing or emerging reservoir management issues takes into account both risks and opportunities.*

The various monitoring programmes for known issues such as the shoreline erosion, wind-driven dust and reservoir sedimentation address both risks and opportunities.

As discussed under topic O-3, Landsvirkjun assesses its GHG emissions as part of commitments to both the GRI and the CDP reporting initiatives. The emissions from the Kárahnjúkar reservoirs have been falling from 1,140 tonnes of CO_2-equivalents/year in 2010 to an average of around 900 tonnes of CO_2-equivalents/year during 2015-2016. This is in line with what would be expected when high-northern-latitude reservoirs age. Emissions are more than offset by carbon sequestration achieved by the revegetation programmes described under topic O-15.

A study has been implemented by the Science Institute of the University of Iceland on the topography under the Brúarjökull outlet glacier. The results show that there is a deep valley under the glacier. If climate change continues as predicted, Brúarjökull will retreat further and that valley will turn into a deep glacial lake. This lake will trap the bulk of sediment generated by the remaining glacier, extending the predicted life span of the reservoir significantly. Together with the result of reservoir measurements mentioned above, this leads to the conclusion that reservoir sedimentation is not likely to ever be an important management issue for the project. Present forecasts predict sediment accumulation to almost stop at a volume loss under 50% around 500 years into the future. Predictions for eventual filling result in such long time horizons (e.g. ~10,000 years) that they are not meaningful in the context of a hydropower project.

Criteria met: Yes

18.2.2 Management

Analysis against basic good practice

Scoring statement: *Measures are in place to manage identified issues.*

All identified issues have effective management measures in place. This is generally a question of monitoring to alert project-management staff to any changes which would necessitate management intervention.

The licence condition was managed by commissioning a study team to carry out the required work.

Management of the reservoir levels and generation planning are carried out by the Generation Planning unit in the Energy Division at Landsvirkjun's as described under topic O-4. There is normally no specific need for flood management by reservoir draw-down to make room for the main summer runoff peak, as Hálslón is always drawn down when the melting period starts. If runoff of a problematic magnitude is predicted as a result of heavy rainfall when the reservoir is full or near full, the management response is to make sure that Jökulsá í Fljótsdal receives as close as possible to the runoff that would have occurred without the project, in order to not threaten infrastructure in the northern, low-lying and inhabited parts of the catchment.

Access to Hálslón by the public is restricted and signing and some fencing has been implemented.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities.*

The project's monitoring programmes and its systematic approach to socio-environmental management together with the communication work carried out by the Community and Environment Manager ensure its ability to anticipate and respond to any emerging risk or opportunity.

The key issues being monitored, inflow and reservoir levels, have revealed a higher-than expected inflow, leading to an opportunity to further increase generation as described under topic O-4. The monitoring of the key issues has identified one important emerging risk, the larger-than-expected shoreline erosion in the Kringilsáranni area, and experience from the dust monitoring has led to a change in the set-up of that monitoring programme, utilising more effective methodology. Both aspects are described under topic O-16.

A potential reservoir-specific opportunity could be tourism activities on Hálslón itself, such as boating and fishing. This has not materialised for several reasons, one of which is that the lake experiences significant wave action as a result of strong winds in the highlands. This makes boating dangerous. One of the local tourism operators has conducted a study on the feasibility of boat services on the lake as part of his university studies. The result was that this opportunity would face issues of low water levels and dust issues in the early summer, making the useful "season" very short. Other opportunities related to tourism are discussed under topic O-8.

Criteria met: Yes

18.2.3 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *Processes and objectives in place for reservoir management have been and are on track to be met with no significant non-compliances or non-conformances, and reservoir management related commitments have been or are on track to be met.*

All general processes and objectives in place for reservoir management, as well as reservoir-related commitments are on track to be met.

Specifically:

- The internal processes for planning and managing reservoir levels and releases for power generation are well established and fully on track, as described under topic O-4.
- When the Environment Agency of Iceland reviewed the fulfilment of the licence conditions concerning the alluvial terraces in 2010, this condition was considered as "fulfilled as far as possible". The reason for this verdict not being simply "fulfilled" was that the report's publication was delayed by scientific disagreement among the experts on the study team. The report has now been published, closing this partial gap.
- There are two commitments under the Eastern Iceland Sustainability Initiative, environmental indicators 2.5, Sediment Deposition in Hálslón Reservoir and 2.13, Greenhouse Gas Emissions. Both have been and are on track to be met through regular monitoring of the reservoir volume (2.5) and the annual assessment and reporting of the reservoir-related emissions to GRI and CDP.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, there are no non-compliances or non-conformances.*

No non-compliances or non-conformances were identified.

Criteria met: Yes

18.2.4 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

18.3 Scoring Summary

Reservoir issues have been comprehensively assessed and all relevant issues are monitored. Key issues include reservoir sedimentation, GHG emissions, reservoir-rim and draw-down zone erosion, and the reservoir's future extent and volume. No significant additional uses for the reservoir have been identified, and access to it is partly restricted for safety reasons.

Present predictions show that less than half the Hálslón reservoir volume will be filled by sediments in the first 500 years. GHG emissions have gone down from just over 1,100 t/year to around 900 t/y between 2010 and 2016. These emissions are more than offset by the extensive revegetation programme implemented by the project. Erosion aspects are covered under topic O-16.

The project has no non-compliances or non-conformances. There are no significant gaps against proven best practice, resulting in a score of 5.

Topic Score: 5

18.4 Relevant Evidence

Interview:	1, 4, 9, 24, 60
Document:	6, 7, 204, 213, 236 – 240, 251
Photo:	8, 9, 10, 11, 12 ,13, 23, 24, 26, 27, 28, 34, 35, 36, 37, 38, 39, 41, 42, 45, 49, 50, 51, 59, 60

19 Downstream Flow Regime (O-19)

This topic addresses the flow regimes downstream of the operating hydropower facility infrastructure in relation to environmental, social and economic objectives. The intent is that issues with respect to the operating hydropower facility's downstream flow regimes are identified and addressed, and commitments with respect to downstream flow regimes are fulfilled.

19.1 Background Information

The flow regimes of all the rivers and streams included in the Kárahnjúkar project underwent significant changes as a result of the project.

The biggest change was the diversion of the glacial Jökulsá á Dal to the power station and from there into Jökulsá í Fljótsdal. This has resulted in a complex flow regime in Jökulsá á Dal where, for most of the year, the flow is significantly reduced and now consists only of dam seepage and lateral inflows below the Hálslón reservoir. For a short period during the late summer to early autumn in years when Hálslón fills up (which it does in most years), water from the Brúarjökull glacier is spilled over the Kárahnjúkar dam into the original river course.

The flow regime in Jökulsá í Fljótsdal is changed by diverting water from the diversions of Jökulsá á Dal and the upper part of its own catchment, including the tributaries of Kelduár and Grjótá, through the power station. The average discharges in the two main rivers before the project were approximately 160 m^3/s in Jökulsá á Dal and 113 m^3/s in Jökulsá í Fljótsdal. Out of that an average of 94 m^3/s and 21 m^3/s respectively are contributing to the 115 m^3/s now diverted through the power station. This means that the flow in the upper part of Jökulsá í Fljótsdal has been reduced by one fifth, while in the lower part it has almost doubled.

The flow below the station is also significantly more even across the year as the summer peak is mainly stored in the Hálslón reservoir, and water from there is released for power generation during the winter, when pre-project flows were very low.

The river stretches affected can be seen in the project-layout map in the introductory section under "Project Description".

This topic has some overlaps with, primarily, topics O-4, O-9, O-15, O-16 and O-18. Under this present topic, the assessment focusses on the flow regimes as such, downstream of the various diversions. Remaining aspects of induced impacts and necessary management are covered under the respective topics mentioned above.

19.2 Detailed Topic Evaluation

19.2.1 Assessment

Analysis against basic good practice

Scoring statement: *Ongoing or emerging issues relating to the operating hydropower facility's downstream flow regimes have been identified, and if management measures are required then monitoring is being undertaken to assess if management measures are effective.*

The downstream flow issues were comprehensively identified as part of the 2001 EIA. Power generation was obviously the primary objective of the Kárahnjúkar project, but the issues identified during the impact assessment led to significant reductions in the scope of river diversions in the highland areas. The most important environmental concern in terms of river diversions was the Hraunaveita area in the eastern parts of the Kelduár catchment. The planned diversions from there were removed from the project scope as the

negative impacts were considered to be too severe. This was also the case for several additional small diversions in the Laugarfellsveita area.

Two downstream flow issues which were considered important enough that they resulted in licence conditions were: the impact on the aesthetic value and attractiveness to tourism of the rivers and water falls in the upper stretches of Kelduár and Jökulsá í Fljótsdal; and the necessary removal of a rock constriction above the Lagarfoss power station. Mitigation measures for these were identified in the licence, and continuous monitoring is in place.

Lake levels and level fluctuations in Lagarfljót lake were predicted not to increase appreciably except the level in winter, because of the considerable flow contributions from the Hálslón reservoir.

Other issues identified related to groundwater level changes, sediment transport issues caused by the flushing of the Ufsarlón reservoir (see topic O-16), impacts on river-bank and lake-shore erosion downstream from the station on Jökulsá í Fljótsdal and Lagarfljót, also dealt with under O-16. Negative impacts on fishing and recreation on Lagarfljót were also identified as issues, as well as positive impacts on fishing in Jökulsá á Dal. These are mainly dealt with under topic O-9.

The assessment identified tributaries and groundwater contributions as contributing to the instream flow in Jökulsá á Dal below the dam, and together with some minor seepages through and past the several dams, the flow in the river today is an average of 5 m^3/s 10 km below the dam.

Monitoring of runoff is conducted at 12 gauges in Jökulsá í Fljótsdal and two gauges in Jökulsá á Dal.

Please refer also to topics O-15 and O-9. These issues are all being monitored, several of them as part of managing the licencing conditions.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, issues identification takes into account both risks and opportunities. In the case of a need to address downstream flow regimes, an assessment has been undertaken that includes identification of the flow ranges and variability to achieve different environmental, social and economic objectives based on field studies as well as relevant scientific and other information.*

The flow regimes, including variability aspects, have been assessed in detail by appropriate expertise, most of them external to Landsvirkjun, for all affected stretches of river. Environmental, social and economic objectives have been taken into consideration and no other downstream uses of water beyond power generation, fishing and other recreation have been identified. Risk assessments have been inherent to these studies, and opportunities have been identified in the form of possibilities to enhance fishing opportunities as well as the removal of the rock constriction in the river in order to lower the water level, hence contribute to reducing the negative impacts of increased runoff in Jökulsá í Fljótsdal and Lagarfljót (see also under topic O-16).

Criteria met: Yes

19.2.2 Management

Analysis against basic good practice

Scoring statement: *In the case of a need to address downstream flow regimes, measures are in place to address identified downstream flow issues; and where formal commitments have been made, these are publicly disclosed.*

Management measures are in place to address those issues for which a need has been identified. Formal commitments have been made, both in terms of licensing conditions but also in terms of the Eastern Iceland Sustainability Initiative where two parameters relevant to this topic are included – “changes in hydrology” and

"flow in water falls". These are publicly available including rationale for the indicator(s), baseline, metric, targets, monitoring protocol and results at the Initiative's website.

The licence condition concerning the rivers and water falls in the upper stretches of Kelduár and Jökulsá í Fljótsdal has a three-step guidance attached to it, which is based on the water level in the Hálslón reservoir and is guided by a simple graph showing lake levels at different dates during the summer season, clearly identifying when a certain licence-relevant condition is likely to occur. The three steps are:

1. Full capacity of the reservoirs is unlikely. If it is unlikely that the Hálslón reservoir will fill, no water is released into the two concerned rivers stretches.
2. More than 50% chance of filling the Hálslón reservoir. Water is then released into the Jökulsá í Fljótsdal following consultation with tourism operators. The length of the release period and the flow to be released is determined by the likelihood of Hálslón filling, by the flow characteristics and stakeholder needs. Water cannot be released into the Kelduár river until the Kelduárlón reservoir is full.
3. Overwhelming chance of full capacity. All inflow to the Ufsarlón reservoir is released into the Jökulsá í Fljótsdal and the inflow into the Kelduárlón reservoir is released into the Kelduár river once Kelduárlón is filled.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In addition, processes are in place to anticipate and respond to emerging risks and opportunities. In the case of a need to address downstream flow regimes, in addition commitments are made in relation to downstream flow regimes that include the flow objectives; the magnitude, range and variability of the flow regimes; the locations at which flows will be verified; and ongoing monitoring.*

The comprehensive monitoring programme takes both emerging risks and potential opportunities into consideration and the commitments include all relevant flow objectives, all publicly available on the Sustainability Initiative's website.

Criteria met: Yes

19.2.3 Stakeholder Engagement

Analysis against basic good practice

Stakeholder engagement is not assessed at level 3.

Analysis against proven best practice

Scoring statement: *In the case of a need to address downstream flow regimes, in addition the assessment and management process for downstream flow regimes has involved appropriately timed and two-way engagement with directly affected stakeholders, and ongoing processes are in place for stakeholders to raise issues with downstream flow regimes and get feedback.*

The assessment and management processes put in place have responded, to the extent possible, to stakeholder concerns and priorities. All stakeholders were able to contribute during the environmental assessment and licencing process and are now aware of how to get in touch with project representatives. There is also a contact function on the dedicated website for the Sustainability Initiative.

Before every summer season, a meeting discussing flow management is held with the representatives for the tourism sector in the Fljótsdal area. These meetings are minuted and distributed. Interviewees attest to their full satisfaction with appropriately timed and two-way engagement.

There is special list kept of the stakeholders affected by sediment flushing from the Ufsarlón reservoir. These stakeholders are notified before any flushing takes place. Similar processes exist in case of spilling from all reservoirs, see topic O-6.

For more details on the general stakeholder engagement, please refer to topic O-1.

Criteria met: Yes

19.2.4 Conformance / Compliance

Analysis against basic good practice

Scoring statement: *In the case of a need to address downstream flow regimes, processes and objectives in place to manage downstream flows have been and are on track to be met with no significant non-compliances or non-conformances, and downstream flow related commitments have been or are on track to be met.*

Downstream flows are regulated by the licence conditions relating to the release of water into Kelduár and Jökulsá í Fljótsdal mentioned above under Assessment and described under Management. The licence condition for removal of a rock flow constriction above Lagarfoss power station was implemented to the satisfaction of the Environment Agency. No significant non-compliance with these requirements have been identified. All downstream-flow-related processes, objectives and commitments have been met.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In the case of a need to address downstream flow regimes, in addition there are no non-compliances or non-conformances.*

No non-compliances or non-conformances were identified.

Criteria met: Yes

19.2.5 Outcomes

Analysis against basic good practice

Scoring statement: *In the case of a need to address downstream flow regimes and commitments to downstream flow regimes have been made, these take into account environmental, social and economic objectives, and where relevant, agreed transboundary objectives.*

The downstream-flow-related commitments of the Kárahnjúkar project have taken economic, environmental and social objectives into account. Environmental objectives were primarily addressed during the licensing process, when several diversions were eliminated from the project layout in order to facilitate continued natural flow in some priority rivers. Economic objectives are addressed through the tourism-related releases. The spilling from the Hálslón reservoir is delayed as long as possible through the releases into Jökulsá í Fljótsdal, protecting the socially important salmon fishery that has developed on Jökulsá á Dal as a result of the project and its reduction of sediment content in that river. The commercial objectives of Landsvirkjun as project owner are fully realised within the flow constraints determined.

The short-term lake-level fluctuations in Lagarfljót have all but disappeared as a result of the project, while the rise in absolute lake levels have been greater than predicted, as a result of higher runoff due to the warming climate and associated glacial melting. This has increased the risk of lakeshore erosion, as described under topic O-16. However, it is important to point out that after implementation of the licence conditions regarding the rock constriction mentioned above, changes caused by Kárahnjúkar to the water levels in Lagarfljót lake above the Lagarfoss station are considered insignificant, in comparison to the impact from Lagarfoss. The

Kárahnjúkar project's impact on raising the water level in Lagarfljót is mainly relevant for a period of two to three months during the winter, and in the late summer.

Criteria met: Yes

Analysis against proven best practice

Scoring statement: *In the case of a need to address downstream flow regimes and commitments to downstream flow regimes have been made, in addition these represent an optimal fit amongst environmental, social and economic objectives within practical constraints of the present circumstances.*

The project was controversial when it was decided and constructed. Against this background it is difficult to imagine a situation where all, or even most, stakeholders are satisfied with the situation, given the considerable changes to flow regimes, clearly focusing on power generation. However, within practical constraints of the present circumstances with the project in place and operating, it is likely that the current flow arrangements represent as near to an optimal fit between different objectives as can be expected. Addressing any of the stakeholder priorities that regularly fall short of satisfaction such as no releases into Kelduár and Jökulsá í Fljótsdal in low-flow years; earlier-than-desired spilling into Jökulsá á Dal, spoiling the fishing in high-flow years; and the increased levels in Lagarfljót lake, addressed under topic O-15; would have meant adding other undesirable impacts, such as the need for considerably larger reservoirs.

Criteria met: Yes

19.2.6 Evaluation of Significant Gaps

Analysis of significant gaps against basic good practice

There are no significant gaps against basic good practice.

0 significant gaps

Analysis of significant gaps against proven best practice

There are no significant gaps against proven best practice.

0 significant gaps

19.3 Scoring Summary

The project is mainly based on an inter-basin transfer from the Jökulsá á Dal to the Jökulsá í Fljótsdal. Early assessment of issues during the EIA led to changes to the project layout, thereby eliminating many negative impacts on downstream reaches of smaller tributaries. Remaining identified issues include: transfer of sediment-laden water from Jökulsá á Dal to Jökulsá í Fljótsdal; lack of water in the upper reaches of Jökulsá í Fljótsdal, affecting the attractiveness of the area to tourists; spilling of sediment-laden runoff into the now clean water of Jökulsá á Dal when the Hálslón reservoir overflows; and raised water levels in Lagarfljót lake. Mitigation measures for the impact on tourism and the water levels in Lagarfljót lake were stipulated as licence conditions. The issue with sediment-laden spills into Jökulsá á Dal is minimised by delaying the onset of spilling as long as possible.

Monitoring is in place and stakeholders are well known, able to raise issues, and attest to receiving timely feedback. Annual meetings are held to support information-sharing. The project is fully compliant and conforms with all its flow-related commitments. Within practical constraints, the current flow arrangements represent as near to an optimal fit between different objectives as can be expected. The project layout leaves little room for other adjustments. Addressing any of the remaining stakeholder priorities would likely mean adding other undesirable impacts, such as the need for considerably larger reservoirs.

There are no significant gaps identified, resulting in a score of 5.

19.4 Relevant Evidence

Interview:	1, 2, 4, 9, 21, 24, 31, 38, 39, 60
Document:	6, 7, 210, 212, 241, 246 – 251, 254
Photo:	2, 8, 27, 28, 29, 30, 31, 34, 35, 40, 60, 97, 121, 122, 130, 132, 133, 134, 135, 139

Appendix A: Written Support of the Project Operator

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Entura Hydro Tasmania
Hobart Office
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Australia

Reykjavík, 17.10.2017
Our ref: 08.03.01

Subject: **Assessment of the Fljótsdalur Power Station using the operation tool of the Hydropower Sustainability Assessment Protocol**

Landsvirkjun has contributed to the development of the Hydropower Sustainability Assessment Protocol (HSAP) as one of the first Sustainability Partners of IHA.

In 2012 Landsvirkjun conducted an assessment for the Hvammur Hydropower Project using the preparation tool of the HSAP.

In 2013 Landsvirkjun conducted an assessment for the operation of the Blanda Power Station.

In 2017 Landsvirkjun is pleased to continue Application of the Protocol, now using the assessment tool for the operation of the Kárahnjúkar-Fljótsdalur Power Station.

Landsvirkjun is committed to using the Protocol. Landsvirkjun has been able to improve its procedures and learn valuable lessons from applications of the Protocol. Landsvirkjun hopes that its participation will increase the adoption of the Protocol around the world.

Landsvirkjun confirms its support and cooperation with the Assessment Team conducting this assessment of the Kárahnjúkar-Fljótsdalur Power Station and Landsvirkjun will provide all information and agreements as required for the assessment.

We look forward to receive your report.

Yours sincerely

Óli G. B. Sveinsson
Óli Grétar Blöndal Sveinsson
Executive Vice President

Einar Mathiesen
Einar Mathiesen
Executive Vice President

Appendix B: Verbal Evidence

No	Interviewee/s	Position/s	Organization	Date	Location	Interviewer
1	Ragnheidur Ólafsdóttir, Sveinn Kari Valdimarsson	Environmental Manager, Project Manager Biodiversity	Landsvirkjun / Development Department	8. Sept.	Reykjavik	Bernt Rydgren
2	Eydís Salome Eiríksdóttir	Chemist	Marine and Freshwater Research Institute	8. Sept.	Reykjavík	Bernt Rydgren
3	Jóna Árný Thórdardóttir, Gudrún Áslaug Jónsdóttir, Signý Ormarsdóttir, Jón Steinar Gardarsson	General Manager, three Project Managers	The East Iceland Bridge (Austurbrú)	8. Sept.	Egilsstadir	Eleni Taylor-Wood
4	Árni Snorrason, Jórunn Hardardóttir, Ódinn Thórarinsson, Njáll Fannar Reynisson	CEO, Research Director, Director of Observations, Monitoring Expert	Icelandic MetOffice	8. Sept.	Reykjavík	Joerg Hartmann, Bernt Rydgren
5	Björn Ingimarsson	Mayor of Fljótsdalshérad	Municipality of Fljótsdalshérad	8. Sept.	Egilsstadir	Eleni Taylor-Wood
6	Sigrún Blöndal	Chairman	East Iceland Municipality Association (SSA)	8. Sept.	Egilsstadir	Eleni Taylor-Wood
7	Björn Stefánsson	Chief Engineer	Landsvirkjun Power	8. Sept.	Reykjavík	Joerg Hartmann
8	Einar Mathiesen, Árni Benediktsson	Executive Vice President, Chief Engineer	Landsvirkjun / Energy Department	8. Sept.	Reykjavík	Joerg Hartmann
9	Eggert Gudjónsson	Manager Generation and Trading	Landsvirkjun / Energy Department	8. Sept.	Reykjavík	Bernt Rydgren
10	Unnur María Thorvaldsdóttir	Manager Asset Management	Landsvirkjun / Energy Department	8. Sept.	Reykjavík	Joerg Hartmann
11	Úlfar Linnet	Manager Resources	Landsvirkjun / Development Department	8. Sept.	Reykjavík	Joerg Hartmann
12	Rúnar Ingi Hjartarson	Regional Representative, North East Iceland	Soil Conservation Service of Iceland	11. Sept.	Egilsstadir	Bernt Rydgren
13	Helga Hreinsdóttir	General Manager	East Iceland Environmental and Public Health Office	11. Sept.	Egilsstadir	Joerg Hartmann, Bernt Rydgren
14	Gunnthórunn Ingólfsdóttir, Anna Jóna Árnmarsdóttir	District Administrative Officer, Member	Municipality of Fljótsdalshreppur	11. Sept.	Fljótsdalur	Eleni Taylor-Wood

		of Municipal Council				
15	Gunnar Jónsson	Farmer / Member of Municipal Council	Municipality of Fljótsdalshérad	11. Sept.	Egilsstadir	Eleni Taylor-Wood
16	Smári Kristinsson	Production Manager	Alcoa Fjardaál	11. Sept.	Egilsstadir	Joerg Hartmann
17	Árni Jóhann Ódinsson	Project Manager Community and Environment	Landsvirkjun / Energy Department	11. Sept.	Fljótsdalur	Eleni Taylor-Wood
18	Sigbjörn Nökkvi Björnsson	Project Manager Dams and Waterways	Landsvirkjun / Energy Department	11. Sept.	Fljótsdalur	Joerg Hartmann
19	Sigurdur Gudni Sigurdsson, Sindri Óskarsson	Manager of Operations, Power Station Manager	Landsvirkjun / Energy Department	11. Sept.	Fljótsdalur	Joerg Hartmann,
20	Jóhanna Harpa Árnadóttir	Project Manager Corporate Social Responsibility	Landsvirkjun / Corporate Office	11. Sept.	Fljótsdalur	Bernt Rydgren
21	Sveinn Kari Valdimarsson	Project Manager Biodiversity	Landsvirkjun / Development Department	11. Sept.	Fljótsdalur	Bernt Rydgren
22	Sindri Óskarsson	Power Station Manager	Landsvirkjun / Energy Department	12. Sept.	Egilsstadir	Joerg Hartmann
23	Kristín Ágústsdóttir, Skarphérdinn Thórisson, Halldór Walter Stefánsson, Gudrún Óskarsdóttir, Erlín Emma Jóhannsdóttir	Manager, Expert, Ornithologist, Plant Ecologist, Expert	East Iceland Nature Research Center	12. Sept.	Egilsstadir	Bernt Rydgren
24	Páll G. Ásgeirsson, Skúli Björn Gunnarsson	Manager Highland Hostel Laugafell, Manager Gunnarsstofnun Cultural Centre	Highland Hostel Laugafell, Upphérad Tourist Organization (Ferdaklasi Upphérads)	12. Sept.	Egilsstadir	Eleni Taylor-Wood, Bernt Rydgren
25	Gunlaugur Jónasson	Manager	Lake Hotel Egilsstadir (Gistihúsid Egilsstödum)	12. Sept.	Egilsstadir	Eleni Taylor-Wood
26	Agnes Brá Bragadóttir	Park Manager	Vatnajökull National Park Eastern Territory	12. Sept.	Egilsstadir	Eleni Taylor-Wood, Bernt Rydgren
27	Haraldur Geir Edvaldsson	Lieutenant	Fire Department	12. Sept.	Egilsstadir	Joerg Hartmann
28	Jónas Thór Jóhannsson	Machinery inspector	Administration of Occupational Safety and Health, East Iceland	12. Sept.	Egilsstadir	Joerg Hartmann

29	Fjölnir Hlynsson	Board Member	Lagarfljót Angling Club	12. Sept.	Egilsstadir	Eleni Taylor-Wood
30	Adalsteinn Jónsson, Thórarinn Hrafnkelsson	Chairman, Board Member	Jökla Angling Club	12. Sept.	Egilsstadir	Eleni Taylor-Wood
31	Gudrún Schmidt, Sævar Thór Halldórsson, Erla Dóra Vogler	Managing Director, two Board Members	Austurland Nature Conservation Association	12. Sept.	Egilsstadir	Bernt Rydgren
32	Páll Gudjónsson	Managing Director	PG stálsmídi ehf.	12. Sept.	Egilsstadir	Eleni Taylor-Wood
33	Dagbjartur Jónsson, Vilhjálmur Jónsson	Power Plant Operators and Shop Stewards	Landsvirkjun / Energy Department	12. Sept.	Egilsstadir	Joerg Hartmann
34	Sturla Jóhann Hreinsson	Human Resources Manager	Landsvirkjun / Corporate Office	12. Sept.	Skype meeting	Joerg Hartmann
35	Ragnheidur Ólafsdóttir	Environmental Manager	Landsvirkjun / Development Department	12. Sept.	Egilsstadir	Bernt Rydgren
36	Eggert Gudjónsson	Manager Generation and Trading	Landsvirkjun / Energy Department	13. Sept.	Reykjavík	Joerg Hartmann
37	Sigurdur Gudni Sigurdsson, Sindri Óskarsson	Manager of Operations, Power Station Manager	Landsvirkjun / Energy Department	13. Sept.	Fljótsdalur	Eleni Taylor-Wood
38	Gudni Gudbergsson	Divison Manager Freshwater Research	Marine and Freshwater Research Institute	13. Sept.	Reykjavík	Bernt Rydgren
39	Jóhannes Sturlaugsson	Biologist	Laxfiskar ehf. (salmon and trout research)	13. Sept.	Reykjavík	Bernt Rydgren
40	Elín Fjóla Thórarinsdóttir	Director Land Information Management	Soil Conservation Service of Iceland	13. Sept.	Reykjavík	Bernt Rydgren
41	Ólafur Gestur Arnalds	Professor - Faculty of Environmental Sciences	Agricultural University of Iceland	13. Sept.	Reykjavík	Bernt Rydgren
42	Kristinn Haukur Skarphédinsson, Sigurdur H. Magnússon	Head of Zoology / Wildlife Ecologist, Plant Ecologist	Icelandic Institute of Natural History	13. Sept.	Reykjavík	Bernt Rydgren
43	Halla Eiríksdóttir	Operational Manager	Health Directorate of East Iceland	13. Sept.	Egilsstadir	Eleni Taylor-Wood
44	Kristján Gunnarsson	Head of Corporate Strategic Finance	Landsvirkjun / Finance Department	13. Sept.	Reykjavík	Joerg Hartmann
45	Yngvi Hardarson	CEO	Analytica	13. Sept.	Reykjavík	Joerg Hartmann

46	Thorvardur Ingimarsson	Farmer / Contractor / Member of Municipal Council	Municipality of Flótsdalshreppur	13. Sept.	Fljótsdalur	Eleni Taylor-Wood
47	Hallgrímur Thórhallsson	Farmer	--	13. Sept.	Fljótsdalur	Eleni Taylor-Wood
48	Sigvaldi H. Ragnarsson, Baldur Grétarsson	Chairman, Steering Group Member	Land Improvement Fund Nordur-Hérad	13. Sept.	Egilsstadir	Eleni Taylor-Wood
49	Eiríkur Kjerulf, Jóhann Thórhallsson	Chairman, Board member	Land Improvement Fund Fljótsdalshrepp	13. Sept.	Egilsstadir	Eleni Taylor-Wood
50	Halldór Halldórsson	Health, Safety and Environment Manager	Landsnet	13. Sept.	Reykjavík	Joerg Hartmann
51	Kristján Kristinsson	Safety Manager	Landsvirkjun / Corporate Office	13. Sept.	Reykjavík	Joerg Hartmann
52	Hjalti Jóhannesson	Expert - Research Center	University of Akureyri	14. Sept.	Skype meeting	Eleni Taylor-Wood
53	Dóra Hjálmarsdóttir	Safety Representative and Consultant	Verkís Consulting Engineers	14. Sept.	Reykjavík	Joerg Hartmann
54	Adolf Fridriksson	Director	Institute of Archeology	14. Sept.	Reykjavík	Eleni Taylor-Wood
55	Gudni A. Jóhannesson, Erla Björk Thorgeirsdóttir	Director General, Project Manager	National Energy Authority	14. Sept.	Reykjavík	Bernt Rydgren
56	Thengill Ásgrímsson	Director of Power Generation	Orkusalan	14. Sept.	Skype meeting	Eleni Taylor-Wood
57	Jón Sveinsson, Geir Arnar Marelsson, Helgi Bjarnason	Head of Legal Affairs, Lawyer, Project Manager	Landsvirkjun / Corporate Office, Development Department	14. Sept.	Reykjavík	Joerg Hartmann, Eleni Taylor-Wood
58	Hildur Jóna Bergthórsdóttir	Human Resources Expert	Landsvirkjun / Corporate Office	14. Sept.	Reykjavík	Joerg Hartmann
59	Ragna Árnadóttir	Deputy CEO	Landsvirkjun / Corporate Office	14. Sept.	Reykjavík	Eleni Taylor-Wood, Joerg Hartmann
60	Hákon Adalsteinsson	Project Manager	Landsvirkjun / Development Department	14. Sept.	Reykjavík	Bernt Rydgren
61	Helgi Jóhannesson	Project Manager	Landsvirkjun / Development Department	14. Sept.	Reykjavík	Bernt Rydgren
62	Helgi Jóhannesson	Project Manager	Landsvirkjun / Development Department	14. Sept.	Reykjavík	Eleni Taylor-Wood
63	Jóhanna Harpa Árnadóttir	Project Manager Corporate Social	Landsvirkjun / Corporate Office	14. Sept.	Reykjavik	Eleni Taylor-Wood

		Responsibility				
64	Ragnheidur Ólafsdóttir	Environmental Manager	Landsvirkjun / Development Department	14. Sept.	Reykjavik	Eleni Taylor-Wood
65	Thurídur Elísa Hardardóttir	Archaeologist	Cultural Heritage Agency of Iceland	22. Sept.	Skype meeting	Eleni Taylor-Wood

Appendix C: Documentary Evidence

No	Author / Organization	Title	Date	Language	Description / Notes / Weblink
1	The New York Times	Smokestacks in a White Wilderness Divide Iceland	2007	English	http://www.nytimes.com/2007/02/04/world/europe/04iceland.html?pagewanted=all
2	National Geographic Magazine	Power Struggle: The people of Iceland awaken to a stark choice: exploit a wealth of clean energy or keep their landscape pristine	2008	English	http://ngm.nationalgeographic.com/2008/03/iceland/del-giudice-text/1
3	IRN - International Rivers Network	Karahnjukar – a Project on Thin Ice: An Analysis of the Karahnjukar Hydropower and Reydaral Aluminum Smelter Project in Iceland	2003	English	http://www.savingiceland.org/wp-content/uploads/2008/01/internationalriversnetwork.pdf
4	Det Norske Veritas	IHA SAP Test Assessment Kárahnjúkar Hydropower Project	2008	English	external report
5	Landsvirkjun	LV-2017-024: Kárahnjúkar Hydropower Station; Implementation of conditions for the power development licence	2017	English / Icelandic	https://www.landsvirkjun.is/Media/lv-2017-024-kar-framkvaemd-skilyrda-fyrir-virkjunarleyfi-net.pdf
6	Landsvirkjun	General Information	2017	Icelandic / English	https://www.landsvirkjun.is
7	Eastern Iceland Sustainability Initiative	General Information	2017	Icelandic / English	http://en.sjalfbaerni.is/
8	Sigurður St. Arnalds	Development of Kárahnjúkar HEP 690 MW (Power Point Presentation)	2017	English	internal
9	Landsvirkjun	VKL-068 Kvartanir, ábendingar og úrbætur/ *Procedure Policy; Complaints, Tips and Remedies*	2016	Icelandic	internal
10	Landsvirkjun	Hagsmunaaðilaáætlun fyrir Fljótsdalsstöð/ *Stakeholders plan for Fljótdalur Power Station (Excel file)*	2013	Icelandic	internal
11	Landsvirkjun	Umhverfisrannsóknir og mótvægisaðgerðir vegna reksturs Fljótsdalsstöðvar - kynning á opnum fundi á Hótel Héraði/ *Environmental studies and counteractions for operation in Fljótdalur Power Station - presentation for an open meeting in Hotel Hérað (Power Point file)*	2014	Icelandic	internal
12	Landsvirkjun	Samráðsfundur, Vettfangsferð í Húsey: Fljótdsalsstöð og Húsey/ *Consultation, Field trip in Husey: Fljotsdalur and Husey (Minutes of meeting)*	2015	Icelandic	internal
13	Landsvirkjun	Samráðsfunur, Landsvirkjun og Húsey/ *Consultation meeting, Landsvirkjun and Husey (Power Point file)*	2015	Icelandic	internal

14	Eastern Sustainability Initiative	Ársfundur Sjálfbærniverkefnisins 2016 - dagskrá/ *Annual open meeting of the Eastern Sustainability Project, year 2016 - program*	2016	Icelandic	http://www.sjalfbaerni.is/um-sjalfbaerniverkefnid/arsfundir/arsfundur-2016/
15	Landsvirkjun	Hagsmunaaðilar og samskipti í virkjanaverkefnum - verkefni og sniðmáti / *Presentation on stakeholder analysis and communication plan*	2017	Icelandic	internal
16	Landsvirkjun	Hagsmunaaðilar og samskipti (almennt) 2017-08 / *Stakeholder analysis and communication plan (general)*	2017	Icelandic	internal
17	Landsvirkjun	Samningur LV og Fljótsdshreppur 2003 / *Contract Fljótsdalshreppur from 23.01.2003*	2003	Icelandic	internal
18	Landsvirkjun	Fjarfundur sveitarstjórnar Fljótsdalshrepps og fulltrúa Landsvirkjunar 13.12 2007 / *Follow up meeting in 13.12.2007*	2007	Icelandic	internal
19	Landsvirkjun	2015_LV_karahnjukabaeklingur_EN / *Project Brochure*	2015	English	public
20	Landsvirkjun	LV_Almennur_Enska_160617_netid / *general Landsvirkjun brochure*	2017	English	public
21	Landsvirkjun	LV guidelines for different stakeholder engagement types	2016	Icelandic	internal
22	Landsvirkjun	STE-003 Umhverfisstefna Landsvirkjunar (útgáfa 4) / *Landsvirkjun's Environmental Policy (4th edition)*	2016	Icelandic	internal, with summaries in public environmental reports
23	The Ministry of Environment	UMH0180004 Ruling for Kárahnjúkar Power Plant / Ministry for the Environment	2001	English	internal
24	Landsvirkjun	Supreme Court ruling on Kárahnjúkar environmental impact assessment in favour of Landsvirkjun and the Icelandic State	2004	Icelandic / English	http://www.landsvirkjun.com/company/mediacentre/news/news-read/611_
25	The National Planning Agency	Kárahnjúkavirkjun allt að 750 MW, Úrskurður Skipulagsstofnunnar um mat á umhverfisáhrifum/ *Kárahnjúkar Power Plant up to 750 MW, Decision of the National Planning Agency (Report)*	2001	Icelandic	http://www.skipulag.is/media/attachments/Umhverfismat/671/2000110003.PDF
26	Assessment Committee for Determination on Compensation due to Water Rights of Kárahnjúkar Power Plant	Úrskurður/ *Ruling on compensation due to Water Rights of Kárahnjúkar Power Plant*	2007	Icelandic	internal
27	Landsvirkjun	Compensation for water rights due to the Kárahnjúkar Power Plant	2007	Icelandic / English	http://www.landsvirkjun.com/company/mediacentre/news/news-read/681_
28	Iceland Review	Land Owners Lose Supreme Court Water Rights Case	2012	English	http://icelandreview.com/news/2012/10/19/land-owners-lose-supreme-court-water-rights-case

29	Landsvirkjun	VKL-075 Samræmi við ytri kröfur / *Compliance with external requirements*	n.d.	Icelandic	internal
30	East Iceland Office for Public Health and Environment	Leiðbeiningar nr. 582/2000, Auglýsing um lista yfir mengandi starfsemi þar sem ekki er krafist ítarlegrar starfsleyfisgerðar/ *Directive no. 582/2000, list of polluting operations where detailed license making is not demanded*	2000	Icelandic	public
31	East Iceland Office for Public Health and Environment	Auglýsing nr. 582/2000 Almenn Starfsleyfisskilyrði fyrir mengandi starfsemi/ *Announcement no. 582/2000 General Conditions on operating permits for Polluting Operations*	2000	Icelandic	http://www.heilbrigdiseftirlit.is/sites/default/files/almenn_starfsleyfisskilyrdi_582_2000.pdf
32	East Iceland Office for Public Health and Environment	Starfsleyfi fyrir raforkuvinnslu/ vatsnaflsvirkjun, Fljótsdalsstöð/ *Operating Permit for Generation of Electricity/ Hydro Power Plant, Fljótsdalur Power Station*	2008	Icelandic	internal
33	East Iceland Office for Public Health and Environment	Starfsleyfi vegna mengunarvarna á bensínstöðvum/ *Work Permit on Pollution Control for Gasstations*	2009	Icelandic	internal
34	East Iceland Office for Public Health and Environment	Starfsleyfisskilyrði fyrir almenn bifreiðaverkstæði og skyldan rekstur/ *General Conditions on Operating Permits for garage*	2003	Icelandic	http://eldri.ust.is/media/skyrslur2003/Starfsleyfisskilyrdi_fyrir_almenn_bifreidaverkstadi.pdf
35	East Iceland Office for Public Health and Environment	Starfsleyfisskilyrði fyrir Starfsmannabúðir/ *General Conditions on Operating Permits for Personnel Residence*	2006	Icelandic	http://eldri.ust.is/media/starfsleyfi2006/Starfsleyfisskilyrdi_fyrir_starfsmannabudir,_endurskodad_27.3.2006.pdf
36	East Iceland Office for Public Health and Environment	Samræmd starfsleyfisskilyrði fyrir stórar spennistöðvar/ *General Conditions on Operating Permits for Substations*	2004	Icelandic	http://eldri.ust.is/media/skyrslur2004/Starfsleyfisskilyrdi_storar_spennistodvar_2004.pdf
37	Landsvirkjun	Landsvirkjun's Code of Conduct	2013	English	http://www.landsvirkjun.com/Media/Landsvirkjun%E2%80%99sCodeofConduct.pdf
38	Landsvirkjun	STE-023 Stefna Landssvirkjunar, útgáfunúmer 15 / *corporate CSR policy*		Icelandic	internal
39	Landsvirkjun	Landsvirkjun´s new Strategy on CSR	2016	English	http://www.landsvirkjun.com/media/news/Strategy-on-Corporate-Social-Responsibility.pdf
40	Landsvirkjun	VKL-075 Samræmi við ytri kröfur / *VKL-075 compliance with external requirements*	n.d.	Icelandic	internal
41	VSÓ	03184 LV Rýnifundur 170131 / *Review session on laws and regulations*	2017	Icelandic	internal

42	Hönnun hf, Landmótun ehf, The Insitute of Natural History, Verkfræðistofa Sigurðar Thoroddsen hf. (VST) and VBB-VIAK	Kárahnjúkar Hydroelectric Project up to 750 MW, Environmental Impact Assessment	2001	English	http://gogn.lv.is/files/2001/2001-002.pdf available also via www.leitir.is
43	Landsvirkjun	Samfélagsábyrgð Landsvirkjunar, Stefna og áherslur 2016/ *Landsvirkjun's Corporate Social Responsibility, Progress and focus in 2016*	2016	Icelandic/ English	http://www.landsvirkjun.is/Media/lvcorporatesocialresponsibi2016ok.pdf
44	Landsvirkjun	LEI-214 Viðbragðsáætlun Fljótsdalsstöðvar vegna olíumengunar/ *Fljótsdalur Power Station Oil Pollution Response Plan (instruction document)*	2003	Icelandic	internal
45	Landsvirkjun	LEI-219 Umhverfisstjórnun Fljótsdalssvæðis/ *Environmental Management Plan for Fljótsdalur Area (instruction document)*	2016	Icelandic	internal
46	Landsvirkjun	LEI-236 Viðbragðsáætlun Fljótsalsstöðvar vegna uppfoks og áfoks í Hálsóni/ *Fljótsdalur Power Station Response Plan for Aeolian Deposition in Hálsón Reservoir (instruction document)*	2016	Icelandic	internal
47	Landsvirkjun	LEI-237 Kröfur sem Landsvirkjun gerir til verktaka og þjónustuaðila varðandi umhverfismál/ *Landsvirkjun's Requirements to Contractors Regarding Environmental Issues (instruction document)*	2016	Icelandic / English	http://www.landsvirkjun.com/Media/v5552landsvirkjuns-requirements-towards-contractors-and-service-providers-with-regard-to-environmental-matters-and-safety.pdf
48	Landsvirkjun	LEI-276 Samskipti við ytri hagsmunaaðila aflstöðva/ *Communication with external stakeholders of Landsvirkjun's Power stations (instruction document)*	2016	Icelandic	internal
49	Landsvirkjun	UN Global Compact, Communication on Progress	2016	English	http://www.landsvirkjun.is/fyrirtaekid/framkvaemdir/Media/lvun-global-compacktlayoutisl03.pdf
50	Berit Hanna Czock and Dwina Soerono (School of Energy, University of Reykjavik)	How can social impact of developments in the energy sector be measured meaningfully? Landsvirkjun Internship Project	2017	English	external
51	Landsvirkjun	SKI-114 Umhverfisþættir í starfsemi Landsvirkjunar/ *Environmental Factors in Landsvirkjun's Operations*		Icelandic	internal
52	Landsvirkjun	VKL-161 Umhverfisstjórnun, Greining umhverfisþátta/ *Environmental Management, Analysis of Environmental Impacts/Factors (Prodecure document)*		Icelandic	internal
53	Landsvirkjun	VKL-163 Greining og viðbrögð við		Icelandic	internal

		mögulegum umhverfisatvikum/ neyðarástandi/ *Analysis and Response to Incidents that may Adversely Affect the Environment (Procedure document)*			
54	Auður Magnúsdóttir and Kristín Þrastardóttir/ VSO consulting	Úttekt á umhverfisstjórnunarkerfi, Fljótsdalsstöð/ *Assessment of Environmental Management System for Fljótsdalur Power Station (Report)*	2017	Icelandic	internal
55	Sigurður M. Garðarsson and Jónas Elíasson/ Engineering Research Institute, University of Iceland	Influence of Climate Warming on Hálslón Reservoir Sediment Filling (article in Hydrology Research)	2006	English	http://hr.iwaponline.com/content/37/3/235
56	Landsnet	Annual Report 2015, An ''Electrified future'' - in Tune with Society (Report, English translation)	2016	English	http://2015.landsnet.is/wp-content/uploads/2016/06/Landsnet_AnnualReport2015_PDF_ENGLISH.pdf
57	Landsvirkjun	LV-2016-009 Vatnamælingar Landsvirkjunar, Vatnsárið 2014/2015/ *Landsvirkjun's Hydrological Metering, hydrological year 2014/2015 (report)*	2016	Icelandic	internal
58	Landsvirkjun	LV-2016-129 Vatnajökull, Mass balance, meltwater drainage and surface velocity of the glacial year 2015-16 (report)	2016	English	internal
59	Landsvirkjun	Vinnsluáætlanir Orkusviðs Vikuyfirlit-08.09.2017 / *Production Plan Energy Division - Weekly View*	2017	Icelandic	internal
60	Landsvirkjun	2017-035 Vatnsárið 2015-2016 Uppgjör / *Wateryear 2015-2016*	2017	Icelandic	internal
61	Monika Wittmann et al.	Impact of dust deposition on the albedo of Vatnajökull ice cap, Iceland (article in The Cryosphere)	2017	English	https://www.the-cryosphere.net/11/741/2017/tc-11-741-2017.pdf
62	Philippe Crochet	Sensitivity of Icelandic river basins to recent climate variations (article in Jökull)	2013	English	http://jokulljournal.is/J63p71.pdf
63	National Energy Authority	OS-2007-011 Effect of climate change on hydrology and hydro resources in Iceland	2007	English	http://www.os.is/gogn/Skyrslur/OS-2007/OS-2007-011.pdf
64	Óli Grétar Blöndal Sveinsson, Úlfar Linnet and Elías B. Elíasson	Hydropower in Iceland, Impacts and adaption in future climate (extended abstract)		English	In: Climate Change and Energy Systems: Impacts, Risks and Adaptation in the Nordic and Baltic Countries, Ch. 10. Th. Thorsteinsson and H. Björnsson eds., Nordic Council of Ministers, TemaNord 2011:502
65	Landsvirkjun	Memorandum - Processing Plan for 2013	2012	Icelandic	internal
66	Vísir	News - Alcoa Fjarðaál dregur úr framleiðslu / *Alcoa reduces production*	2014	Icelandic	http://www.visir.is/g/20141401191109

67	Verkfræðistofan Vatnaskil, Sveinn Óli Pálmarsson and Hjalti Sigurjónsson	Kárahnjúkavirkjun; Endurskoðun rennslislíkans fyrir Jökulsá á Brú, Jökulsá í Fljótsdal og Kelduá / *Review of hydrological runoff model for Jökulsá á Brú, Jökulsá i Fljotsdal and Keldua*	2013	Icelandic	Report for Landsvirkjun
68	Verkfræðistofan Vatnaskil, Sveinn Óli Pálmarsson and Hjalti Sigurjónsson	Memo: Effect of climate change on runoff Þjórsár-Tungnaarsvaethi and Kárahnjúkavirkjun	2015	Icelandic	Report for Landsvirkjun
69	Philippe Crochet	Quality analysis of different long-term inflow scenarios	2017	English	Report for Landsvirkjun
70	Magnús Sigurðsson og Úlfar Linnet, Landsvirkjun	LV-2010-122 Aukning orkuvinnslu virkjana Landsvirkjuar / *Possible generation increase in Landsvirkjuns existing power system*	2010	Icelandic	internal
71	Landsvirkjun	Memo: Aukinn skerðanlegur markaður á Austurlandi / *Possible delivery of power in East Iceland without delivery guaranties*	2011	Icelandic	internal
72	Landsvirkjun	Value of transmission system strengthening (Power Point presentation)		Icelandic / English	internal
73	Landsvirkjun	LV 2017-035 Vatnsárið 2015-2016 Uppgjör / *Water Year 2015-2016*	2017	Icelandic	internal
74	Landsvirkjun	Asset Management Department, overview	2013	English	internal
75	Landsvirkjun	Fljotsdalur long term maintenance plan	2017	Icelandic	internal
76	Landsvirkjun	Áætlun um rof og vinnu í flutningskerfinu og tengdum vinnslueiningum / *KAR Outage plan 2017*	2017	Icelandic	internal
77	Landsvirkjun	Ástandsmat v Vél 1 samantekt 2017 / *summary of condition of machine 1 in 2016*	2017	Icelandic	internal
78	Landsvirkjun	HydroAmp einkunarspjöld-Vél 6 20151 / *HydroAmp Rating cards engine 6 2015*	2017	Icelandic	internal
79	Landsvirkjun	*GENERATION AVAILABILITY REPORT 2016*	2017	Icelandic	internal
80	Landsvirkjun	OAK Tiltækigögn 2013-2016 / *Data on availability 2013-2016*	2017	Icelandic	internal
81	Landsvirkjun	Greinagerð: Nýtni aflstöðva í rekstri - vinnsluáætlanir / *Operational efficiency of Landsvirkjun's power stations*	2013	Icelandic	internal
82	Unnur María Þorvaldsóttir/ Boudewijn Neijens	Asset Management is Key to Operations for Landsvirkjun, National Power Company of Iceland	2015	English	http://www.hydroworld.com/articles/print/volume-23/issue-6/features/asset-management-is-key-to-operations-for-landsvirkjun-national-power-company-of-iceland.html

83	Andritz Hydro	HPP Karahnjukar turbine efficiency curve		English	internal
84	Helgi Thor Helgason / Kristján Mar Sigurjónsson / Árni Benediktsson / Sveinn Ingi Ólafsson	Reliable power delivery from a powerstation dedicated to a single user - The Kárahnjúkar Powerstation in Iceland	2009	English	http://www.verkis.com/media/pdf/2009_04-Hydro-Paper-Helgi-Thor-Helgason.pdf
85	Landsvirkjun	LV-2016-120: Hraunaveita, Stíflueftirlit árið 2016/ *Hraunaveita Distribution, Dam Monitoring 2016*	2016	Icelandic	internal
86	Landsvirkjun	LV-2016-132: Sauðárdalsstífla, Stíflueftirlit árið 2016 / *Sauðárdalur Dam, Dam Monitoring 2016*	2016	Icelandic	inernal
87	Landsvirkjun	LV-2017-001: Kárahnjúkastífla, Stíflueftirlit árið 2016 / *Kárahnjúkar Dam, Dam Monitoring 2016*	2017	Icelandic	inernal
88	Landsvirkjun	LV-2017-002: Desjarárstífla, Stíflueftirlit árið 2016/ *Desjará Dam, Dam Monitoring 2016*	2017	Icelandic	internal
89	Freysteinn Sigmundsson et al.	Earthquakes and faults in the Kárahnjúkar area Review of hazards and recommended further studies	2005	English	https://www.landsvirkjun.is/media/2005/kar_hazard_report_march18_2005.pdf
90	Landsvirkjun	LV-2006/055 Kárahnjúkavirkjun Flóð vegna stíflurofs Endurskoðun / *Kárahnjúkar flooding due to dam break: a review*	2006	Icelandic with English summary	https://www.landsvirkjun.is/media/2006/skyrsla_lv_2006_055_stiflurof.pdf
91	Landsvirkjun	LEI-151 Viðbragðsáætlun vegna stíflurofs við Kárahnjúka, Ásamt fylgiskjölum (A, B1, B2, C, D1, D2, D3 og D4)/ *Response Plan for Dam Breaks in Kárahnjúkar Area, with Enclosures:A, B1, B2, C, D1, D2, D3 og D4 (Instruction Documents)*		Icelandic	internal
92	Landsvirkjun	STE-029 Skipulag rafmagnsöryggisstjórnkerfis Landsvirkjunar (RÖSK), ásamt fylgiskjali/ *Landsvirkjun's Electrical Safety Management System Plan, with Enclosure (Policy Document)*		Icelandic	internal
93	Landsvirkjun	VIN-172 Eftirlit með stíflum og vatnsvegum á vatnasviði Fjótsdalsstöðvar/ *Dams and Channels Supervision in the Drainage Area of Fljótdsdalur Power Station*	2012	Icelandic	internal
94	Landsvirkjun	LEI-225 Viðbragðsáætlun neyðarstjórnar / *Emergency Management Response Plan*		Icelandic	internal
95	Landsvirkjun	General public safety - examples of warning and information signs at Kárahnjúkar	2017	English	compilation for assessment

96	MetOffice	Jarðskjálftavirkni við Kárahnjúka 2011-2013, Þeistareyki og Kröflu og á hálendi / *Earthquake activity at Kárahnjúkar 2011-2013, Þeistareyki and Krafla and the highlands*	2014	Icelandic	Report for Landsvirkjun
97	MetOffice	Jarðskjálftavirkni við Þeistareyki og Kröflu árin 2012–2014, við Kárahnjúka og hálendi norðan og vestan Vatnajökuls árið 2014 / *Earthquake activity at Þeistareyki and Krafla 2012-2014, Kárahnjúka and the highland north and west of Vatnajökull in 2014*	2015	Icelandic	Report for Landsvirkjun
98	MetOffice	Memo: Jarðskorpuhreyfingar við Kárahnjúka 2014 / *Earth crustal movements at Kárahnjúkar 2014*	2014	Icelandic	Report for Landsvirkjun
99	MetOffice	Jarðskorpuhreyfingar við Kárahnjúka og norðan Vatnajökuls 2016 / *Earth crustal movements at Kárahnjúkar and north of Vatnajökull in 2016*	2017	Icelandic	Report for Landsvirkjun
100	Landsvirkjun	Yfirlit samninga LV við VÍ 2004-2017 vegna GPS- og jarðskorpumælinga á Kárahnjúkasvæði / *Summary of LV's agreement with VÍ 2004-2017 for GPS and geothermal surveys in Kárahnjúkar area*		Icelandic	internal
101	MetOffice	Jarðskjálftavirkni suðvestur af Vatnajökli 2013–2015 og á svæðum frá Vatnajökli og Kárahnjúkum norður að Kröflu og Þeistareykjum árið 2015 / *Earthquake activity southwest of Vatnajökull 2013-2015 and in areas from Vatnajökull and Kárahnjúkur north to Krafla and Þeistareykir in 2015*	2016	Icelandic	Report for Landsvirkjun
102	MetOffice	Jarðskjálftavirkni á Austurlandi norðan Vatnajökuls og við Kárahnjúka, og yfirlit jarðskjálftavirkni á Suðurlandi og Norðausturlandi / *Earthquake activity in the eastern part of the north of Vatnajökull and at Kárahnjúkar, and an overview of earthquake activity in south Iceland and northeastern Iceland*	2017	Icelandic	Report for Landsvirkjun
103	Fjóla Guðrún Sigtryggsdóttir	Results from the monitoring of geohazards in the Hálslón Reservoir area	2017	English	Report for Landsvirkjun
104	G.G.Tomasson, S.M.Gardarsson, T.H.Leifsson and B.Stefansson	Flood design criteria for Kárahnjúkar dam – a glacially dominated watershed	2009	English	http://www.verkis.com/media/pdf/2009_03-IAHR-KAR-FloodDesign.pdf
105	Landsvirkjun	Kárahnjúkar Project; Halslon reservoir impoundment, dam site investigations, design and construction	2006	English	https://www.landsvirkjun.is/media/2006/kar_reservoir_dam_22082006.pdf
106	S.M.Gardarsson, M.Pfister, A.Gunnarsson	Karahnjukar dam spillway: Comparison of operational data and results from hydraulic modelling	2015	English	https://infoscience.epfl.ch/record/217258/files/2015-1060_Gardarsson_Gunnarsson_To

	and G.G.Tomasson				masson_Pfister_%20Karahnjukar%20dam%20spillway%20Comparison.pdf
107	Mannvit	LV-2017-083: Desjarár- og Sauðárdalsstífla; Úttekt samkvæmt NVE/ *Desjará and Sauðárdal dams; Evaluation according to NVE*	2017	Icelandic	Report for Landsvirkjun
108	Yngvi Hardarson	A Simulation Study on the Profitability of Energy Sales to Reydaral. Presentation to a Meeting with Landsvirkjun Owners Committee	2002	English	internal
109	Iceland Review	Cost of Kárahnjúkar Dam Exceeds Estimates	2008	English	http://icelandreview.com/news/2008/03/07/cost-karahnjukar-dam-exceeds-estimates
110	Iceland Review	Enlargement Plans for East Iceland Alcoa Smelter	2012	English	http://icelandreview.com/news/2012/05/04/enlargement-plans-east-iceland-alcoa-smelter
111	Helge Sigurd Næss-Schmidt, Martin Bo Westh Hansen, David von Below	Copenhagen Economics 2017 - Energy market reform options in Iceland, Promoting security of supply and natural sesource value	2017	English	http://www.landsvirkjun.com/Media/copenhagen-economics-2017-lokaeintak.pdf
112	Þorsteinn Siglaugsson	Karahnjukar Estimate Profitability for Iceland Nature Conservation Association 2002	2002	English	http://www.inca.is/newspageiv.asp?ID=25
113	Gamma GAM Management hf	Sæstrengur og hagur heimila, greining áhrifa sæstengs á afkomu heimila landsins / *Analysis of the impact of selling energy to Europe*	2013	Icelandic	http://www.gamma.is/media/skjol/GAMMA_Saestrengur.pdf
114	Iceland Review	National Power CEO: Kárahnjúkar Plant not Profitable	2011	English	http://icelandreview.com/news/2011/11/16/national-power-ceo-karahnjukar-plant-not-profitable
115	Landsvirkjun	Revised profitability assessment for Kárahnjúkar Power Plant	2006	English	http://www.landsvirkjun.com/company/mediacentre/news/news-read/656
116	Gamma GAM Management hf	Landsvirkjun´s Renewable Energy Potential and its Impact on Iceland´s Economy	2011	English	http://www.gamma.is/en/news/nr/1347
117	Moody´s Investors Service	Landsvirkjun Update following publication of Q1 2017 results	2017	English	https://www.landsvirkjun.is/Media/2017-07-moodys-credit-opinion1.pdf
118	Landsvirkjun	Landsvirkjun´s results for the first three months of 2017	2017	English	http://www.landsvirkjun.com/company/mediacentre/news/news-read/landsvirkjuns-results-for-the-first-three-months-of-2017
119	Landsvirkjun	Consolidated Financial Statements 2016	2016	English	https://www.landsvirkjun.is/Media/financial-statements-lv-20161.pdf
120	Landsvirkjun	Financial Statements 2016 - Presentation	2017	English	http://www.landsvirkjun.com/Media/landsvirkjun-2016-financial-results-presentation.pdf

121	Landsvirkjun	Managements´s presentation of the operation of Landsvirkjun, key figures		English	http://www.landsvirkjun.com/finance/keyfigures
122	Standard and Poors	RatingsDirect; Research Update-Icelandic Power Company Landsvirkjun Upgraded to'BBB/A-2'. Following Sovereign Upgrade; Outlook Stable	2017	English	https://www.landsvirkjun.is/Media/landsvirkjun-research-update-jan.-2017.pdf
123	Askja Energy Partners	Alcoa´s tariff in Iceland renegotiated before 2028	2017	English	https://askjaenergy.com/2017/05/20/alcoas-tariff-in-iceland-renegotiated-before-2028/
124	Reval	Landsvirkjun Chooses Reval to Automate Treasury Management	2016	English	https://www.reval.com/landsvirkjun-chooses-reval-automate-treasury-management/
125	Landsvirkjun	Framlög 2016 / *Contributions to various parties 2016*	2017	Icelandic	internal
126	Landsvirkjun	Samningar OAK í gildi / *Fljótsdalsstöð contracts 2017*	2017	Icelandic	internal
127	Landsvirkjun	Skýrsla sumarvinnu Landsvirkjunar Fljótsdalsstöð 2016 / *Report of the summer work group of Landsvirkjun Fljótsdalsstöð 2016*	2016	Icelandic	internal
128	Ferðamálastofa	Tourism in Iceland in Figures - April 2014	2014	English	https://www.ferdamalastofa.is/static/files/ferdamalastofa/Frettamyndir/2014/mai/toursim_in_icland_infigf2014.pdf
129	University of Akureyri Research Centre	Large scale activities and small scale communities (Power Point Presentation)	2010	English	http://www.norden.org/en/search?SearchableText=Hjalti+J%C3%B3hannesson
130	Austurbru	East Iceland: Official Tourist Guide	2016	English	https://www.east.is/en/travel/east-iceland-official-tourist-guide
131	Statistics Iceland	General information	2017	Icelandic/ English	http://www.statice.is/
132	Landsvirkjun	Minnisblað, Bakkavarnir Fljótsbakka – Fljótsdalshéraði / *Memorandum, Riverbank Protection in Fljótsbakki - Fljótdalshérað Municipality*	2017	Icelandic	internal
133	Landsvirkjun	Minnisblað, Bakkarof í landi Fljótsbakka, Eiðaþingá – Fljótdalshéraði / *Riverbank Erosion in land of Fljótbakki, Eiðaþingá - Fjótsdalshérað Municipality*	2015	Icelandic	internal
134	Grétar Þ. Eyþórsson, Hjalti Jóhannesson and Kjartan Ólafsson/ University of Akureyri, Research Center	Kárahnjúkavirkjun, Mat á Samfélagslegumáhrifum/ *Kárahnjúkar Power Plant, Social Impact Assessment (Report)*	2001	Icelandic	https://www.rha.is/static/files/Rannsoknir/2001/karahnjukavirkjun.pdf
135	Landsvirkjun	Fljótsdalsstöð - Viðhald girðinga verksamningur 2016-2018, ásamt	2016	Icelandic	internal

		fylgiskjali/ *Fljótsdalur Power Station - Contract for Maintenance of fences for years 2016-2018, with enclosure*			
136	Byggðastofnun	Hagvöxtur landshluta 2008-2015 / *GDP growth (by regions) 2008-2015*	2017	Icelandic	https://www.byggdastofnun.is/static/files/Hagvoxtur/hagvoxtur_landshluta_2008-2015.pdf
137	Hjalti Jóhannesson et al./ University of Akureyri, Research Center	Social Impacts of an Aluminium Plant in East Iceland 2002-2008. Main Findings	2010	English	https://www.rha.is/static/files/Rannsoknir/2010/Social-impacts_East_Iceland_vs_Maniitsoq_June-2010.pdf
138	Landsvirkjun	Skipulag öryggisstjórnunar hjá Landsvirkjun/ *Landsvirkjun's Safety Management Plan (Diagram)*		Icelandic	internal
139	Landsvirkjun	STE-002 Öryggis-, heilsu og vinnuverndarstefna Landsvirkjunar/ *Landsvirkjun's Safety, Health and Working Environment Policy (Policy Document)*		Icelandic	internal
140	Landsvirkjun	STE-006 Jafnréttisstefna Landsvirkjunar/ *Landsvirkjun's Gender Equality Policy (Policy Document)*		Icelandic	internal
141	Landsvirkjun	STE-024 Starfsmannastefna Landsvirkjunar/ *Landsvirkjun's Human Resource Policy (Policy Document)*		Icelandic	internal
142	Landsvirkjun	VKL-066 Þjálfun og starfsþróun/ *Training and Career Development (Procedure Document)*		Icelandic	internal
143	Landsvirkjun	LV-2016-033 Öryggisskýrsla Landsvirkjunar 2015 / *Annual Safety Report*	2016	Icelandic	https://www.landsvirkjun.is/Media/oryggisskyrsla-lv-2015.pdf
144	Landsvirkjun	Fljótdalsstöð - Kárahnjúkavirkjun (Kynning fyrir sumarvinnuhópa)/ *Fljótsdalur Power Station - Kárahnjúkar Hydropower Plant, Presentation for Summer Employees (Power Point Document)*	2017	Icelandic	internal
145	Landsvirkjun	OHU skráningar - sagan / *HSE records*	2017	Icelandic	internal
146	Landsvirkjun	OHU skráningar samantekt 2 / *HES registration summary 2*	2017	Icelandic	internal
147	Landsvirkjun	Fljótsdalur staff list	2017	Icelandic	internal
148	MATIS	Fljótsdalsstöð neysluvatn / *results drinking water Fljótsdalsstöð 2017*	2017	Icelandic	lab reports for Landsvirkjun
149	MATIS	Inntak Hálslón neysluvatn / Results drinking water 2017 Inntak Hálslón	2017	Icelandic	lab reports for Landsvirkjun

150	MATIS	Inntak Ufsarlón 2017 neysluvatn /Results drinking water 2017 Inntak Ufsarlón	2017	Icelandic	lab reports for Landsvirkjun
151	MATIS	Vesturbakki Hálslón neysluvatn / *results drinking water service house Hálslón*	2017	Icelandic	lab reports for Landsvirkjun
152	Landsvirkjun	Code of Conduct for Suppliers of Landsvirkjun	2015	English	http://www.landsvirkjun.com/Media/code-of-conduct-lv-ensk.pdf
153	Icelandic Confederation of Labour (ASI)	Icelandic Labour Law	2013	English	http://www.asi.is/media/7250/Icelandic_labour_law_-6_utg_.pdf
154	Gallup	Vinnustaðagreining Fljótsdalssvæði 2017 / *Workplace analysis of Fljótsdalur area 2017*	2017	Icelandic	Report for Landsvirkjun
155	Landsvirkjun	Vatnsaflsdeild - Yfirlit rekstrar 2016 / *Hydropower Division - Overview of operations 2016*	2017	Icelandic	internal
156	Landsvirkjun	Fljótsdalsstöð/Orkusvið - Ársfjórðungsskýrsla 2. Ársfjórðungur / *Quarterly Report 2nd quarter*	2017	Icelandic	internal
157	Landsvirkjun	OAK report Q2 2017	2017	English	internal
158	Landsvirkjun	Hættumál 03-2017 / tölfræði fyrstu 6 mánuði ársins 2017 / *Hazards 03-2017 / Statistics for the first 6 months of the year 2017*	2017	Icelandic	internal
159	Landsvirkjun	Operation and progress plan for HSE in Landsvirkjun 2017 - status beginning of September	2017	Icelandic	internal
160	Adolf Friðriksson/ Institute of Archaeology	Fornleifakönnun vegna fyrirhugaðrar virkjunar við Kárahnjúka/ *Archaeological survey due to intended hydropower plant at Kárahnjúkar (Report)*	2001	Icelandic	https://rafhladan.is/bitstream/handle/10802/9754/FS135-00061%20K%C3%A1rahnj%C3%BAkar.pdf?sequence=1
161	Gavin Lucas/ Institute of Archaeology	LV-2007/018 Fornleifauppgröftur á Pálstóftum við Kárahnjúka 2005/ *Archaeological Excavation in Hálslón Reservoir Area (Report)*	2007	Icelandic	http://www.nabohome.org/uploads/fsi/KHN05_Palstoftir.pdf
162	Adolf Friðriksson and Ragnar Edvardsson/ Institute of Archaeology	Kárahnjúkavirkjun - Fornleifar og vatnafar, minnisblað/ *Kárahnjúkar Power Plant - Antiquities and Water Conditions*	2001	Icelandic	Report for Landsvirkjun
163	Cultural Heritage Agency	Kárahnjúkavirkjun. Áhrif breytinga á vatnsborði á fornleifar, bréf til Landsvirkjunar/ *Kárahnjúkar Power Plant. Effect of Changes in Water level on ruins (Letter to Landsvirkjun)*	2007	Icelandic	internal
164	Landsvirkjun	Minnisblað fundur FLJ og Minjastofnun / *Memo meeting of Fljótsdalur and Cultural Heritage Agency*	2014	Icelandic	internal

165	Iceland Review	Ruins discovered at Kárahnjúkar	2005	English	http://icelandreview.com/news/2005/08/10/ruins-discovered-karahnjukar
166	Directorate of Health	Heilbrigðisstofnun Austurlands, úttekt á heilsugæsluþjónustu/ *East Iceland Healthcare Center, assessment on Public Health Service (Report)*	2011	Icelandic	http://www.landlaeknir.is/servlet/file/store93/item2858/4880.pdf
167	Lancet	Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990–2015: a novel analysis from the Global Burden of Disease Study 2015	2017	English	http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(17)30818-8/abstract
168	European Observatory on Health Systems and Policies	Iceland Health system review	2014	English	https://www.ncbi.nlm.nih.gov/pubmed/25720021
169	World Health Organization	Iceland: WHO statistical profile	2015	English	http://www.who.int/countries/isl/en/
170	Central Bank of Iceland	Economy of Iceland	2016	English	https://www.cb.is/library/Skraarsafn---EN/Economy-of-Iceland/2016/Economy_of_Iceland_2016.pdf
171	Ministry of Health and Social Security	The Icelandic National Health Plan to the year 2010	2004	English	https://eng.velferdarraduneyti.is/media/Skyrslur/heilbenska5mai.pdf
172	Steinunn Hilma Ólafsdóttir and Sigmar Arnar Steingrímsson/ Marine Research Institute	LV-2007/074 Kárahnjúkavirkjun. Botndýralíf í Héraðsflóa. Grunnástand fyrir virkjun Jökulsár á Dal og Jökulsár í Fljótdal / *Benthic fauna in the Héraðsflói Bay: A base line study prior to water regulations of the glacier rivers, Jökulsá á Dal and Jökulsá í Fljótsdal, by the Kárahnjúkar hydroelectric plant (Report)*	2007	Icelandic	http://www.hafro.is/Bokasafn/Timarit/fjolrit-141.pdf
173	Landsvirkjun	LV-2012-011 Kárahnjúkavirkjun, Frágangur vinnusvæða/ *Kárahnjúkar Power Plant, Completion of Work Areas (Report)*	2012	Icelandic	http://www.landsvirkjun.is/media/2011/Karahnjukavirkjun_fragangur_vinnusvaeda.pdf
174	Landsvirkjun	LV-2012-069 Kringilsárrani, Rannsóknir á gróðurbreytingum með samanburði gervitunglamynda frá 2002 og 2010/ Kringilsárrani, *Assessment on changes of vegetation with usage of satellite images from years 2002 and 2010 (Report)*	2012	Icelandic	http://www.sjalfbaerni.is/media/2.28-grodur-a-snaefellsoraefum/2012-069-Kringilsarrani,-Rannsoknir-a-grodurbreytingum-med-samanburdi-gervitunglamynda-fra-2002-og-2010.pdf
175	Benóný Jónsson, Friðþjófur Árnason and Ingi Rúnar Jónsson/ Institute of	LV-2013-014 Göngur merktra laxfiska í Lagarfljóti árin 2010-2012/ *Runs of tagged Salmon fish in Lagarfljót River in years 2010-2012 (Report)*	2013	Icelandic	http://gogn.lv.is/files/2013/2013-014.pdf

	Freshwater Fisheries				
176	Iris Hansen, Finnur Ingimarsson et al./ Institute of Freshwater Fisheries and Kópavogur Nature Research Center	LV-2013-068 Kísilþörungar og smádýr í Lagarfljóti 2006-2007/ *Diatoms in Lagarfljót in years 2006-2007 (Report)*	2013	Icelandic	http://www.veidimal.is/files/Skra_0066681.pdf
177	Halldór W. Stefánsson/ East Iceland Nature Research Center	LV-2014-037 Vöktun skúms á Úthéraði 2005-2013/ *Great Skua Monitoring in Úthérað Region, years 2005-2013* (Report)	2014	Icelandic	http://gogn.lv.is/files/2014/2014-037.pdf
178	Halldór W. Stefánsson/ East Iceland Nature Research Center	LV-2014-096 Áhrif Kárahnjúkavirkjunar á grágæsir/ *Impacts of Kárahnjúkar Power Plant on Graylag Gooses (Report)*	2014	Icelandic	http://gogn.lv.is/files/2014/2014-096.pdf
179	Ingi Rúnar Jónsson and Friðþjófur Árnason/ Institute of Freshwater Fisheries	LV-2015-119 Fiskirannsóknir á vatnasviði Lagarfljót og Gilsár 2014/ *Research on Fish in drainage area of Lagarfljót and Gilsá River, year 2014 (Report)*	2015	Icelandic	http://gogn.lv.is/files/2015/2015-119.pdf
180	Guðni Guðbergsson and Eydís Njarðardóttir/ Institute of Freshwater Fisheries	LV-2016-056 Útbreiðsla og ástand seiða í Jökulsá á Dal og hliðarám hennar 2015/ *Distribution and condition of fry in Jökulsá a Dal and tributaries (Report)*	2016	Icelandic	http://gogn.lv.is/files/2016/2016-056.pdf
181	Rúnar Ingi Hjartarson/ Soil Conservation Service of Iceland	LV-2016-117 Gróðurstyrking við Hálslón og á Hraunum, Fljótdalsheiði. Framkvæmdir og framkvæmdavinna 2016/ *Strengthining of Vegetation at Hálslón Reservoir and Hraunum, Fljótsdalsheiði heath. Implementation and methods, year 2016 (Report)*	2016	Icelandic	http://gogn.lv.is/files/2016/2016-117.pdf
182	Rúnar Ingi Hjartarson/ Soil Conservation Service of Iceland	LV-2016-118 Gróðurstyrking í Húsey. Framkvæmdir og Framkvæmdavinna 2016/ *Strengthening of Vegetation in Húsey. Implementation and methods, year 2016 (Report)*	2016	Icelandic	http://gogn.lv.is/files/2016/2016-118.pdf
183	Halldór W. Stefánsson and Skarphéðinn G. Þórisson/ East Iceland Nature	LV-2017-033 Heiðagæsarannsóknir á vatnasviði Kárahnjúkavirkjunar árið 2016/ *Research on Pink-footed Goose in the drainage area of Kárahnjúkar Power Plant, year 2016 (Report)*	2017	Icelandic	http://www.na.is/images/stories/utgefid/2017-2018/NA-170166-2016 LV-2017-033 Heidagaes.pdf

	Research Center				
184	Ingi Rúnar Jónsson et al./ Marine and Freshwater Research in Iceland	LV-2017-044 Rannsóknir á hryggleysingjum á fjörusteinum í Lagarfljóti 2014/ *Invertebrates Monitoring on Shore stones by Lagarfljót River in year 2004 (Report)*	2017	Icelandic	http://www.landsvirkjun.is/Media/rannsoknir-a-hryggleysingjum-a-fjorusteinum-i-lagarfljoti-2014.pdf
185	Sigurður H. Magnússon and Ásta Eyþórsdóttir/ Icelandic Institute of Natural History	NÍ-13006 Gróðurbreytingar 2006-2012 á Hvalbeinsrandarsandi og í Kílamýri í landi Húseyjar á Úthéraði/ *Changes of vegetation in years 2006-2012 in Húsey (Report)*	2013	Icelandic	http://utgafa.ni.is/skyrslur/2013/NI-13006.pdf
186	Halldór W. Stefánsson/ East Iceland Nature Research Center	LV-2017-049 Vatna- og sundfuglar á Jökulsá á Dal og endur á Lagarfljóti og á vörnum á Fljótdalsheiði árið 2016/ *Ducks monitoring in Lagarfljót River and Jökla River (Report)*	2017	Icelandic	http://www.na.is/images/stories/utgefid/LV_skyrslur/NA_170169 - LV_2017-049_Vatna- og sundfuglar.pdf
187	Skarphéðinn G. Þórisson and Rán Þórarinsdóttir/ East Iceland Nature Research Center	NA-160163 Vöktun Náttúrustofu Austurlands 2015 og tillaga um veiðikvóta og ágangssvæði 2016/ *Monitoring on Reindeer, year 2015, and proposal for hunting quotas for year 2016/Report)*	2016	Icelandic	http://gogn.lv.is/files/2016/NA-160163.pdf
188	Guðrún Óskarsdóttir et al./ East Iceland Nature Research Center	LV-2017-054 Gróðurvöktun á Fljótdalsheiði, Samanburður á samsetningu og þekju gróðursins árin 2008 og 2016/ *Vegetation monitoring in Fljótsdalsheiði Heath, Comparison on Combination and Overgrowth in years 2008 and 2016(Report)*	2017	Icelandic	http://na.is/images/stories/utgefid/2017-2018/NA-170170-LV-2017-054%20Grodurvoktun.pdf
189	Eiríkur J. Kjerúlf, Jóhann F. Þórhallsson and Anna Bryndís Tryggvadóttir/ Fljótdsalshreppur Municipality's Land Improvement Fund	Landbjótasjóður Fljótdalshrepps, Ársskýrsla stjórnar 2015/ *Annual Report for year 2015*	2016	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/Landbotasjodur-Fljotsdalshrepps-Arsskyrsla-2015-(1).pdf
190	Land Improvement Fund of Norður Hérað (LBNH)	Landbótasjóður Norður-Héraðs, Ársskýrsla 2016/ *Annual Report for year 2016*	2017	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/Arsskyrsla-LBNH-2016.pdf
191	Land Improvement Fund of Norður Hérað (LBNH)	Landbótasjóður Norður-Héraðs, Ársreikningur 2015/ *Annual Financial Statement for year 2015*	2016	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/Arsskyrsla-LBNH-2015.pdf

192	Fljótdsals-hreppur Municipality's Land Improvement Fund	Landbjótasjóður Fljótdalshrepps, Ársreikningur 2015/ *Annual Financial Statement for year 2015*	2016	Icelandic	internal; general information at http://www.fljotsdalur.is/pages/landbF3tasjF3F0ur.php
193	Dick Vuijk	Plants on Iceland	2017	English	http://www.iceland-nh.net/plants/index.html
194	Sveinn Kári Valdimarsson , Ingi Rúnar Jónsson, Guðni Guðbergson (Landsvirkjun, and Iceland Institute of Freshwater Fisheries)	Tale of two Rivers. The largest Hydro Project in Iceland and its Influence on two Rivers (11th International Symposium on Ecohydraulics)	2016	English	http://proceedings.ise2016.org/tracks/1017/abstract/26592.html
195	Landsvirkjun	LV-2015-061: Útbreiðsla og ástand seiða í Jökulsá á Dal og hliðarám hennar 2014/ *Distribution and condition of salmonids in Jökulsá á Dal and tributaries 2014*	2015	Icelandic	https://umhverfisskyrsla2015.landsvirkjun.is/skjologutgafa
196	Landsvirkjun	LV-2015-071: Vatna- og sundfuglar á Jökulsá á Dal og endur á Lagarfljóti og á vötnum á Fljótsdalsheiði árið 2014/ *Waterbirds on Jökulsá á Dal and ducks on Lagarfljót and on lakes in Fljótsdalsheiði in 2014*	2015	Icelandic	https://umhverfisskyrsla2015.landsvirkjun.is/skjologutgafa
197	Landsvirkjun	LV-2015-068: Heiðagæsir á vatnasviði Kárahnjúkavirkjunar árið 2014/ *Pink-footed geese on Kárahnjúkar's waterways in 2014*	2015	Icelandic	https://umhverfisskyrsla2015.landsvirkjun.is/skjologutgafa
198	Bern Convention Standing Committee	Hydropower Development in Iceland: Damage to habitats and species of European importance Report by the NGOs	2003	English	https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=1326823&SecMode=1&DocId=1440846&Usage=2
199	Landsvirkjun	LV-2013-077 Áhrif Kárahnjúkavirkjunar á grunnvatnsstöðu við Hálslón og á Fljótdalsheiði/ *Impact of Kárahnjúkar Power Plant on Groundwater around Hálslón Reservoir Area and at Fljótsdalsheiði Heath (Report)*	2013	Icelandic	https://rafhladan.is/handle/10802/7022
200	Egill Axelsson/ Landsvirkjun	Minnisblað, Grunnvatnsmælingar í Fljótsdal og á Úthéraði 2015 og 2016/ *Memorandum, Groundwater Monitoring in Fljótdalur and in Úthérað Region, years 2015 and 2016*	2017	Icelandic	internal
201	Egill Axelsson/ Landsvirkjun	Minnisblað, Grunnvatnsmælingar í Húsey 2016/ *Memorandum, Groundwater Monitoring in Húsey, year 2016*	2017	Icelandic	internal

202	Landsvirkjun	LV-2014-021 Breytingar á grunnvatns-og jarðvatnsborði á áhrifasvæði Kárahnjúkavirkjunar / *Groundwater changes in the Kárahnjúkar area*	2014	Icelandic	https://rafhladan.is/handle/10802/10293
203	Björn Sigurbjörnsson and Sveinn Rúnólfsson/ Soil Conservation Service of Iceland	Hefting áfoks úr Hálslóni með vökvun lónsstæðis, Tillaga til Landsvirkjunar/ *Impediment of Sand from Hálslón Reservoir with Irrigation, Proposal to Landsvirkjun*	2006	Icelandic	internal
204	Landsvirkjun	LV-2012-007 Hálslón 2011, Kortlagning strandsvæða/ *Hálslón Reservoir - year 2011, Mapping of Coast (Report)*	2012	Icelandic	https://rafhladan.is/handle/10802/8601
205	Landsvirkjun	LV-2012-085 Fljótsdalsstöð, Ný aðferð til að meta uppfok úr Hálslóni/ *Fljótsdalur Power Station, New Method to Evaluate Dust in Hálslón Reservoir*	2012	Icelandic	internal
206	Gerður Guðmunds-dóttir/ East Iceland Nature Research Center	LV-2014-042 Fallryksmælingar við Hálslón og í byggð á Fljótsdalshéraði sumarið 2013/ *Monitoring of Airborn Dust at Hálslón Reservoir and in Residential Area in in Fljótdalshérað Municipilaity, summer 2013 (Report)*	2014	Icelandic	https://rafhladan.is/handle/10802/7020?show=full
207	Elín Fjóla Þórarinsdóttir et al./ Soil Conservation Service of Iceland	LV-2014-094 Úttekt og mælingar á áfoki við strönd Hálslóns/ *Aeolian Monitoring at the Coast of Hálslón Reservoir, year 2014 (Report)*	2014	Icelandic	http://gogn.lv.is/files/2014/2014-094.pdf
208	Jóhann Þórsson and Ágústa Helgadóttir/ Soil Conservation Service of Iceland	LV-2014-121 Vöktun á áfoki í Kringilsárrana/ *Aeolian Monitoring at Kringilsárrani Area (Report)*	2014	Icelandic	https://rafhladan.is/bitstream/handle/10802/8880/2014-121.pdf?sequence=1
209	Elín Fjóla Þórarinsdóttir, Ágústa Helgadóttir and Jóhann Þórsson / Soil Conservation Service of Iceland	LV-2016-119 Úttekt og mælingar á áfoki við strönd Hálslóns/ *Aeolian Monitoring at the Coast of Hálslón Reservoir, year 2016 (Report)*	2016	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/LV_2016_119_afok_2.29.pdf
210	Gunnar Guðni Tómasson and Hrafnhildur Brynjólfsdóttir/ Verfræðistofa Sigurðar Thoroddsen hf.	LV-2005/ 087 Mælingar á bökkum við Lagarfljót neðan Lagarfoss og Jökulsár á Dal við Húsey/ *Measurements on Lagarfljót riverbanks, below Lagarfoss and Jökulsá á Dal - Ground state (Report)*	2005	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/2.4-rof-i-arbakka-grunnastand-fyrir-tilkomu-virkjunar-skyrsla.pdf

211	Ólöf Rós Káradóttir and Hrafnhildur Brynjólfsdóttir/ Verfræðistofa Sigurðar Thoroddsen hf.	LV-2008/067 Héraðsflói - Vöktun strandar, Grunnástand/ *Héraðsflói region - Coast Monitoring, Ground State (Report)*	2008	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/KAR-Strond-Heradsfloa-grunnastand-2008_067.pdf
212	Elín Fjóla Þórarinsdóttir and Sigurjón Einarsson/ Soil Conservation Service of Iceland	LV-2012-109 Skráning á landbroti á bökkum Lagarfljóts og Jökulsár í Fljótsdal/ *Land Erosion Registration in Lagarfljót riverbanks and Jökulsár River in Fljótsdalur (Report)*	2012	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/2012-109-Skraning-a-landbroti-a-bokkum-Lagarfljots-og-Jokulsar-i-Fljotsdal.pdf
213	Landsvirkjun	LV-2014-050 Sniðmælingar Hálslóns sumarið 2013/ *Measurements on Hálslón Reservoir, summer 2013 (Report)*	2014	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/LV_2014_050_SnidmaelingarHalsloni2013.pdf
214	Jórunn Harðardóttir and Svava Björk Þorláksdóttir/ MetOffice	Yflirlit yfir svifaursmælingar samkvæmt samningum við Landsvirkjun árið 2016/ *Suspended Stream Load Monitoring in accordance to contracts with Landsvirkjun, year 2016*	2017	Icelandic	Report for Landsvirkjun
215	Eydís Salome Eiríksdóttir/ University of Iceland	Weathering and riverine fluxes in pristine and controlled river catchments in Iceland *(Doctoral thesis)*	2016	English	https://skemman.is/bitstream/1946/23831/1/Eyd%c3%ads Salome Eir%c3%adksd%c3%b3ttir.final.prenta%c3%b0.loka%c3%batg%c3%a1fa.pdf
216	Landsvirkjun / Svarmi	Heradsfloi strond ós 6 7 2017 loftmynd LV Svarmi 2016 / *Heradsfloi coast / river mouth aerial photo*	2017	Icelandic	internal
217	Ólafur Arnalds, Pavla Dagsson-Waldhauserova , Haraldur Ólafsson	The Icelandic volcanic aeolian environment: Processes and impacts. A review	2016	English	http://www.sciencedirect.com/science/article/pii/S187596371530015X
218	Landsvirkjun	130603 Fögruhlíðará/ *Memo movement of Lagarfljót river estuary*	2013	Icelandic	internal
219	Landsvirkjun	Færsla óss Lagarfljóts og Jöklu Verklokaskýrsla/ *Movement of Lagarfljót and Jökla Closing Report*	2015	Icelandic	internal
220	Landsvirkjun	Hagsmunaaðilagreining fyrir framkvæmdir við ós Lagarfljóts og Jöklu/ *Stakeholder analysis for construction on Lagarfljót and Jöklu*		Icelandic	internal
221	Ólafur Arnalds and B.H. Barkarsonn	Soil erosion and land use policy in Iceland in relation to sheep grazing and government subsidies (article in Environmental Science & Policy)	2003	English	http://www.sciencedirect.com/science/article/pii/S1462901102001156
222	Environment Agency	Kringilsárrani stjórnunar- og verndaráætlun 2017-2026 / *Kringilsárrani; management and protection plan*	2017	Icelandic	To be published
223	Ólafur Arnalds,	LV - 2010-088 Gróðurrannsóknir vegna	2010	Icelandic	https://rafhladan.is/handle/10802

	Ása L. Aradóttir and Kristín Svavarsdóttir / Agricultural University of Iceland	hættu á áfoki Hálslón / *Vegetation studies due to risk of aeolian deposition*			/9376
224	University of Akureyri	Helstu uppfoksstaðir jarðvegs á Austurlandi og möguleikar á að meta uppfok og mistur frá þeim / *The main drifting sites of soil in East Iceland and the possibility of evaluating drifting and fogging from them*	2013	Icelandic	https://skemman.is/bitstream/1946/15252/1/Ritger%C3%B0%20-%20Loka%20-%20Sandra.pdf
225	MetOffice	Yfirlit yfir svifaursmælingar samkvæmt samningum við Landsvirkjun árið 2012 / *Summary of silt measurements*	2013	Icelandic	Report for Landsvirkjun
226	Pascale Louvat, Sigurdur Reynir Gislason, and Claude Jean Allegre	Chemical and mechanical erosion rates in Iceland as deduced from river dissolved and solid material (article in American Journal of Science)	2008	English	https://notendur.hi.is/sigrg/greinar_pdf/Louvat.et.al.AJS.2008_Island e.pdf
227	Johanna Hardardottir	Recent development of sediment monitoring of glacial rivers in Iceland		English	http://www.comm-tec.com/Library/Technical_Papers/Various/p18Hardardottir.pdf
228	J. Hardardottir, S.B. Thorlaksdottir and A. Snorrason	New Evaluation of suspended Sediment Load in Icelandic Rivers (article in Geophysical Research Abstracts)	2005	English	http://www.cosis.net/abstracts/EGU05/08793/EGU05-J-08793.pdf
229	Ása L. Aradóttir	Lessons fram a century of erosion control and restoration in Iceland (slides)	2011	English	http://www.bioforsk.no/ikbViewer/Content/91206/Aradottir%20Island%20ECONADA%20Fl%C3%A5m.pdf
230	Landsvirkjun	Memo: Umhverfisáhrif KAR á láglendi-Mótvægisaðgerðir vegna landbrots / *Memo: Environmental impact of KAR on lowlands- Environmental measures for land degradation*	2017	Icelandic	internal
231	Jórunn Harðardóttir and Svava Björk Þorláksdóttir/ MetOffice	Yflirlit yfir svifaursmælingar samkvæmt samningum við Landsvirkjun árið 2016/ *Suspended Stream Load Monitoring in accordance to contracts with Landsvirkjun, year 2016*	2017	Icelandic	Report for Landsvirkjun
232	Eydís Salome Eiríksdóttir o.fl. / Institute of Earth Sciences	Direct evidence of the feedback between climate and nutrient, major, and trace element transport to the oceans	2015	English	http://www.sciencedirect.com/science/article/pii/S0016703715003889
233	Eydís Salome Eiríksdóttir o.fl. / Institute of Earth Sciences	The impact of damming on riverine fluxes to the ocean - A case study from Eastern Iceland	2017	English	http://www.sciencedirect.com/science/article/pii/S0043135416309708

234	Eydís Salome Eiríksdóttir o.fl. / Institute of Earth Sciences	Áhrif eldgossins í Bárðarbungu 2014–2015 á efnasamsetningu og framburð Fellsár í Fljótsdal / *The impact of the volcanic eruption in Bárðarbunga 2014-2015 on the chemical composition and depostition of Fellsár í Fljótsdalur (draft)*	2017	Icelandic	draft for publication
235	Landsvirkjun	Gruggsýni samantekt 2017 / *Turbidity samples 2017*	2017	Icelandic	internal
236	Andri Gunnarsson, Theódór Theódórsson, Ragnar Þórhallsson, Jón Búi Xuyi, Gunnar Þór Jónsson / Landsvirkjun	Sniðmælingar Hálslóns sumarið 2013 / *Measurement on Hálslón reservoir 2012*	2014	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/LV_2014_050_SnidmaelingarHalsloni2013.pdf
237	Departement de Genie Civil Institut d'Hydraulique et d'énergie	2001-169 Karahnjukar Hydroelectric Project waterways	2001	English	internal
238	Landsvirkjun	LEI-220 Fastbundnar takmarkanir fyrir Fljótsdalsstöð / *LEI-220 Fixed restrictions for Fljótsdalur station*		Icelandic	internal
239	Landsvirkjun	Press release - Halslon Reservoir fills up	2013	English	http://www.landsvirkjun.com/company/mediacentre/news/news-read/halslon-reservoir-fills-up
240	Landsvirkjun	The status of Landsvirkjun´s water supply (Power Point Presentation)	2013	English	internal
241	Landsvirkjun	LV-2008/089 Áhrif Kárahnjúkarvirkjunar á fossa/ *Kjárahnjúkar Power Plant's Effects on Waterfalls*	2008	Icelandic	http://www.sjalfbaerni.is/media/visar/austurland/umhverfi/skyrsla-ahrif-Karahnjukavirkjuar-a-fossa.pdf
242	Landsvirkjun	LV-2012-099 Áhrif Kárahnjúkavirkjunar á vatnsborð og grunnvatn á láglendi á Héraði/ *Impact of Kárahnjúkar Power Plant on Water Level and Groundwater in the regional lowlands*	2012	Icelandic	http://www.vedur.is/media/vedurstofan/utgafa/skyrslur/2012/2012_007.pdf
243	Landsvirkjun	LV-2014-074 Endurmat á gegnsæi í Lagarfljóti fyrir og eftir gangsetningu Kárahnjúkavirkunar/ *Revaluation of Silt in Lagarfljót river, before and after Kárahnjúkar Power Plant commissioning*	2014	Icelandic	http://gogn.lv.is/files/2014/2014-074.pdf
244	Landsvirkjun	LV-2014-075 Hiti í Hálslóni og frárennsli Fljótsdalsstöðvar 2009-2012/ *Water Temperature in Hálslón Reservoir and tailrace water from Fljótsdalur Power Plant, years 2009-2012*	2014	Icelandic	https://umhverfisskyrsla2014.landsvirkjun.is/tolulegt-bokhald-og-skyrslur/utgefnar-skyrslur
245	Landsvirkjun	LV-2014-076 Vatnshiti í Lagarfljóti fyrir og eftir gangsetningu Kárahnjúkavirkjunar/ *Water Temperature in Lagafljót River, before*	2014	Icelandic	http://gogn.lv.is/files/2014/2014-076.pdf

		and after Kárahnjúkar Power Plant commissioning			
246	Þórhildur Guðmundsdóttir/ Verkis	Minniblað, Vatnsborð í Lagarfljóti/ *Memo: Waterlevel in Lagarfljót River*	2014	Icelandic	internal
247	Egill Axelsson/ Landsvirkjun	Minnisblað, Grunnvatnsmælingar í Fljótdal og á Úthéraði 2015 og 2016/ *Memorandum, Groundwater Monitoring in Fljótdalur and in Úthérað region, years 2015 and 2016*	2017	Icelandic	internal
248	Egill Axelsson/ Landsvirkjun	Minnisblað, Grunnvatnsmælingar í Húsey 2016/ *Memorandum, Groundwater Monitoring in Húsey, year 2016*	2017	Icelandic	internal
249	Andri Gunnarsson and Theódór Theódórsson/ Landsvirkjun	Minnismiði, Mælingar í Lagarfljóti sumarið 2012/ *Memo, Transects in Lagarfljót River, summer 2012*	2012	Icelandic	internal
250	Árni Óðinsson/ Landsvirkjun	160331 minnisblað fundur FLJ, Laugarfell og Óbyggðasetur Austurlands / *Memo meeting 2016*	2016	Icelandic	internal
251	Landsvirkjun	Stakeholders for flushing of Ufsarlón	2017	Icelandic	internal
252	Landsvirkjun	LV-2014-004 Mat á jarðvegsrofi í Kringilsárrana / *Assessment of soil erosion in the Kringilsárrana*	2014	Icelandic	http://gogn.lv.is/files/2014/2014-004.pdf
253	Landsvirkjun	LV-2010-062 Gróðurvöktun á Vesturöræfum, Kringilsárrana og Fljótsdalsheiði með notkun gervitunglamynda. Samanburður á milli ára 2002, 2007 og 2008/ *Vegetation monitoring at Vesturöræfi, Kringilsárrana and Fljótsdalsheiði using satellite satellites, comparison between the years of 2002, 2007 and 2008.*	2010	Icelandic	http://www.na.is/images/stories/utgefid/LV_skyrslur/NA-100102-LV-2010-062.pdf
254	Icelandic Institute of Natural History	Áhrif Lagarfossvirkjunar og Kárahnjúkavirkjunar á gróður og landbrot við Lagarfljót 1976-2014 / *Impacts of Lagarfoss and Kárahnjúkar power Plans on vegetation and erosion at Lagarfljót 1976-2014.* Report to Orkusalan.	2016	Icelandic	http://utgafa.ni.is/skyrslur/2016/NI-16001.pdf
255	Soil Conservation Service of Iceland	Lr-2014-08 Náttúrufar og landgræðsluþörf íKringilsárrana / *Natural resources and soil conservation needs in Kringilsárrani*	2014	Icelandic	http://land.is/wp-content/uploads/2015/11/Lr-2014_08.-N%C3%A1tt%C3%BArufar-og-landgr%C3%A6%C3%B0slu%C3%BE%C3%B6rf-%C3%AD-Kringils%C3%A1rrana-mars-2014.pdf
256	Landsvirkjun	LV-2016-064 Gróðurvöktun í Kringilsárrana – Samanburður á samsetningu og þekju gróðursárin 2006 og 2015 / *Vegetation monitoring in the*	2014	Icelandic	http://gogn.lv.is/files/2016/2016-064.pdf

		Kringilsárrana – Comparison of composition and coverage of flora between 2006 and 2015			
257	Fljótsdals-hreppur Municipality	Meeting minutes	2017	Icelandic	http://fljotsdalur.is/
258	Fljótsdalshérað Municipality	Meeting minutes	2017	Icelandic	http://egilsstadir.is/
259	Leitir	Online national database and archive	2017	Icelandic / English	https://leitir.is
260	Cultural Heritage Agency	General Information	2017	Icelandic/ English	http://en.minjastofnun.is/
261	Pavla Dagsson-Waldhauserova , Agnes Ösp Magnusdottir, Haraldur Olafsson, Olafur Arnalds	The Spatial Variation of Dust Particulate Matter Concentrations during Two Icelandic Dust Storms in 2015	2016	English	http://www.mdpi.com/2073-4433/7/6/77/pdf
262	Bjarni Jónasson, Einar Rafn Haraldsson, Hildigunnur Svavarsdottir, Jón Helgi Þorarinsson, Sigurðsson, Stefán Þorarinsson	Recruitment and Retention of Health Care Providers in Remote Rural Areas: Status report for Iceland	2011	English	http://www.recruitandretain.eu/uploads123/status_report_from_Iceland.docx
263	Directorate of Health	Health care statistics	2017	Icelandic/ English	https://www.landlaeknir.is/english/statistics/
264	MetOffice	General information on hydrology, water quality etc.	2017	Icelandic/ English	http://en.vedur.is/

Appendix D: Visual Evidence

Photo 1: Surface melting on Eyjabakkajökull outlet glacier

Photo 2: Part of the assessment team and guides with physical model of the scheme

Photo 3: Participants in field trip in front of Snaefell mountain

Photo 4: Edge of Eyjabakkajökull, with warning sign

Photo 5: Runoff from Eyjabakkajökull

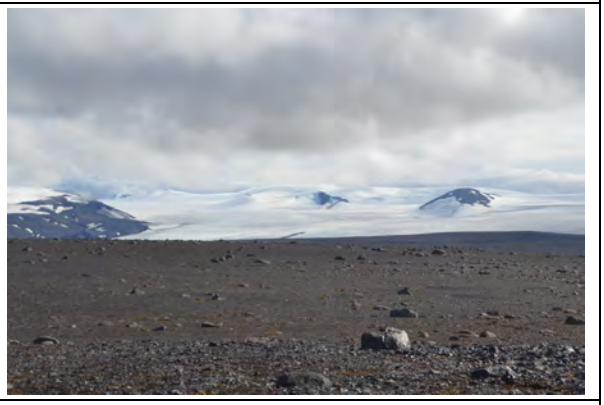

Photo 6: Vatnajökull ice cap

Photo 7: Eyjabakkajökull outlet glacier, eastern part of catchment

Photo 8: Brúarjökull outlet glacier, western part of catchment, with tail end of Halslón reservoir

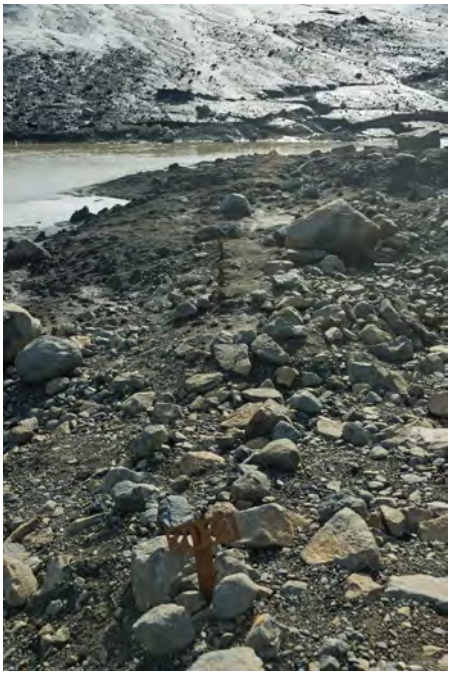

Photo 9: Annual retreat of Eyjabakkajökull outlet glacier (2013 sign in foreground)

Photo 10: Halslón reservoir access restrictions

Photo 11: Bank material, Halslón reservoir eastern shoreline

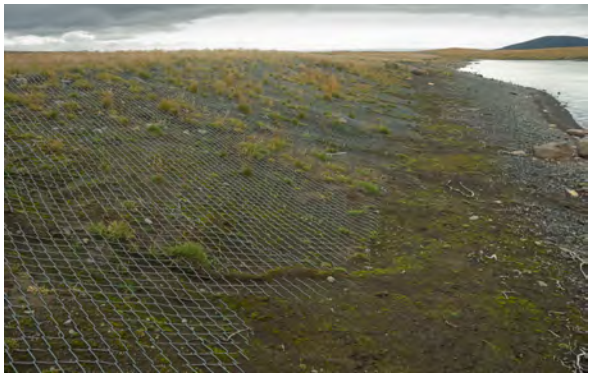

Photo 12: Bank-erosion protection on eastern shore of Halslón

Photo 13: Sediment traps for wind-eroded material, eastern shore of Halslón

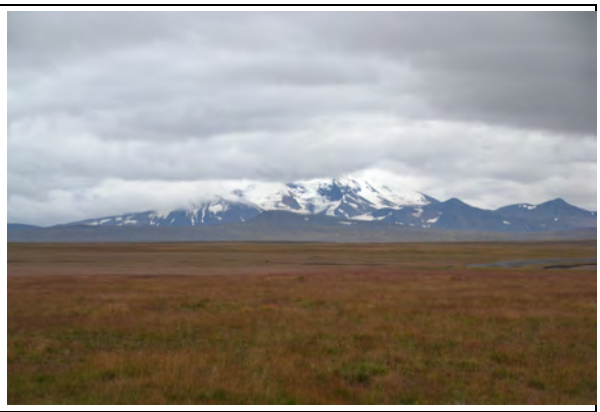

Photo 14: View across rehabilitated land to Snaefell

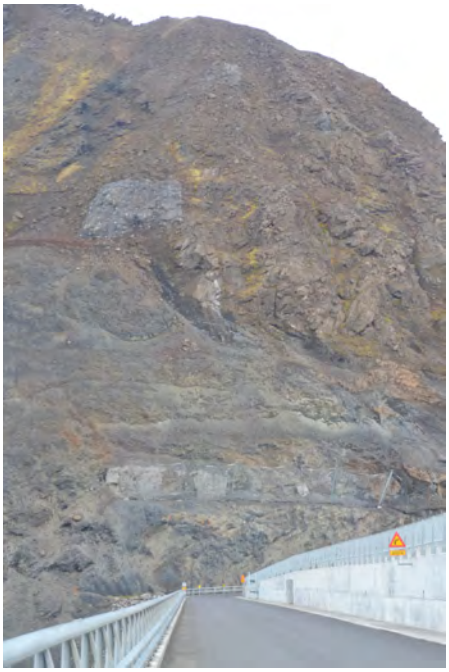

Photo 15: Road across Kárahnjúkar dam with rock fall protection fencing and netting

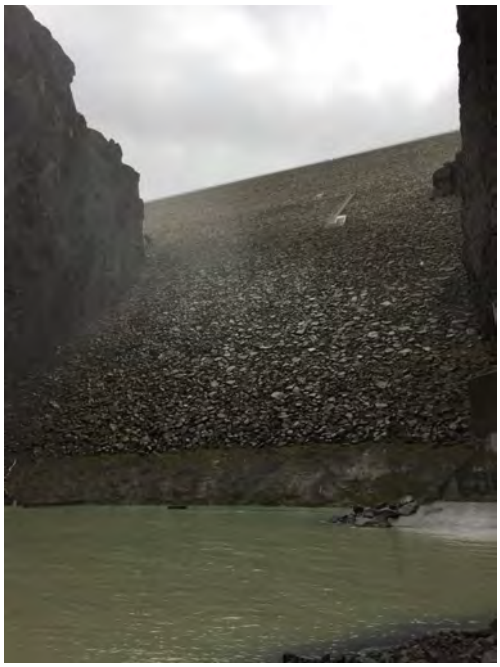

Photo 16: Downstream face of Kárahnjúkar dam

Photo 17: Picnic tables and interpretative signs at Kárahnjúkar dam, artwork in background

Photo 18: Fencing on Kárahnjúkar mountain to protect road users from rock fall

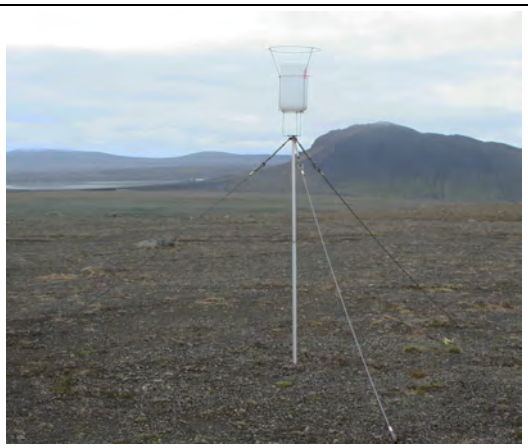

Photo 19: Dust meter with Kárahnjúkar mountain in background (photo: Landsvirkjun)

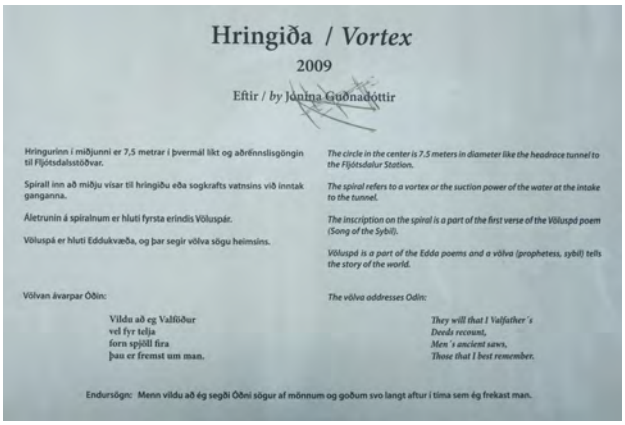

Photo 20: Explanation of the 'Vortex' art work at Kárahnjúkar dam

Photo 21: Diversion tunnel lower end, Kárahnjúkar dam

Photo 22: Bottom outlet lower end, Kárahnjúkar dam

Photo 23: Desjará saddle dam with Kárahnjúkar mountain and Halslón intake on left

Photo 24: Fuse plug section of Desjará dam

Photo 25: Concrete barrier between fuse plug and main part of Desjará dam

Photo 26: Safety signs at Kárahnjúkar spillway

Photo 27: Kárahnjúkar dam ungated spillway

Photo 28: Kárahnjúkar spillway in operation

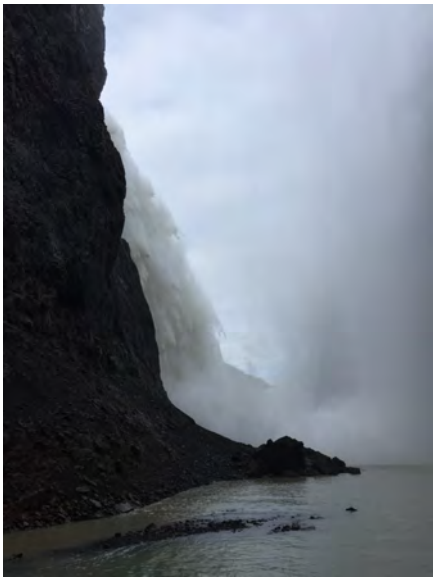

Photo 29: View of Kárahnjúkar dam spilling from bottom of Hafrahvammar canyon

Photo 30: Advert for hiking tours in Hafrahvammar canyon

Photo 31: Hafrahvammar canyon below the Kárahnjúkar dam

Photo 32: Snaefell mountain from the west

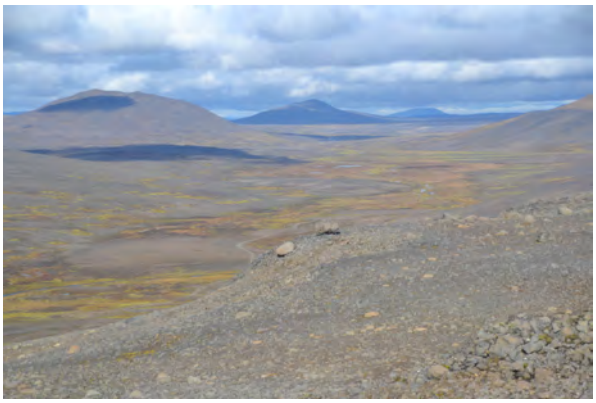

Photo 33: Part of Vatnajökull National Park

Photo 34: Grjótá diversion pond

Photo 35: Grjótá overflow spillway

Photo 36: Grjótá dam bottom outlet

Photo 37: Kelduarlón reservoir with inflow from Grjótá in foreground and spillway on right

Photo 38: Arctic Char in Kelduarlón reservoir

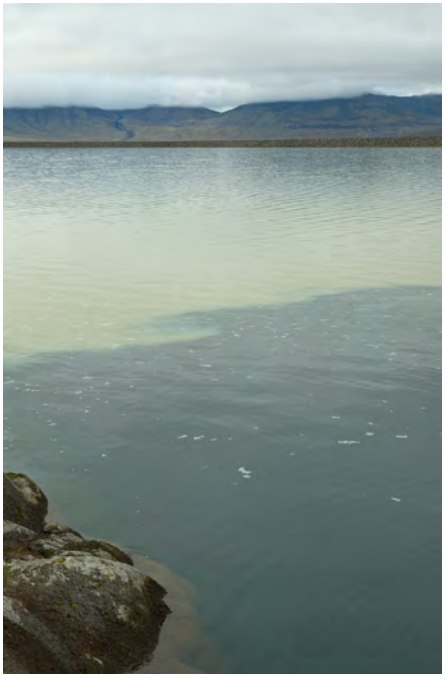

Photo 39: Difference between glacial and non-glacial runoff, Kelduarlón reservoir

Photo 40: Spilling warning signage

Photo 41: Kelduarlón spillway with seepage monitoring in foreground

Photo 42: Kelduar dam downstream face

Photo 43: Kelduar dam seepage monitoring weir

Photo 44: Kelduar dam instrumentation building

Photo 45: Ufsarlón intake reservoir

Photo 46: Revegetated area near Ufsarlón, overview

Photo 47: Revegetated area near Ufsarlón, close-up

Photo 48: Sheep grazing on revegetation area

Photo 49: Safety fencing for sheep at Ufsarlón dam

Photo 50: Ufsarlón intake gate house blending into landscape

Photo 51: Safety barriers at intake gate house

Photo 52: Individual safety locks for work on equipment in intake gate house

Photo 53: Medical emergency signage

Photo 54: Self-illuminating emergency exit signage

Photo 55: Operator handbook attached to controls

Photo 56: Oil spill equipment

Photo 57: Heating system for Ufsarlón intake gate

Photo 58: Ufsarlón intake gate closed for full river flow

Photo 59: Blocked Ufsarlón reservoir access and septic tank ventilation

Photo 60: Spill from Ufsarlón into Jökulsa i Fljótsdal river

Photo 61: Signage and fencing at tunnel access

Photo 62: Interpretive sign at pressure tunnel adit 1

Photo 63: Road restricted to LV staff and local farmers

Photo 64: Art work on ventilation shaft

Photo 65: Laugarfell highland hostel and start of walking trails to waterfalls

Photo 66: Laugarfell hostel

Photo 67: Meteorological station at Laugarfell

Photo 68: Fljótsdalur power station entry registry

Photo 69: Electric car in powerhouse access tunnel

Photo 70: Signage in access tunnel

Photo 71: Boat for powerhouse flooding emergencies

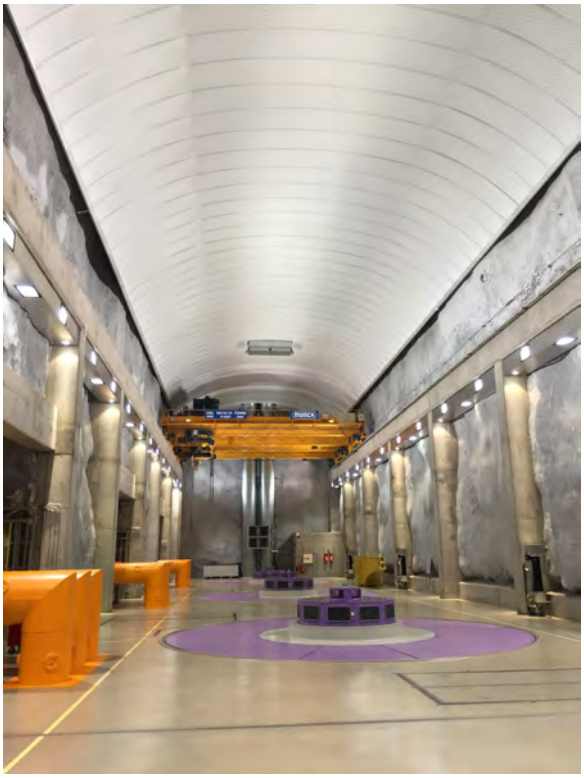

Photo 72: Machine hall

Photo 73: Machine hall with spare runner seen from visitor room, with explanatory diagrams on glass separation

Photo 74: Generator cover

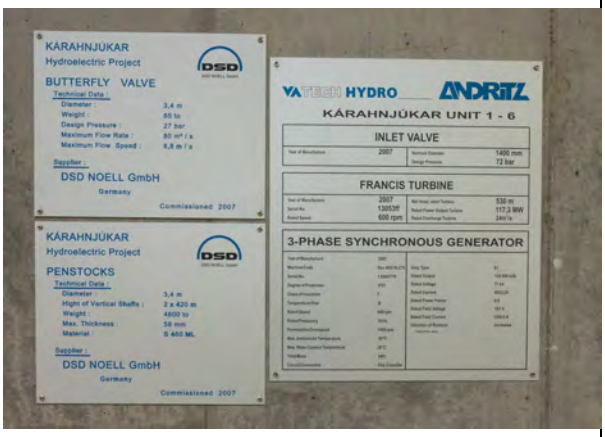

Photo 75: Manufacturer's technical data

Photo 76: Rock bolts and instrumentation on machine hall wall

Photo 77: Air filters for oil mist in machine hall

Photo 78: Ventilation, firefighting equipment, safety masks, alarms in machine hall

Photo 79: Turbine inlet valve

Photo 80: Reflective tape with escape route directions

Photo 81: Fire detector and sprinkler on generator level

Photo 82: First aid instructions for eye injuries

Photo 83: Safety signage

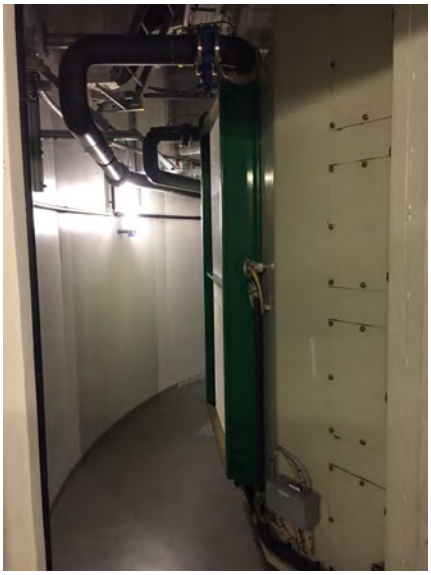

Photo 84: Generator access

	
Photo 85: Generator controls	Photo 86: Argon fire extinguishing system
	
Photo 87: Generating unit shaft	Photo 88: Flooding and fire alarms
	
Photo 89: Cable ducts from machine hall to transformer hall	Photo 90: Underground transformer

Photo 91: Fire safety doors in transformer hall

Photo 92: Emergency escape route from powerhouse through cable tunnel

Photo 93: Beginning of cable tunnel

Photo 94: Cable tunnel

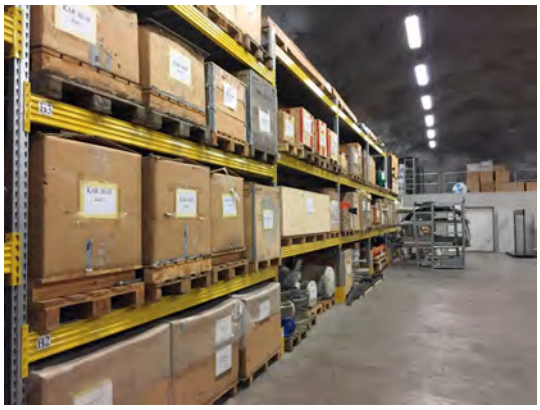

Photo 95: Spare parts storage

Photo 96: Fljótsdalur power station tailrace channel with art work

Photo 97: Fljótsdalur power station's tailrace channel (front), Jökulsa í Fljótsdal and Kelduár River in the background

Photo 98: Aboveground buildings at Fljótsdalur power station (aerial photo: Landsvirkjun). From left to right: switchgear building, service building, workshop building, and access tunnel entrance

Photo 99: Workshop

Photo 100: Meeting room in service building

Photo 101: Canteen

Photo 102: Office

Photo 103: Staff accommodation

Photo 104: Staff recreation room

Photo 105: Staff recreation room 2

Photo 106: Staff gym

Photo 107: Staff sauna

Photo 108: Staff hot tub

Photo 109: Fire alarm zoning

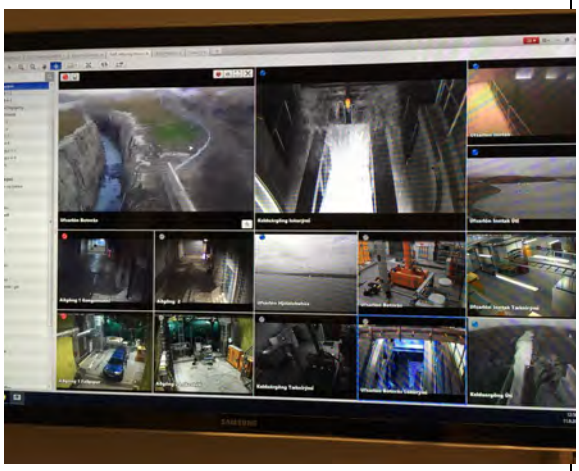

Photo 110: Remote camera controls

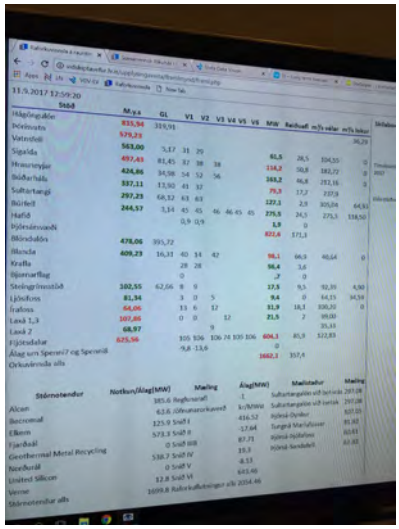

Photo 111: Online real time data from Landsvirkjun's control system

Photo 112: Original OHSAS 18001 certificate, on display in service building

Photo 113: Original ISO 14001 certificate, on display in service building

Photo 114: Original ISO 9001 certificate, on display in service building

Photo 115: PPE in service building

Photo 116: Switchgear house avalanche protection

Photo 117: Beginning of 220 kV transmission lines to Fjardaál

Photo 118: Parallel transmission lines over Jökulsa í Fljótsdal river

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Photo 120: Alcoa Fjardaál smelter

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Photo 122: View across Lagarfljót towards east

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Photo 124: Defunct tourist boat 'Wyrm' on Lagarfljót lakeshore

Photo 125: Bank-erosion protection on Lagarfljót lakeshore near Egilsstadir

Photo 126: Bank-erosion protection on Lagarfljót lakeshore near Egilsstadir 2

Photo 127: Original Egilsstadir farm and hotel on edge of Lagarfljót lake

Photo 128: Museum, library and local archive in Egilsstadir

Photo 129: Information on reindeer monitoring in Egilsstadir museum

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Photo 132: Lagarfoss fish ladder

Photo 133: Lagarfoss fish ladder

Photo 134: Original river channel at Lagarfoss (no migration obstacle)

Photo 135: Bank erosion on Lagarfljót river downstream from Lagarfoss

Photo 136: Remains of old farmhouse in distance, close to riverbank

Photo 137: Sign about soil conservation efforts at Héradssöndum

Photo 138: Sign about wildlife of coastal plain

	
Photo 139: Lagarfljót river near mouth	