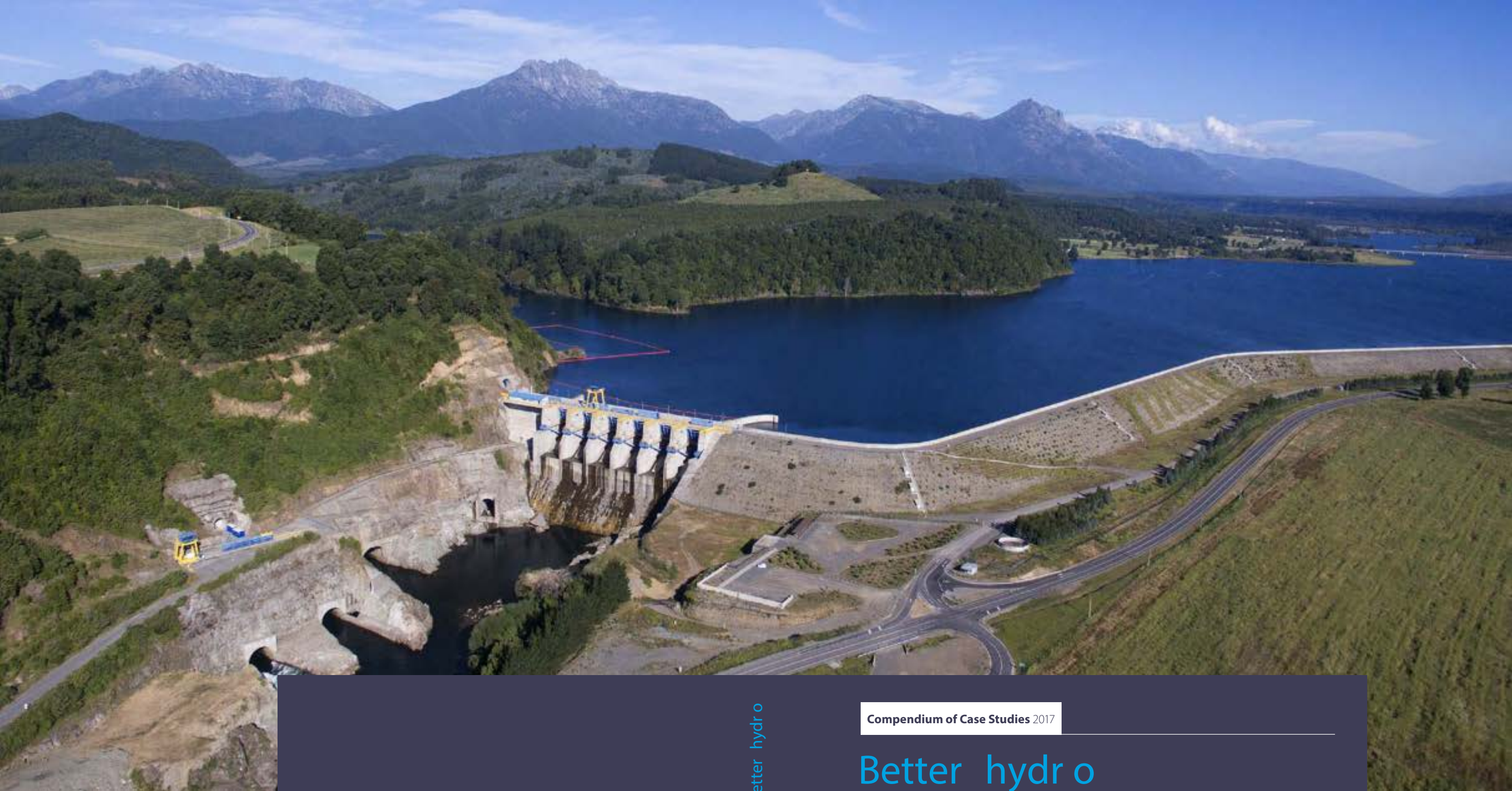




iha Better hydro

Compendium of Case Studies 2017

Better hydro

Better **understanding**,
Better **examples**,
Better **policies**.

www.hydropower.org/better-hydro



Editorial information

Better Hydro: Compendium of Case Studies 2017 was produced by the team at IHA central office in collaboration with the World Bank Group, Hydropower Sustainability Assessment Protocol accredited assessors and project owners.

The following organisations have contributed to writing and editing the case studies presented in this publication:

- AF Consult
Central Asia Regional Economic Cooperation (CAREC)
Colbún S.A.
Électricité de France (EDF)
Empresa de Servicios Públicos de Colombia (EPM)
Generadoras de Chile
Inter-American Development Bank

- International Finance Corporation (IFC)
ISAGEN
Kabeli Energy Limited
Landsvirkjun
Itaipu Binacional
Manitoba Hydro
Santo Antônio Energia
Sarawak Energy
Statkraft
Odebrecht
Uniper

With contributions from:
Albert Koch
Doug Smith
Eduard Wojczynski

Disclaimer

With respect to any information available from this publication, neither IHA, nor its employees or members, make any warranty, express or implied, including warranties of merchantability and fitness for a particular purpose, nor does IHA assume any legal liability or responsibility for the accuracy, completeness or usefulness of any information, product or process disclosed, nor does IHA represent that its use would not infringe upon privately owned rights.

Copyright

© 2017 International Hydropower Association Limited. The "International Hydropower Association" name and logo are the property of International Hydropower Association Limited, a not-for-profit company limited by guarantee, incorporated in England (No. 08656160), the operator of the International Hydropower Association.
Contact: iha@hydropower.org www.hydropower.org
All rights reserved. No part of this publication may be reproduced, stored or transmitted without the prior permission of the publisher.

Contents

Forewords	4
Topic case studies	8
A collection of 24 case studies examining good-practice examples of specific aspects of hydropower development.	
Project case studies	64
Hydropower projects from around the world that have demonstrated overall good practice in sustainable development.	
Initiative case studies	86
Examples of broader schemes undertaken in relation to hydropower projects to address commonly problematic development challenges.	

“Hydropower can only deliver to its full potential if developed responsibly and in collaboration with a broad range of stakeholders.”

Forewords

Better Hydro: Compendium of Case Studies 2017 is a collaboration between the International Hydropower Association and the World Bank Group



Welcome to *Better Hydro: Compendium of Case Studies 2017*, a publication that compiles and highlights examples of sustainability in hydropower, encompassing all aspects of project development from a variety of local and regional contexts around the world.

In a world facing the pressures of population growth, complex water and energy challenges, and a changing climate, the tangible benefits that hydropower can provide to society are possibly greater today than they ever have been.

Hydropower can only deliver to its full potential if developed responsibly and in collaboration with a broad range of stakeholders. A much richer dialogue within the hydropower community and advances in technology have enabled rapid progress in key areas; however, many challenges remain.

A decade ago, a multi-stakeholder forum began a three-year-long process to address an issue not yet successfully tackled on an international, sector-wide scale: the need for consensus among all parties on how hydropower can be developed in a sustainable manner. The product of this work is the Hydropower Sustainability Assessment Protocol, which has now been applied in all regions of the world, and has become established as the primary tool for measuring and improving sustainability performance in the sector.

By using the protocol, project developers have been able to identify gaps in their practices and processes, and better understand how they can be addressed. This has brought forth some invaluable information for the sector as a whole, but until now this has not been made widely accessible. With the publication of this compendium, we are taking an important step towards sharing these examples.

The case studies you will read on these pages have been written by the accredited assessors who have carried out the project assessments on-site. They cover examples from all stages of project development from early stage through to operation, and encapsulate all facets of sustainability: social, environmental, economic and technical.

"A decade ago, a multi-stakeholder forum began a three-year-long process to address an issue not yet successfully tackled on an international, sector-wide scale."

This publication has been in the making for many years. I hope it also signifies the beginning of a new journey towards building a sector that is better connected, better informed and better prepared.

I would like to thank everyone who has been involved in the Better Hydro initiative to date, and look forward to expanding our collaboration in taking it to the next stage.

Richard Taylor
Chief Executive,
International Hydropower Association

"It is the first time that such a broad scope of cases has been compiled into a single manual."



It is my pleasure to introduce you to *Better Hydro: Compendium of Case Studies 2017*. This publication brings together practical examples of responsible hydropower development from all over the world, covering a range of sustainability considerations.

The case studies are drawn from projects that applied the Hydropower Sustainability Assessment Protocol, a rigorous, an objective tool that evaluates more than 20 sustainability issues in a standardised way.

"The challenge of energy, food and water security have become more urgent, particularly in developing countries."

The protocol, which looks at technical, social, environmental and financial issues, was developed through a multi-stakeholder process that included governments, industry, non-governmental organizations, and the multi-lateral development banks.

The World Bank has been involved in the development of the protocol from the outset and has participated, as an observer, in the forum that created it. Since it was launched in 2011, the protocol has been implemented in all regions of the world and in many different contexts, making this the perfect time to reflect on what has been learned so far and how we can improve going forward.

The challenge of energy, food and water security have become more urgent, particularly in developing countries. Hydropower projects often find themselves at the epicentre of these issues, which, together with climate change, require increasingly sophisticated approaches by all stakeholders. At the World Bank we view the protocol not just an assessment tool, but as a means of building capacity for the development of sustainable hydropower. We are applying this approach in a number of countries around the world.

At the World Bank we are firmly committed to the responsible development of hydropower projects, both large and small. When hydropower is done in a socially, financially and environmentally sustainable way, the development outcomes are impressive. I hope you find something in these case studies that inspires you as we work together to reach the more than a billion people in the world who still do not have access to power. Hydropower has a vital role to play in our joint mission to end energy poverty.

William Rex
Global Lead, Hydropower and Dams,
World Bank Group

Better Hydro: an introduction

What follows is a compendium of case studies that, under the aegis of the Better Hydro initiative, casts light on innovative local and regional approaches to the preparation, implementation and operation of selected hydropower projects from across the globe. These can be considered as going beyond basic good practice as defined in the Hydropower Sustainability Assessment Protocol and which demonstrate a clear contribution to sustainable practice in the hydropower sector.

The Hydropower Sustainability Assessment Protocol

The protocol, developed over three years from 2007 to 2010, is a reference framework that enables the development of a full sustainability profile of a hydropower project. Informed by existing international safeguard policies and frameworks such as the Equator Principles, to date 20 official assessments have taken place around the world. Moreover, a much larger number of informal applications have helped foster a greater understanding of sustainability in the sector.

Official assessments are carried out by a team of accredited assessors, experts in the field of sustainability and hydropower, who assess the sustainability performance of a project against over 20 topics. These range from 'economic and financial viability' to 'erosion and sedimentation' and 'biodiversity'. Cross cutting issues such as climate change and respect of human rights are also addressed in the Protocol. An assessment can be carried out from early stage

development and more specifically through the preparation, implementation and operation stages of particular projects.

Each topic is assessed against six criteria: assessment, management, stakeholder engagement, stakeholder support, conformance and compliance, and outcomes. The results are presented in the form of a spider diagram displaying the results clearly and unambiguously with a score from 1 to 5 with 3 being equivalent to basic good practice and 5 being equivalent to proven best practice.

The protocol is governed by a multi-stakeholder body, using a consensus approach. This governing body includes representatives of social and environmental organisations, governments, financial institutions and the hydropower sector, meeting four times a year to guide the Protocol's work programme. IHA acts as the management entity for the Protocol's day-to-day operations, covering tasks such as overseeing training and accreditation, liaising on assessments, and co-ordinating governance activities.



A Hydropower Sustainability Assessment Protocol training session during the 2015 World Hydropower Congress, Beijing

Background to this compendium

Since the first protocol assessments were carried out, there has been discussion within the hydropower community as to how best to record, understand and disseminate the results of what was developed in 2010 through identifying and capturing good examples of successful outcomes of value to be shared within the sector. In order to achieve this and to identify a baseline upon which to describe what constitutes 'proven best practice' around the specific protocol topics, the sector identified the need for case studies describing specific examples of how a project scored highly (a 4 or a 5) against the protocol for a specific topic.

To respond to this need, terms of reference were subsequently drawn up by the World Bank's Hydropower and Dams Global Solutions Group. Better Hydro itself consists of three task areas; these are:

- better information (relating to IHA's research areas on sector monitoring on deployment, clean energy systems, greenhouse gas reporting, climate resilience and adaptation, regional development, finance and investment, sediment management and operations and maintenance);
- better policies relating to preparation facilities, markets and incentives; and
- better examples which showcase highly scoring projects under the Hydropower Sustainability Assessment Protocol and other more general initiatives.

The work to develop this compendium of case studies addresses this last task area.

The case studies

The case studies within this compendium have been developed around projects that have undergone a protocol assessment. The majority address one of the key topics of the protocol in either the preparation, implementation or operation phases and against which the project scored highly, detailing how the specific project achieved that score and listing the principal policy and practice lessons.

The case studies have been authored by experienced, accredited assessors with on-site experience that have worked on the project in question or in some cases by the project owners themselves. In order to ensure consistency across the case studies, to better compare and contrast between the different examples of best practice and to enhance the reading experience, the same template has been retained throughout the Compendium.

Each case study contains essential project statistics (i.e. the project developer, the installed capacity of the project, where relevant the stage being assessed as well as the river basin and geographical area) and key policy and practice lessons that are summarised at the beginning of the study and then highlighted within the body of the text. In drawing up the work, emphasis has been placed on identifying and showcasing case studies from developing countries. In addition, a number of more holistic studies have been developed around specific projects that have performed well in all-around sustainability. Finally, a number of studies examine broader initiatives such as multi-purpose schemes, strategic river basin management and capacity building.

You can find out more about the Hydropower Sustainability Assessment Protocol and download full published project assessments at:

www.hydrosustainability.org

Scipio Topics



Topic case studies

1. Asset reliability and efficiency: Nam Lik 1-2, Laos	10
2. Biodiversity and invasive species: Itaipu, Brazil–Paraguay	12
3. Communications and consultation: Romanche-Gavet, France	16
4. Cultural heritage: Kabeli-A, Nepal	18
5. Demonstrated need and strategic fit: Kabeli-A, Nepal	22
6. Downstream flow regimes: Walchensee, Germany	24
7. Economic viability: Hvammur, Iceland	26
8. Environmental and social issues management: Chaglla, Peru	28
9. Erosion and sedimentation: Blanda, Iceland	30
10. Financial viability: Murum, Malaysia	32
11. Governance: San Francisco, Colombia	34
12. Hydrological resource: Jostedal, Norway	36
13. Indigenous peoples: Keeyask, Canada	38
14. Infrastructure safety: Sogamoso, Colombia	40
15. Integrated project management: Trung Son, Vietnam	42
16. Labour and working conditions: Santo Antônio, Brazil	44
17. Procurement: Sogamoso, Colombia	48
18. Project-affected communities: Itaipu, Brazil–Paraguay	50
19. Project benefits: Miel I, Colombia	52
20. Public health: Mangdechhu, Bhutan	54
21. Resettlement: Chaglla, Peru	56
22. Waste, noise and air quality: Santo Antônio, Brazil	58
23. Water quality: Semla IV, Sweden	62

Topic case study 1:

Asset reliability and efficiency: Nam Lik 1-2, Laos

Policy and practice lessons

- Automated measurements support routine monitoring
- Manuals and a monthly process systematises routine monitoring
- Asset categorisation enables prioritisation of maintenance.
- Pre-emptive upgrades ensure optimal condition
- Proactive investigation helps identify opportunities for new technology

Key project features

Project stage: operation

Developer/operator: Nam Lik Power Company (NLPC)

Capacity: 100 MW

Annual generation: 485 GWh

Reservoir area: 1,383 km²

Head: 84 m

Purpose: power generation

Commissioning: 2010

Mechanical equipment is replaced based on performance rather than predicted lifespan

Rigorous monitoring of equipment performance, together with an effective maintenance routine, has enabled the Nam Lik 1-2 project to exceed the terms of its power purchase agreement and generation target every year since commissioning. This example demonstrates excellent asset reliability and maintenance.

Nam Lik 1-2 is located on the main stream of the Nam Lik river, to the north-west of the capital of Laos, Vientiane. The dam is located in the district of Mueng Fueng, and the river flows downstream through the Hin Heup district, where it joins the Nam Xong to form the Nam Ngum. This flows into the Mekong river, downstream of Venetiane.

The project has an installed capacity of 100 MW, and is equipped with two 50 MW Francis turbines, which are coupled with 58 MVA generators. The turbines and generators were manufactured by the Hangzhou Resource Power Equipment Company, and have a predicted lifespan of 25 years. The main structures of the project are: a reinforced concrete-faced rockfill dam; spillway; flood release tunnel; headrace tunnel; powerhouse; switchyard (located on the top of the powerhouse); and a saddle dam.

The project is fully owned by the Nam Lik Power Company (NLPC), which is a joint venture between the China International Water and Electric Corporation (CWE) and



Électricité du Laos (EDL). NLPC does not own or operate any other project. CWE owns a 90 per cent share of NLPC and EDL owns 10 per cent. CWE is a subsidiary of the China Three Gorges Corporation, and manages CTG's overseas investments.

NLPC and the Lao Committee for Planning and Investment agreed in 2006 to a 25-

year build-own-operate-transfer contract. The project was licensed in 2007 and commissioned in July 2010.

Rigorous monitoring of equipment performance, combined with an effective maintenance routine, has enabled the project to exceed the terms of its power purchase agreement and its generation target every year since commissioning.

NLPC undertakes routine monitoring of the condition, availability and reliability of the project assets using automated and manual methods. This approach has helped the company to regularly identify many minor, and some major, asset maintenance and management issues. The company uses a range of operating manuals, procedures and guidelines. Activities revolve around a monthly production meeting where engineers review asset maintenance and safety issues from the previous month and plan the following month's maintenance.

Automated measurements support routine monitoring

NLPC undertakes routine monitoring of asset condition using automated and manual methods. Because the project is relatively new, it is equipped with automated asset monitoring and error reporting systems. Every two hours, engineers walk around the plant carrying out routine checks on equipment and recording performance data. Each month, the maintenance department analyses data recorded by the manual inspections and the automated monitoring, and compares performance with the manufacturer's guidance.

This routine monitoring of all equipment allows NLPC to identify any emerging risks.

Each month, NLPC holds a meeting to review the asset maintenance and safety issues of the previous month.

In 2012, routine monitoring highlighted overspeed in one of the turbines. This prompted a complete overhaul of the turbine, which would normally not have occurred until planned maintenance in 2017. When an issue is spotted, this triggers a physical investigation and full technical review by NLPC engineers. Engineers also compile incident reports following unexpected events that affect generation, such as a lightning strike in March 2015 and a grid failure in

May 2014. They then use this information to prepare for similar events in the future.

Manuals and a monthly process systematises routine monitoring

NLPC uses a range of operating manuals, procedures and guidelines for routine monitoring and maintenance requirements of the operating facility. Two comprehensive manuals set out the "operation and maintenance procedures" and the "overhaul procedures", to guide operation and maintenance activities. The manuals cover generating equipment, speed control systems, transformers, distribution equipment, diesel generators, computer monitoring, communication systems, water supply systems, compressed air systems and the spillway gates. They also include procedures to follow when monitoring identifies an emerging risk.

Each month, NLPC holds a production meeting to review the asset maintenance and safety issues of the previous month, and to plan the following month's maintenance. The monthly plan allocates tasks and daily activities to individual staff members. NLPC reports to CWE on a monthly basis with a summary of the monitoring results for generation, maintenance and safety.

Asset categorisation enables prioritisation of maintenance

To manage longer-term asset replacement, NLPC classifies equipment into three different categories, according to the required frequency of maintenance and replacement. Category A equipment is the responsibility of the operation group and requires replacement every six to eight years. Category B is also the responsibility of the operation group and requires replacement every three to four years. Category C equipment is the responsibility of the maintenance group and requires replacement annually. NLPC has scheduled the first full overhaul of Category A equipment for 2017, and completed the second category B round in 2016.

Pre-emptive upgrades ensure optimal condition

Engineers measure the exact level of wear and tear to equipment in their routine monitoring, and determine the optimal time for replacement. NLPC replaces most mechanical assets based on the performance of the equipment rather than its predicted lifespan. The company also plans to implement efficiency improvements as new technology develops, rather than through a planned long-term



The site of the Nam Lik 1-2 hydropower project

programme of upgrades. There is, however, a long-term programme for electrical assets, requiring replacement and upgrading every seven to eight years, regardless of condition. This is because the engineers believe that technology will improve sufficiently to justify replacement on financial grounds.

Proactive investigation helps identify opportunities for new technology

NLPC's production team is tasked with investigating areas for improvement in reliability and efficiency, using a number of channels to learn about new technology or research. CWE and CTG send regular updates regarding technological innovations and Chinese regulations on asset performance. The parent companies often send in-house experts to review and advise on emerging issues, such as a review and redesign of the hydrological monitoring system. NLPC employees also have the opportunity to attend CWE and CTG training courses on maintenance.

Each new investment must be justified on financial grounds. Examples of proposals advanced and implemented by the production team include improvements to the back-up power system, and an enhanced telecommunications system to facilitate better communication internally and with local authorities during bad weather.

This case study is based on an official assessment of Nam Lik 1-2 using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2015, with an on-site assessment in April 2015.

Topic case study 2:

Biodiversity and invasive species: Itaipu, Brazil–Paraguay

Policy and practice lessons

- Contributions to habitat protection and ecological restoration can continue many years after project development
- Regional-scale investment, in partnership with experienced agencies, is essential to address regional-scale challenges
- Projects can contribute to scientific research on conservation biology

Key project features

Project stage: operation

Developer/operator: Itaipu Binacional

Capacity: 14,000 MW (20 x 700 MW units)

Annual generation: 103,098 GWh

Reservoir area: 1,350 km²

Head: 118 m

Purpose: power generation

Commissioning: 1984–91 (plus additional units in 2006–07)

Itaipu is located in a globally important eco-region, where many species are at risk. This case study demonstrates how a project can make a vital contribution to protecting biodiversity in the surrounding area.

Itaipu is a bi-national project, located on the border between southern Brazil and eastern Paraguay on the Paraná river, 20 km upstream from the border with Argentina. The project is operated by Itaipu Binacional, which is owned equally by the governments of Brazil and Paraguay.

Itaipu was built between 1975 and 1982, with the 170 km long reservoir reaching its operating level in 1984. The initial 18 units were commissioned between 1984 and 1991, with a further two added in 2006–07.

The Paraná river is one of the largest in the world in terms of length and discharge. Itaipu has generated almost twice as much electricity as any other power plant in the world, providing 79 per cent of Paraguay's total electricity and 14 per cent of Brazil's.

Itaipu is located in the Atlantic Forests, a highly biodiverse but critically endangered ecological region. This is a region of global conservational importance, recognised by WWF as one of the Global 200 priority eco-regions.



The Atlantic Forests consist of tropical and sub-tropical moist broadleaved forests, located across the south-eastern coast of Brazil, reaching west into Argentina and Paraguay. Isolation from the Amazon Basin by the drier Cerrado region means the

forests are home to highly endemic species. The forests originally would have covered an area of 1,234,000 km², although only 7 per cent remains.

Itaipu is located within the Upper Paraná Atlantic Forest, which is the largest of the 15 eco-regions that make up the Atlantic Forest eco-region. Logging, agricultural expansion and associated road building threaten this globally important region of biological diversity. Many of the species are facing habitat loss, hunting and the wildlife trade.

A list of noteworthy species in the region is featured on page 15, although not all of these species occur within Itaipu's influence zone. Some, like the jaguar (*Panthera onca*), the harpy eagle (*Harpia harpyja*), the giant river otter (*Pteronura brasiliensis*) and the white-lipped peccary (*Tayassu pecari*), require large expanses of continuous forest, while others have very restricted distributions.

The Upper Paraná river is recognised by WWF as a Global 200 freshwater eco-region ('the Upper Paraná Rivers and Streams'). It has remarkably diverse fauna, including over 300 species of fish, a variety of aquatic vertebrates and invertebrates, and a high degree of endemism.

Protected areas include, to the south-east of the plant, the Iguazú National Park in Argentina, which is contiguous with the Iguacu National Park on the Brazilian side, and the Ilha Grande National Park to the north of the reservoir.

Itaipu's original development resulted in the permanent loss of forests (estimated at 600 km²) due to the creation of the reservoir. It also altered the connectivity of aquatic habitats by creating a barrier to migration as well as flooding a natural barrier, the Salto del Guairá/Sete Quedas waterfalls.

In Brazil, Itaipu has planted a total of 23.2 million trees since 1979, firstly to establish the protection zone and the Bela Vista and Santa Helena reserves.

Itaipu has implemented a series of important programmes to address the decline in biodiversity in the Atlantic Forests and changes to aquatic communities driven by the formation of the reservoir.



The Paraná river close to the site of the Itaipu hydropower project

These include the protection of remaining forests through a network of reserves, forest restoration (especially in protection zones around the reservoir shore), ecological corridors, captive breeding programmes and environmental education. It is widely acknowledged that Itaipu is making a significant contribution to terrestrial biodiversity conservation in the region. The project has also invested considerably in research and development of a fish migration channel.

Contributions to habitat protection and ecological restoration can continue many years after project development

According to satellite imagery, the Paraguayan Atlantic Forest eco-region was 73.4 per cent covered by forest in the early 1970s. By 1989 this figure had reduced to 40.7 per cent, and declined to 24.9 per cent by 2000. When development began on Itaipu in the 1980s, Brazil's forests had been largely converted into agriculture, but remained extensive in Paraguay. Since then, the decline has been driven by the conversion of large areas of forest into agriculture by private landowners in Paraguay.

Itaipu initially established protected areas to compensate for the original loss of forest resulting from the reservoir. Since then, the project has established and supported more areas, both for conservation of remaining forest and the re-establishment of forest in previously cropped areas. The area managed by Itaipu now totals 100,732 ha including the reservoir's protection zones, compared

to an estimated loss of 60,000 ha forest, and a reservoir area of 135,000 ha.

In Brazil, Itaipu has:

- established two Itaipu-owned biological refuges, the Bela Vista Biological Reserve (1,908 ha, established in 1984), and the Santa Helena Biological Reserve (1,483 ha), through reforestation programmes;
- contributed to the establishment of an ecological corridor (the Santa Maria Corridor), linking Iguacu National Park with the protection zone around the reservoir, since 2002. It bridges a distance of 12 km between the national park and the protection zone, and consists of a network of parcels of restored forest that are 36 km long and 454 ha in total; and
- planted a total of 23.2 million trees since 1979, firstly to establish the protection zone and establish the Bela Vista and Santa Helena reserves, and more recently through the Cultivando Agua Boa programme (read more on page 94).

In Paraguay, Itaipu has:

- established eight Itaipu-owned areas to protect primary and secondary forest, totalling 50,096 ha (bringing the total to 49,855 ha with Bela Vista and Santa Helena). The project also developed five-year management plans for all of these, comprising vision, mission and strategic objectives, and long-, medium- and short-term objectives; and
- launched the Itaipu Preserva programme to reforest a protection zone along the reservoir margin using native species, with a similar protection zone along the left bank.


230,000 ha
of protected areas have been supported by Itaipu

- supported the protection of a total of 230,000 ha of protected areas, including its own, through the Paraguay Biodiversity programme. The area spanned from the San Rafael reserve in the south of Paraguay to the Mbaracayú national forest reserve in the north, and included habitat restoration to establish connectivity between them
- recently established a further protected area, Pozuelo (5,200 ha), on the right margin reservoir bank, in Nueva Esperanza in Canindeyú.

Regional-scale investment, in partnership with experienced agencies, is essential for regional-scale challenges

Itaipu's contribution to terrestrial biodiversity conservation in the region is significant, and is widely recognised by partners such as Instituto Chico Mendes de Conservação da Biodiversidade, Fundación Moisés Bertoni, Red Paraguaya de Conservación en Tierras Privadas and SEAM.

The extent of Itaipu-managed protected areas and their links with other reserves and corridors makes them particularly important. Their comparatively effective management is also an important success factor, given that only a handful of the 38 publicly owned protected areas in Paraguay have management plans and sufficient staff. The Fundación Moisés Bertoni and Itaipu reserves combined make up the majority of the remaining Atlantic Forest in Paraguay, contributing to the vision for Atlantic Forests conservation established by WWF in 2000.

The Itaipu project partners with upstream and downstream hydropower projects to monitor fish migration.

Itaipu's protected areas and zones are important for linking the Atlantic Forest eco-region with the wetland ecosystems

of Ilha Grande National Park. The Paraguay Biodiversity Project would be impossible without Itaipu's involvement, and it also contributes to institutional and legal strengthening in Paraguay and to the country's Plan 2030 for Sustainable Development.

Itaipu's investment in biodiversity is considerable: in Brazil, the Biodiversidade Nosso Patrimônio (Biodiversity – Our Heritage) programme amounted to USD 1.3 million in 2015; in Paraguay, Biodiversidad Nuestro Patrimônio was USD 1.9 million in 2015, Infrastructure for Protected Areas was USD 3.8 million, Itaipu Preserva was USD 4.8 million in 2015, and corridors for biodiversity (under the Paraguay Biodiversity project) was USD 4 million, all in 2015.

Partnerships are essential for these programmes. In Brazil, the Itaipu project:

- was invited to participate and contribute financially to the Santa Maria Corridor by the Brazilian Environmental Agency (IBAMA), in order to create a continuous habitat from Iguazu National Park in the south to Ilha Grande National Park in the north

- supported the Ilha Grande National Park by participating in its Consultative Council, financing the building and maintenance of infrastructure such as a headquarters building, and supported Paraná river cleaning campaigns;
- partners with upstream and downstream hydropower projects (Porto Primavera and Yacretá) to monitor fish migration with the use of an internal transponder (chip) system;
- partnered with IUCN (International Union for the Conservation of Nature), IBAMA, the State Environment Institute and the State Fauna Conservation Programme on captive breeding;
- worked jointly with environmental agencies to take legal action against the illegal extraction of timber and hunting, which has emerged as a risk to the biodiversity value of the protection zone; and
- contracts 24-hour policing of biological refuges, the protection zone and reservoir by the Paraná State Security Secretary (Green Force Environmental Police Battalion) and Mato Grosso do Sul (Department of Border Operations) to prevent illegal fishing, hunting and logging.

In Paraguay, Itaipu has provided USD 6 million over three years in co-financing for the Paraguay Biodiversity programme, jointly with SEAM (Paraguayan Ministry of Environment), the Ministry of Agriculture, the World Bank financed PRODERS project, and the GEF (Global Environment Facility).

Projects can contribute to scientific research on conservation biology

The practice of conservation, including habitat protection, ecological restoration and species conservation, is a relatively new concept in all areas of the world. Scientific understanding of ecology, behaviour and genetics is limited, and linking limited scientific knowledge with conservation practice is a challenge. Itaipu is supporting the science of conservation biology through a range of initiatives.

The Bela Vista Reserve is a centre for environmental education and conservation, combining the Piracema Canal (a fish passage), the Roberto Ribas Lange zoo, a captive breeding area, a veterinary hospital and training centre, tree seedling and medicinal plant production, a jetty on the reservoir and a monitoring laboratory. It is also important for tourism.

In both Brazil and Paraguay, Itaipu has supported successful captive breeding programmes, for example the harpy eagle in Brazil, and large cats and swamp deer in Paraguay. Itaipu is now testing a method for wildlife "enrichment" (introductions in areas where the species is not yet extirpated) with the collared peccary (*Pecari tajacu*) and a deer species (*Mazama gouazoubira*). In Brazil, Itaipu is establishing a Biodiversity Research Centre, which is currently being built in partnership with the Federal University of Paraná.

In Paraguay, Itaipu's Wild Animals Research Centre hosts research projects concerning, for example the red-footed tortoise (*Chelonoidis carbonaria*), tapir (*Tapirus terrestris*), red-rumped caciques (*Cacicus haemorrhous*), and the jaguar (*Panthera onca*). It is home to 32 species of mammals, 24 species of bird and 10 species of reptile, many of which are classed as 'near threatened' or 'vulnerable' according to their IUCN Red List Category. The centre has successfully bred some of these species (seven mammal and three bird species), including the bush dog (or 'vinegar dog', *Speothos venaticus*).

Itaipu contributes to publications on biodiversity, including books on the fish of Paraguay, and booklets on protected areas and the fauna in the zoo. Itaipu zoos on both banks coordinate their activities with other captive breeding centres, and share information on nutrition and species of mutual interest. Biodiversity conservation is strongly linked to environmental education through the protected areas and zoos on both margins.

Itaipu has also invested considerably in the research and development of a fish migration channel, the Piracema Canal. This is the longest fish pass system in the world, at nearly 10 km. Itaipu monitors fish passage in the Piracema Canal and supports a considerable number of academic studies. These have examined the effectiveness of the canal for fish migration and its ecological implications (with some over the long term, for example a 10-year mark recapture study, spanning a 1,425 km section of the river).

This case study is based on an official assessment of Itaipu using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2015, with an on-site assessment in August 2015.



The Bela Vista Reserve is a centre for environmental education and conservation.



Noteworthy species in the region:



Golden lion tamarin (*Leontopithecus rosalia*)



Muriqui/woolly spider monkey (*Brachyteles arachnoides*)



Maned sloth (*Bradypus torquatus*)



Three-toed jacamar (*Jacamaralcyon tridactyla*)



Jaguar (*Panthera onca*)



Harpy eagle (*Harpia harpyja*)



Giant river otter (*Pteronura brasiliensis*)



White-lipped peccary (*Tayassu pecari*)

Topic case study 3:

Communications and consultation: Romanche-Gavet, France

Policy and practice lessons

- **Commitment to communication underpins a diversity of professional approaches**
- **Continuous updating of communication approaches ensures responsiveness to emerging issues**
- **Separate strategies for stakeholder groups enables tailoring to interests**

Key project features

Project stage: implementation

Developer/operator: EDF (Électricité de France SA)

Capacity: 94 MW

Annual generation: 560 GWh

Reservoir area: run-of-river project with reservoir contained within existing river channel

Purpose: power generation and restoration of the Romanche river through the decommissioning of six small-scale facilities

Up to
1,300
people attended public meetings

The Romanche-Gavet project used a comprehensive mapping process to identify key stakeholders and design tailored plans for how best to engage with them. This case study demonstrates how a constructive consultation and communications approach facilitates good stakeholder relations.

The 94 MW project is located on the right bank towards the middle of the Romanche river, in the Isère department in the French Alps, in south-eastern France. The project replaces six facilities with a total capacity of 82 MW, built in the early 20th century. Average annual generation will increase by over 30 per cent.

The design of the project directly addresses the need to reduce the adverse impacts of hydropower generation in the Romanche valley. Old plants and water transport infrastructure are being removed, conditions for recreation and tourism improved, and some of the decommissioned plants will be repurposed for cultural heritage conservation or economic uses. The valley is a popular route for tourists on their way to the nearby Alps.

EDF is part of the multinational EDF Group which owns, or has holdings in, transmission companies in France and utilities across Europe and internationally. EDF Group is 80 per cent owned by the French state.



Consultations are a regulatory requirement of the concession application process in France. The regional administration representing the national government ('prefecture') appoints a consultation facilitator to organise public meetings and



communications activities. The facilitator issues a report to the regulator (DREAL, Direction Régionale de l'Environnement, de l'Aménagement et du Logement), which is responsible for monitoring compliance with the report's recommendations.

The project used a communications plan and stakeholder mapping to identify key stakeholders and determine how best to engage them.

The plan set out activities for 2011–18 and consisted of several detailed sub-plans. Stakeholders were involved in the prioritisation of activities and events, and regular meetings were organised for consultation and provision of information.

Well-established and regular engagement opportunities meant stakeholders had easy access to project staff for timely exchanges of opinion and feedback. Stakeholders played a major role in defining the focus of the engagement sessions, and project staff were responsive to stakeholders' needs. A constructive climate for communication laid the foundations for good stakeholder relations throughout the construction and decommissioning of the old plants.

Since the project was assessed in 2013, construction works have made significant progress. Currently most of the underground powerhouse and tunnels have been completed and dam removal is ongoing. Environmental and social programmes are well under way. The project has, however, experienced construction delays due to heavy rain periods and gravel sliding onto construction areas.

Commitment to communication underpins a diversity of professional approaches

EDF appointed a regional-level staff member to dedicate 70 per cent of their activities to communications for the Romanche-Gavet project. Another staff member, based at the local project office, was responsible for external relations.

Communication and consultation approaches used by the project included:

- using the project offices as a public information centre (the Maison Romanche Energie, MRE), open one morning and one afternoon each week;
- a quarterly newsletter featuring interviews with stakeholders on relevant issues;
- frequent public meetings – two per year plus additional meetings on topics of special interest – allowing for exchange of opinions and ideas, and gathering feedback on key issues. Events were attended by up to 1,300 people, equivalent to almost the entire local population;
- 'open house' events on topics identified by stakeholders as being particularly important, such as learning about the tunnel-boring machine;
- distribution of invitations and information on all public activities, through leaflets delivered to local households, posters at the town hall and tourist office, and adverts in the press and newsletter;
- around 80 news articles each year;
- dedicated service for visitors to the construction site, provided by a specialist company. By the time of this assessment, 620 people had visited the project and its construction sites; and
- a logbook for complaints, used as a grievance mechanism for stakeholders, noting the question/complaint filed, response and date of closure.

Formal agreements were made between the two main contractors on their responsibilities in ongoing communications and consultation.

The contractors played an active role in organising public information and open-house events. This approach improved the relevance of communications, timeliness of responses, and ability to respond to emerging communications risks and opportunities.

Separate strategies for stakeholder groups enables tailoring to interests

EDF developed a communication plan in 2011 identifying the project's approach to internal and external communications and consultation. The company also drew up a stakeholder mapping document.

Stakeholders were divided into six groups, each with clear needs: local (department level, municipality and individual community members); internal to EDF; suppliers; elected decision-makers; public authorities; and civil society.

The internal stakeholder group was sub-divided into three categories: staff at the six existing plants in the Romanche valley; hydropower staff in the Alps unit; and EDF staff across France. Stakeholders were comprehensively identified and described, establishing a communication strategy for each group. For example:

- signs and viewing areas were set up to give views on key construction sites and information, for the public and tourists;
- open-house activities were organised on weekends, ensuring the greatest number of local people could participate; and
- schoolchildren were invited to participate in a naming contest and ceremony for the tunnel-boring machines.

Identification of particularly important stakeholders took into account vulnerable and disadvantaged groups and young people. Several initiatives were implemented to address decreasing economic activity and high unemployment in the local area.

Continuous updating of communication approaches ensures responsiveness to emerging issues

The communications plan was a living document subject to continuous updating. Each year, the company prepared a review of communications activities from the preceding year, and an outlook for the coming year. These reports clearly distinguished specific groups and their respective needs. This included targeting local schools, developing a dedicated website, celebrating the national science day, organising public events, and engaging with the press, contractors, internal EDF stakeholders, and those interested in heritage preservation. Special events showcasing the tunnel-boring machines and the construction site were organised in direct response to stakeholder requests.

This case study is based on the findings of an official assessment of Romanche-Gavet using the implementation tool of the Hydropower Sustainability Assessment Protocol. The assessment was carried out in May to July 2013, with an on-site assessment encompassing a visit to the project and interviews with stakeholders in June 2013.

Topic case study 4:

Cultural heritage: Kabeli-A, Nepal

Policy and practice lessons

- Local anthropological and heritage expertise is essential for the identification of all impacts
- Involving stakeholders in cultural heritage assessment and planning fosters community support and engagement
- Tailored plans addressing each potential impact are necessary, with mechanisms to respond to unexpected risks

Key project features

Project stage: preparation

Developer/operator: Kabeli Energy Ltd, a majority-owned subsidiary of Butwal Power Company (BPC)

Capacity: 38 MW

Annual generation: 206 GWh

Purpose: power generation

10%



of mean monthly flow will be released during driest months to support cultural heritage activities

Rivers in Nepal can hold important cultural significance, and the Kabeli-A example demonstrates how a hydropower project can be developed in an area of cultural importance to local communities, working closely with indigenous peoples.

The project is currently under preparation and is set to be located 800 km east of Kathmandu. When complete, Kabeli-A will divert water from the Kabeli river, discharging it 5.6 km downstream, after Kabeli's confluence with the Tamor river.

The Tamor loops around from an east–west to west–east direction, then flows into the Koshi river, crossing the border with India and entering the Ganges.

Kabeli-A is set to be a peaking run-of-river plant, using a head of 118 m and a small diversion dam allowing short-term storage. Upon completion, the reservoir will cover an area of just 10 ha, of which 9.1 ha is the existing river or its flood zone. Its main components are a 14.3 m dam, intake and settling basin, a tunnel over 4 km in length, powerhouse and tailrace.

River waters in Nepal can be of significant cultural importance. Hindu ritual practice requires water for bathing and funeral rites, and certain fish species are involved in ritual and religious practices.

There are a number of heritage sites near the Kabeli-A project that are of importance



to the local communities. These include: the Panchayan Shivalaya Temple on the left bank of the Kabeli River, 2 km downstream of the dam site in the stretch with reduced flows; three cremation sites along the reduced flow stretch, Kholakharka, Kabeli and Sirupa; and a rest house, Pati, near the powerhouse site at Pinase Ghat.

The Kabeli river itself holds significant cultural and spiritual value to local communities, and is regarded as the holiest of rivers by people in the region. Large numbers of worshippers visit the Panchayan Shivalaya Temple, especially during festivals such as Shiva Ratri and Ekadashi, when bathing is an important purification ritual.

Hindu pilgrims from the surrounding area come to bathe in the Tamor and Kabeli Rivers on religious holidays. Hindus also perform cremations at the Kholakharka, Kabeli and Sirupa sites. A Majhi community (a Punjabi ethnic group) from a nearby village uses the resthouse for funeral processions and to perform rituals. Among the fish in the river, trout (*Schizothorax spp.*) and stone carp (*Psilorhynchus pseudochenus*) are used by the Limbu, Rai and Majhi ethnic groups in rituals.

This case study presents an example of a project to be developed in an area where the river itself is of cultural importance to local communities, sites of local cultural importance could be affected by altered flows, and indigenous peoples are among the affected communities.

The developer of the Kabeli-A project took a comprehensive approach to the assessment of cultural heritage. This took into account intangible practices and rituals, and engaged experts with anthropological knowledge of the area. Affected communities were involved in the assessment and the planning of management measures, resulting in widespread support for the measures. The project developed an array of recommended and suggested measures to mitigate its impacts on sites of cultural significance, as well as associated cultural and religious practices.

Local anthropological and heritage expertise is essential for the identification of all impacts

Kabeli-A engaged senior anthropologists and specialists on the local indigenous peoples as part of its social impact assessment (SIA). The project initially used a screening exercise to map out the cultural and archaeological sites likely to be affected. Then, a participatory methodology was used to identify and assess impacts, with rigorous and extensive community consultation. This identified the sites of cultural and religious sensitivity, including the temple, cremation sites, rest house and ritual sites.



Temple by the Kabeli river

Photo: Bernt Rydgren

It became clear that the temple and cremation sites could be affected by the significantly reduced flow in the Kabeli river at certain times of year. Furthermore, the rest house could be affected by construction activities, and the influx of workers may lead to cultural clashes.

The experts were also able to recognise the importance of the trout and stone carp fish species, and found five archaeological sites associated with the Limbu ethnic minority in the project area.

Involving stakeholders in cultural heritage assessment and planning fosters community support and engagement

Consultation with local communities during the preparation phase of Kabeli-A was extensive, including:

- 12 formal consultation meetings during the scoping phase of the environmental impact assessment;
- 14 focus group community discussions for the social impact assessment and preparation of a social action plan (SAP); and
- extensive informal household visits and community discussions.

Further rounds of consultation would be included in the SAP implementation. Mapping to identify a comprehensive range of stakeholders pinpointed a specific group as users of the cremation sites. A summary of the environmental impact assessment and the SAP were translated into Nepali and the local ethnic languages of the major indigenous groups in the project area.

Kabeli-A adopted a series of measures addressing the cultural importance of the river.

The Kabeli-A developer made a concerted effort to include heritage in consultations to ensure it was fully understood and assessed.

The potential for impacts on heritage sites and religious rituals was a key agenda item in the focus group discussions and formal meetings with government.

As a result of meetings with the Kabeli-A Cooperation Concern Committee (KACCC), a group representing the local community, it was suggested that the project should release more water than the established minimum when special needs are defined.

Such events include cremations, which happen around twice a month.

This suggestion was duly incorporated into the social action plan.

Tailored plans addressing each potential impact are necessary, with mechanisms to respond to unexpected risks

Kabeli-A adopted a series of measures addressing the cultural importance of the river:

- at least 10 per cent of mean monthly flow during the driest month will always be released to preserve cultural and religious values associated with the river (and address issues such as aquatic ecology);

- released environmental flows will be channelled into the Ghat cremation area and the Panchayan Shivalaya Temple, providing sufficient water for cremation and religious practices;
- additional flows will be organised during cultural and religious festivals, and additional water storage infrastructure will be constructed to guarantee the continued supply of water for religious practices;
- maintenance of the affected cremation and customary sites; and
- provision of, or improvements to, road access to cremation sites at the confluences of the Tamor and Kabeli rivers.

With participation and consent from local people, Kabeli-A made further

commitments to programmes providing financial support. These address the preservation and protection of historical, archaeological, religious and cultural sites in the project area.

To avoid cultural clashes between construction workers and local communities, Kabeli-A developed management plans for the conduct of workers. These included:

- awareness-raising programmes to ensure workers understand and respect the cultural and traditional practices of local people;
- a code of conduct to prevent workers from interrupting or interfering with cultural and other traditional activities of local people; and

- special consideration given to workers from the local area for holidays during local festivals and rituals.

Culturally important trout and stone carp populations are expected to be affected by reduced flow in the 5.6 km stretch between the intake of the Tamor confluence during the dry season.

The project will however monitor and manage aquatic impacts through an Aquatic Ecology Management Plan.



To avoid cultural clashes between construction workers and local communities, Kabeli-A developed management plans for workers' conduct.

Photo: Bernt Rydgren



Kabeli-A project information centre

Photo: Bernt Rydgren

However, both species are also present and common in the Tamor river and upstream of the dam throughout the year. The impact on their availability for ritual is therefore expected to be negligible.

The project will, however, monitor and manage aquatic impacts through an Aquatic Ecology Management Plan.

Measures include: restricting fishing among construction workers; restricting illegal and damaging fishing methods; designing and constructing a fish passage; establishing a fish hatchery for targeted red-listed species and planned releases of fingerlings; prohibiting muck disposal into the river; prohibiting aggregate mining in the wetted river channel; and prohibiting fishing in certain locations and restricting fishing in others.

Kabeli-A has also developed a series of measures to pick up on any unexpected impacts and emerging risks, both for heritage and others.

These measures include: a monitoring and evaluation mechanism; the presence of a team of social experts on-site; a grievance mechanism; monitoring of implementation by an external engineering supervision consultant; and a third-party external monitoring including a panel of experts.

A chance-find procedure will be incorporated into the contractor bidding documents, and workers will be trained in the procedures through special training programmes.

This case study is based on an official assessment of the Kabeli-A project using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The process took place in 2014, with an on-site assessment in August–September 2014.



Indigenous groups

Nepal has considerable cultural, linguistic, religious and ethnic diversity. There are 59 officially recognised indigenous groups, referred to collectively as Adivasi Janajati. They make up 37 per cent of Nepal's population, each with their own territory, language, traditional rites and customs, distinct cultural identity, social structure and history. They are traditionally outside the Hindu caste system.

Over 50 per cent of people in the project area are Adivasi Janajati. The most populous are the Limbu (56 per cent of Adivasi Janajati), Rai (14 per cent), and Tamang (10 per cent). The people of the most directly affected village are Limbu, Tamang and Majhi. Despite belonging to different ethnicities, they share common approaches and patterns in their economic and livelihood activities.

Limbu are considered to be the "original" inhabitants of the area, as all other groups have migrated at a later stage. They have a communal land tenure system inherited from their ancestors. In the project area, villages and rivers are named in the Limbu language, acquiring Hindu meanings at a later date.

Rai are an indigenous group that began migrating to the area in the 18th century from Majhi Kirat. They also have traditional communal land ownership situated in the project area.

Tamang is one of the major Tibeto-Burman-speaking communities in Nepal, and they maintain a belief that they originally came from Tibet. Every ritual of Tamang is guided by Lamaism, i.e. Tibetan Buddhism.

Majhi are traditionally known as fishermen. The main traditional occupations of the Majhi people are boat building and river transport services. Majhi people identified in the project area have lost their mother tongue. They are economically, socially and politically vulnerable and a highly marginalised group.

There are also some Newar people in the project area. They live in the downstream area and have totally lost their culture, language and traditional lifestyle. With the Limbu and Rai, they are the least disadvantaged group among the Adivasi Janajati.

Topic case study 5:

Demonstrated need and strategic fit: Kabeli-A, Nepal

Policy and practice lessons

- Multi-stakeholder participation in the definition of needs provides a sound basis for options assessment
- Integration of environmental and social issues into options development strengthens the case for a project

Key project features

Project stage: preparation

Developer/operator: Kabeli Energy Ltd, a majority-owned subsidiary of Butwal Power Company (BPC)

Capacity: 38 MW

Annual generation: 206 GWh

Purpose: power generation

The Kabeli-A hydroelectric project responds to the urgent need for additional power in Nepal without compromising other development priorities. This case study explains how a strong case was made for the project's development.

The project is located approximately 800 km east of Kathmandu. It is a peaking run-of-river plant, using a head of 118 m and a small diversion dam enabling short-term storage.

Upon completion, the reservoir will cover an area of just 10 ha, of which 9.1 ha is the existing river or its flood zone. The project's main components include a 14.3 m dam, intake and settling basin, a tunnel over 4 km, a powerhouse and tailrace.

The plant will divert water from the Kabeli river, discharging it downstream following Kabeli's confluence with the Tamor river as it loops from an east–west direction to west–east. The Tamor flows into the Koshi river, which crosses the border with India and enters the Ganges.

Nepal has a limited supply of electricity, falling far short of the country's rapidly growing demand. Nepal has just over 700 MW of installed capacity, over 90 per cent of which is hydropower. Due to limited storage, generation is often far below



installed capacities in winter. This seasonal shortfall has reached at least 500 MW in recent years, sometimes higher, given that the severely restricted supply limits suppressed demand.

The country expects a continued shortage of power. The 2017 projection is for 900 MW of unsatisfied demand during the dry season, despite a predicted 200 per cent increase in installed capacity. Load shedding, up to 18 hours per day in late 2012, contributes to significant losses to the country's economy, estimated at an eighth of GDP.

Kabeli-A was first identified by a basin masterplan study in 1983–85.

The project has a strong fit with identified priorities and needs at national level.

The project was ranked among the top seven projects in an internationally funded study in the 1990s to screen potential developments in Nepal. The project has a strong fit with identified priorities and needs at a national level.

Kabeli-A responds to the urgent need for additional power in the country without compromising any other development priorities. Through the larger Kabeli Transmission Corridor project, it will also address rural electrification in a remote part of the country.

At regional and local level, stakeholders have been given the opportunity to offer their perspectives on project design and options through the feasibility studies and comprehensive environmental and social impact assessments.



Overview of the project site



Powerhouse site and Tamor river from the air

Multi-stakeholder participation in definition of needs provides a sound basis for options assessment

Kabeli-A was considered in the 'Medium Hydropower Study' financed by the Canadian International Development Agency in the 1990s. The study assessed a range of proposed options for hydropower projects in Nepal in the range of 10 to 300 MW.

The study included an inter-governmental process and significant inter-agency work within the government of Nepal, encompassing planners and policy makers. Subsequent preparation of water and power sector policies and plans were based on this inter-agency cooperation of high-level stakeholders, defining strategic priorities and development needs.

The water and hydropower sectors are closely linked in a planning framework underpinned by the 2002 Water Resources Strategy, the 2005 National Water Plan, the 2003 Irrigation Policy and the 2001 Hydropower Development Policy. Together these documents provide a comprehensive assessment of the needs for both water and energy services at national level.

The Water and Energy Commission Secretariat (WECS), established by the government of Nepal in 1975, is made up of representatives from 11 different ministries, with the minister of energy as its chair. The WECS is responsible for overall coordination on water resource development.

It also draws its membership from well-known water resource and energy specialists in Nepal's universities and professional associations.

Integration of environmental and social issues into options development strengthens the case for a project

A three-stage process of screening, coarse ranking and fine ranking was used to identify the most attractive projects. This process combined technical, economic, environmental and social criteria, and included site visits and consultations. The socio-environmental criteria related to physical, biological and socio-cultural aspects, such as the need for land, catchment conditions, downstream impacts, number of affected people and cultural issues.

The study report included a special volume on environmental aspects of the screening, and the Hydropower Development Policy document makes triple-bottom-line sustainability a clear priority.

The Sectoral Environmental Assessment conducted as part of the Medium Hydropower Study supported the selection of Kabeli-A as one of the top seven ranked projects. A special-purpose Strategic Environmental Assessment of the studied projects was also undertaken.

This case study is based on an official assessment of the Kabeli-A project using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The process took place in 2014, with an on-site assessment in August–September 2014.

Topic case study 6:

Downstream flow regimes: Walchensee, Germany

Policy and practice lessons

- The combination of various intakes enables the establishment of a continuous minimum flow regime
- Older plants with minimal or no downstream flow commitments can build stakeholder support by restoring minimum flow
- Extensive studies provide a scientific basis for minimum flow determination
- Nature and innovation combine to minimise downstream flow impacts

Key project features

Project stage: operation

Developer/operator: Uniper Kraftwerke GmbH

Capacity: 124 MW

Annual generation: 300 GWh

Active storage: 110 million m³

Head: 197 m

Purpose: power generation

Commissioning: 1924

The Walchensee project has implemented two important mitigation initiatives to address downstream flows, a concept that was unheard of at the time of project construction. This case study demonstrates how downstream flow measures can support local activities and wildlife.

The project is situated on the Isar river, which runs into the Danube in south-eastern Germany, just before it reaches the border with Austria.

The station has been generating power for more than 90 years. Commissioned in 1924, Walchensee was recognised as a national monument in 1983. It is a peaking plant, generating power for the electricity grid with four Francis units, as well as single-phase power with four Pelton turbines for Deutsche Bahn, Germany's national railway. These services inevitably result in variable downstream flows.

Water from the upper Isar is diverted into the Walchensee, a natural lake, and discharged into another natural lake, the Kochelsee, taking advantage of a 197 m head between the two. Water flows from Walchensee to Kochelsee via a group of six penstocks, with a total length of 400 m.

Walchensee generates 300 GWh per year, approximately 5 per cent of the electricity generated by Uniper's German hydropower



fleet. It is one of Germany's largest high-pressure storage power stations. As a storage plant with the ability to produce high-value peak power and ancillary grid services, Walchensee is an important power station for Uniper.

Uniper Kraftwerke GmbH operates 109 plants in Germany and has a total capacity of approx. 1,900 MW. The Uniper Group operates 178 plants in Germany and Sweden, with a total capacity of approximately 3,600 MW.

Uniper has completed a project to re-establish flow on the Obernach stream.

The concept of downstream flow releases for environmental and social purposes was unknown when Walchensee was constructed in the 1920s. Growing stakeholder concerns and changing societal demands have led Walchensee to address downstream flows through two important mitigation projects.

The project is making the most of the area's topography and plentiful water supply to maintain peak production while minimising downstream flow impacts. Firstly, the project restored a minimum release on the Isar river, varying this between summer and winter. Secondly, it restored a minimum release on another stream, Obernach, which combined with new fish passages has enabled spawning of the Walchensee population of lake trout.

The combination of various intakes enables the establishment of a continuous minimum flow regime

There was no downstream flow release when the Walchensee project was



Inside the powerhouse



Penstocks at Walchensee power plant

developed in the 1920s. A weir on the Isar at Krün diverted waters into the Obernach stream for delivery into Walchensee. There are now a total of nine weirs diverting water from further upstream of the Obernach, and from the Rißbach, a tributary of the Isar that joins the river downstream of Krün. Two small power plants utilise some of the head from these diversions. This has enabled a minimum flow release to be established on the Isar at Krün.

Uniper has published a formal commitment to release 4.8 m³/s to the main Isar river course below the Krün weir in summer, and 3.0 m³/s in winter. A higher minimum flow release in summer than winter was chosen in an attempt to mimic pre-regulation variability. Inevitably there are flow impacts on the other streams, including the Obernach, but Uniper has recently mitigated these in partnership with local fishermen.

Older plants with minimal or no downstream flow commitments can build stakeholder support by restoring minimum flow

Uniper has completed a project to re-establish flow on the Obernach stream. This was specifically designed to create spawning areas for the Walchensee population of lake trout.

The company cooperated closely with the authorities and the local fishermen's organisation to assess the situation and design measures to mitigate the impacts of the diversion.

There is a now constant release of 0.5 m³/s at the diversion, and fish can pass freely from the Obernach outlet into the Walchensee, and up to further lakes in the system.

Extensive studies provide a scientific basis for minimum flow determination

The flow regime of the upper Isar has been the subject of extensive analyses, debate and discussions ever since the diversion at Krün. Detailed studies needed to be carried out due to the complexity of the issues, and extensive studies by external experts underpin the agreed minimum flow releases.

Nature and innovation combine to minimise downstream flow impacts

Walchenseekraftwerk is important for high-value peak power and ancillary grid services (including black-start capability).

Deutsche Bahn owns the rights to a third of the plant's generation, and due to the extreme variations in Deutsche Bahn's power demand, short-term regulation is a fundamental priority.

However, this does not lead to significant flow variations downstream of the powerhouse, as Kochelsee acts like a natural re-regulating basin before waters enter the Loisach stream.

This case study is based on an official assessment of Walchensee using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in March 2012.

Topic case study 7:

Economic viability: Hvammur, Iceland

Policy and practice lessons

- Detailed, independent economic studies give credibility to master planning
- Integrating economic analysis into broader processes facilitates public involvement
- Strategic basin planning has facilitated the project's development

Key project features

Project stage: preparation

Developer/operator: Landsvirkjun

Capacity: 93 MW

Annual generation: 720 GWh

Purpose: power generation

Economic aspects were considered in detail by an independent expert group

Currently under development, the Hvammur project is an example of in-depth economic viability analysis. Much of the information from this process was made public, facilitating public engagement in project development.

The project is being developed by the state-owned Landsvirkjun, which generates 75 per cent of Iceland's electricity. The Icelandic parliament moved Hvammur from the 'under consideration' to 'appropriate for development' category in its 2015 Masterplan for Hydro and Geothermal Energy Resources.

The proposals for development on the Þjórsá river included a plant at the Urriðafoss waterfall, further downstream, and two alternative proposals upstream, near Núpur mountain. The two alternatives were a single power plant, Núpur Power Plant, with a 56 m head, or two power stations, Hvammur and Holt, with heads of 32 and 18 m. Landsvirkjun has since abandoned the Núpur proposal and intends to build Hvammur, Holt, and Urriðafoss.

Hagalón, the intake reservoir for Hvammur, would be formed by a dam over the Þjórsá river, situated above Viðey island, and by dykes along the eastern banks of the river. The powerhouse would be mostly



underground, located on the farmlands after which the project takes its name.

Two 180 m long pressure pipes would lead from Hagalón to the power station, from which water would re-enter the Þjórsá river below another island, Ölmóðsey, via a partly underground, partly open tailrace.

The Icelandic planning agency accepted the proposals, with conditions, in 2003. The minister for the environment then confirmed the planning agency ruling, with further conditions, in 2004. The decision was made on the basis of an environmental impact assessment (EIA) prepared in 2003. Landsvirkjun has placed great emphasis on mitigation measures to minimise negative environmental impacts, especially on fish stocks. However, after more than 10 years had elapsed, the agency was legally obliged to assess the need for a partial or complete review of the EIA. The agency concluded that the impact of development on the landscape, its visual impact and implications for tourism and recreation should be reviewed. Work on the review is now underway, following a scoping of issues in 2016.

In 2012 Landsvirkjun used the protocol for the first time to assess the preparation stage for Hvammur. The company subsequently commissioned an official assessment of the Blanda Power Plant in September 2013 (see pages 30 and 66).

The results of Landsvirkjun's cost-benefit ratio calculation, and total capital expenditure were released to the public.

Landsvirkjun was inspired by its experience with the protocol to develop its own Geothermal Sustainability Assessment Protocol.

This was recently applied for the first time on the Theistareykir project. Between geothermal and hydropower, Iceland's electricity supply is 100 per cent renewable.

Standard cost-benefit analysis (CBA) including socio-environmental costing is not practiced as a practical evaluative tool in Iceland. However, all projects that were part of the national master-planning exercise had to list a range within which their capital costs would fall.

Landsvirkjun analysed Hvammur's economic viability in great detail, including sensitivity analyses for the base, best and worst cases. A calculated cost-benefit ratio along with the total capital expenditure was made public.

Most importantly, the economic aspects of the project were considered in detail by an independent expert group, as part of Iceland's national master planning exercise.

In developing Hvammur, Landsvirkjun is engaged in a methodical and comprehensive planning process for future growth.

The company is considering the need for power for energy-intensive industries and encouraging a diversification of users, including through a sea cable to either the UK or mainland Europe.

Detailed, independent economic studies can be integrated into master planning

Landsvirkjun had already estimated the cost of Hvammur in detail, including estimates of the costs of mitigation and compensation for social and environmental impacts.

On this basis, the company developed a cost-benefit ratio on this basis, including financing costs. It also calculated an internal rate of return (IRR) and assessed base, worst- and best-case scenarios, as it does for all projects.

A study commissioned by Landsvirkjun concluded that strong continued development of Iceland's renewable energy potential would have a considerable positive impact on the nation's economy.

Integrating economic analysis into broader processes facilitates public involvement

The results of Landsvirkjun's cost-benefit ratio calculation and total capital expenditure were released to the public. More broadly, the EIA and the national master planning processes have facilitated public involvement in analysing aspects of project development, including economic issues, in a comprehensive manner. The process has drawn on a diversity of expert opinion, incorporated public opinion and been discussed in parliament. Government at national and municipal levels has been involved and the process is open for public review and opinion.

Strategic basin planning has facilitated the project's development

Early ideas for hydropower development of the lower Þjórsá river were discussed in the 1950s and 1980s close to and downstream from the Hvammur Farm. However, at the time, none of the projects were considered economically viable, as considerable storage was required to optimise the use



Site of the tailrace at Hvammur

of the discharge in the unharnessed Þjórsá river, and it was not considered feasible to incorporate storage reservoirs for these projects inundating large farmed areas

Hydropower development in the upper Þjórsá river started in the 1970s when the first plant in the basin, the Búrfell hydropower plant, was commissioned. Later, five more hydropower plants were added upstream from Mount Búrfell as well as three storage reservoirs, all contributing to water regulation and storage.

Today the discharge in the lower Þjórsá river downstream from Mount Búrfell is highly regulated, and the Hvammur hydropower project can be developed with little storage, making the project economically viable.

The Hvammur project will be operated as a part of an optimised power production network, which adds to the economic viability of the project.

This case study is based on an official assessment of Hvammur using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in May 2012.

Topic case study 8:

Environmental and social issues management: Chaglla, Peru

Policy and practice lessons

- Methodical reporting procedures ensure systematic mitigation of impacts
- Monitoring and reporting systems deliver excellent contractor performance
- Independent third-party reviews boost performance and innovation
- Engaging with local communities and partners improves pre-project conditions

Key project features

Project stage: implementation

Developer/operator: Empresa de Generación Huallaga S.A. (EGH), a subsidiary of Odebrecht Energía S.A.

Capacity: 456 MW

Annual generation: 2,736 GWh

Reservoir area: 4.74 km²

Height of dam: 202 m

1,489

people benefited from capacity-building programme

The Chaglla project is an example of thorough environmental and social risk assessment. All impacts of project construction and operation were comprehensively assessed, and there was excellent communication with local communities and environmental consideration.

There are no other hydropower plants on the Huallaga river, although a number of smaller plants are under construction in Huánuco.

Environmental management is highly regulated in Peru. An environmental impact assessment (EIA) is required before a concession can be awarded by the Ministry of Energy and Mines (MEM). The EIA and an environmental management plan (EMP) must be approved by a directorate within the MEM, with input from the agencies for water resources and protected areas. Another agency, the Agency for Environmental Assessment and Enforcement (OEFA), is responsible for overseeing compliance with the EMP.

The Chaglla project is financed by international institutions, so was also required to comply with international environmental and social performance standards.

Socio-environmental issues and risks were assessed in two EIAs and an environmental statement, and ongoing assessment of impacts and emerging risks is part of project



procedures. The EIA covered associated facilities, such as access roads, quarries and borrow areas. A second, separately approved EIA addressed the transmission line. All impacts during construction and operation were comprehensively assessed

The implementation of EMPs and project-specific management procedures guided the management of socio-environmental issues. A 'socio-environmental management system' was established and audited internally, and processes were verified by a third party.

The Chaglla project appointed a sustainability team to implement its environmental, social, health and safety management plan.

Stakeholders were able to raise issues through a variety of means, and project-affected communities and regulators found the feedback to be thorough and timely. The project regularly reported back to OEFA on the EIA requirements, and to lenders and their consultants. These measures were successful in avoiding, minimising or compensating for the project's potential or actual adverse impacts. The project has enhanced pre-project conditions through project-related activities and partnerships, and thanks to Odebrecht's corporate sustainability programmes.

Methodical reporting procedures ensure systematic mitigation of impacts

The Chaglla project established clear sustainability procedures and appointed a sustainability team to implement its environmental, social, health and safety management plan (ESHSMP). The procedures covered: management (identification of impacts, inspections and non-conformities); specific issues (waste management, potable water treatment, compensation for land acquisition); and risk and emergency response. For example, a procedure for the socio-environmental management programme described how the project would follow the corporate socio-environmental strategy and commitments. Procedures were regularly reviewed and modified.

Most of the socio-environmental programmes included ongoing monitoring of issues through investigations and analyses. The monitoring programme incorporated a range of new risks and opportunities that became evident during implementation.

Monitoring and reporting systems deliver excellent contractor performance

The sustainability team supervised contractor compliance, undertaking periodic inspections and identifying opportunities for improvement. The EPC contractor identified and assessed impacts from each activity in a matrix format, linked to regulatory requirements. It reported on environmental and social management and sustainability indicators on a monthly basis. The regulator, OEFA, carried out annual environmental on-site inspections, and EGH sent OEFA an 'annual environmental management report'.

Independent third-party reviews promote high performance and innovation

At the time of seeking project finance, the original 2009/2010 EIA and EMP were subject to a gap analysis to ensure compliance with IFC performance standards. The developer prepared additional assessments on fish and ecology, water quality modelling, downstream flow modelling, a resettlement action plan, and analysis of the project's carbon footprint. The EMP was updated to incorporate the results of the analysis.

A number of third-party review processes supported strong performance: lenders' environmental and socio-environmental reviews; and an expert panel of three external environmental and social specialists with experience in hydropower and international standards.

Engaging with local communities and partners improves pre-project conditions

The project engaged community stakeholders through: ongoing meetings with the directly affected population, both general and issue-specific; circulation of a monthly community bulletin; an "ethics line"; visits of EGH's social officers; and community offices. Regulators (e.g. OEFA) and local government were able to raise issues directly with the project developers through inspections and direct communication. All stakeholders considered the feedback to be thorough and timely. Opportunities were taken for partnerships and support to local and regional institutions, such as to the Huánuco government for the protection of the Carpish forest, and a capacity-building programme for local workers.



The project achieved well beyond the management of its own impacts, by delivering improvements in a range of areas. For example:

- new social services and agricultural extension services were established;
- a local capacity-building programme entitled 'Creer' trained 1,489 people, of which 800 (26 per cent women) worked on the project;
- a waste management centre was set up to sort, re-use, recycle and dispose of all types of waste, achieving 100 per cent composting of organic wastes;
- discovering and registering new species, and supporting national parks with the publication of biodiversity books; and
- facilitating the recognition of, and support for, protection of the highly biodiverse Carpish range of forest, a recognised 'important bird area'.

This case study is based on an official assessment of the Chaglla project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. This was conducted in 2015, with an on-site assessment in June 2015.

Topic case study 9:

Erosion and sedimentation: Blanda, Iceland

Policy and practice lessons

- Catchment-wide research allows in-depth understanding of geomorphology
- Partnerships with habitat restoration experts maximise success in catchment revegetation
- In-river geomorphological changes can also deliver benefits for local communities

Key project features

Project stage: operation

Developer/operator: Landsvirkjun

Capacity: 150 MW (3 x 50 MW units)

Annual generation: 800 GWh

Reservoir area: Blöndulón 56 km² and Gilsárlón 5 km²

Head: 287 m

Purpose: power generation

Commissioning: 1991

Over
500,000 t
reduction in
sediment load
downstream

The Blanda project carried out one of the largest revegetation and erosion control programmes in Iceland's history. This case study demonstrates how the project's efforts to reduce sedimentation and erosion have benefited local communities and biodiversity.

Blanda lies on the fringe of the central highland plateau, with gentle hills and heathland on shallow soils. The climate in the area is dry, cold and windy, with a mean annual precipitation of 400 mm and a mean annual temperature of 0.6 °C.

Blöndulón reservoir is formed by two dams, on the Blanda river and the Kolkukvísl river, and water is diverted through 9,800 m of diversion canals and four lakes to an intake reservoir (Gilsárlón). From Gilsárlón, water runs through a 1,300 m canal and a 347 m headrace tunnel, before dropping vertically through a 236 m penstock to the underground power station. From the turbines, the water flows through a 1,700 m tailrace tunnel into the Blanda river.

The Blanda river used to be a highly turbid glacial river. It presents an interesting example of a system that has, in the view of affected communities, largely benefited from trapping sediment in an upstream reservoir. River banks have stabilised, primary productivity has increased due to greater light penetration, abundance



of aquatic life has increased, and the opportunities for angling have improved. The project's development had few adverse environmental and social impacts. One of the most significant impacts, the loss of vegetation and sheep grazing lands to create the reservoir, has been compensated

by a large-scale revegetation programme. The area that was inundated was once an area with high-quality soils, the best land for sheep grazing in the region. The absence of vegetative and soil cover is a national environmental problem in Iceland, so the loss of these fertile soils prompted widespread concerns. This resulted in one of the largest revegetation and erosion control programmes in the country's history. Extensive revegetation efforts have been and are being undertaken to compensate for and extend well beyond the loss of the grazing area.

Watershed-wide research allows in-depth understanding of geomorphology

Landsvirkjun and researchers have studied the geomorphology of the Blanda river system in depth. Any changes to erosion and sedimentation that would positively or negatively affect power generation or other river uses will be identified through a broad array of monitoring initiatives:

- long-term suspended sediment sampling was undertaken at the Langamýri gauge downstream of the power station from 1965 to 2011; this data was used in baseline geomorphology studies and pre- and post-project sediment rating curves;
- samples of suspended and bedload sediments have been taken regularly across the basin;
- glaciological research has been established upstream;
- aerial pictures and site visits of the downstream river reach and the river mouth were used to monitor channel stabilisation; and
- data and studies have either been published or are accessible in the Iceland Meteorological Office database.

Shoreline erosion and sediment accumulation in the Blanda reservoir are monitored. For example, a bathymetric survey using echo sounders was conducted in 2012 as part of a Landsvirkjun programme to survey all reservoirs, which will be repeated every five to 10 years.

Partnerships with habitat restoration experts maximise success in catchment revegetation

The revegetation programme around the reservoir compensated for the loss of grazing land and avoided displacing grazing pressure onto soils susceptible to erosion. Farmers with lands in the valley floor are

benefiting from improved grazing and even some grain production.

Since 1975, more than 20 studies have been carried out to assess land use change and the impact of grazing and land reclamation in the region. Numerous grazing experiments were undertaken by the Soil Conservation Service of Iceland between 1975 and 1989 to find effective ways of meeting grazing requirements without damaging vegetation.

The Soil Conservation Service runs the revegetation programme in partnership with Landsvirkjun and a farmers' cooperative. There are two formal meetings a year to discuss the programme's direction and any issues arising.

The programme also brings benefits for biodiversity. This is notable in an area to the west of the river where native vegetation is developing in place of grass cover, made possible by the soil depth and land cover created by the former cultivated grassland. The Institute of Natural History believe that a decrease in grazing pressure from sheep and horses, and a change in climate, have contributed to the success of the revegetation programme.

The fertilisation of some areas, creating good grazing land, has enabled the movement of animals, allowing overgrazed areas to recover.

The revegetation programme around the reservoir compensated for the loss of grazing land and avoided displacing grazing pressure onto soils susceptible to erosion.

Silt or dust storms are typical in Iceland, where much of the landscape is not covered by vegetation due to harsh natural conditions and centuries of overgrazing and wood harvesting. At low water levels and high winds, sediment from the exposed area can be windblown. Sand then settles close to the reservoir, threatening to cover the low vegetation, whilst finer silt is blown further and can be a nuisance.

In partnership with the Icelandic Institute of Natural History, Landsvirkjun has established measures to stabilise areas of land around the reservoir affected by windblown sand. This includes the application of fertiliser



The Blanda project power station

to encourage plant growth, and fencing to prevent grazing. If dust storms were to become a more regular occurrence, there is an intention to replicate Landsvirkjun's ongoing monitoring programme from the Kárahnjúkar project.

In-river geomorphological changes can also deliver benefits for communities

As a glacial river, the Blanda river was carrying high sediment loads of around 570,000 tonnes per year. Damming the river has substantially reduced sediment load downstream to about 63,000 tonnes per year. However, the erosive capacity of the river is also reduced as spring floods are curtailed. The river has changed from a dynamic braided system with frequently changing channels to a largely static one, and gravel banks in the channel have become vegetated.

The project also had unanticipated benefits for local communities, arising from altered river geomorphology. The effects of the project on erosion and sedimentation are generally seen as positive by the local population. Angling – in particular for salmon – has significantly increased, both because the river provides a better habitat and because of increased visibility. It was also possible to relocate the national road from Blönduós to Akureyri as the river was stabilised and flooding reduced.

This case study is based on an official assessment of Blanda using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2013, with an on-site assessment in September 2013.

Topic case study 10:

Financial viability: Murum, Malaysia

Policy and practice lessons

- **Sophisticated risk analysis and monitoring against key performance indicators played an essential role in cost control**
- **Board-level oversight of updated analysis ensures financial viability is kept on track**

Key project features

Project stage: implementation

Developer/operator: Sarawak Energy Berhad (SEB)

Capacity: 944 MW

Annual generation: 6,000 GWh

Reservoir area: 245 km²

Height of dam: 145 m

Purpose: power generation

Commissioning: 2014–15

The Murum project takes its name from the Murum river, in the uppermost part of the Rajang river basin. The project is located approximately 200 km from Bintulu, in the Malaysian province of Sarawak, on the island of Borneo.

Murum is the second project to be constructed in a plan comprising four hydropower projects on the upper Rajang.

This is part of a broader Government of Sarawak strategy, the Sarawak Corridor of Renewable Energy (SCORE).

When Sarawak Energy Berhad (SEB) initially decided to go ahead with Murum, there were no proven revenue streams. However, decisions for each project within SCORE were made on the basis of their contribution to the overall SCORE strategy.

The cost of constructing Murum was USD 670 million (2.98 billion Malaysian ringgit). This figure includes an additional USD 119 million (MR 530 million) negotiated after provisional sums in the construction contract were confirmed. The project was financed by SEB using a USD 3.4 billion (RM 15 billion) corporate bond programme.

Murum comprises a 145 m roller-compacted concrete dam, intake, and 2.7 km of tunnels supplying water to a 944 MW powerhouse, access road and transmission line. The main components of the project



were constructed by the Three Gorges Development Company, Malaysia (TGDCM) under a single contract with SEB. Filling of the reservoir began in July 2013 and the first

generator was commissioned in December 2014. The fourth and final turbine was commissioned in June 2015.

Bakun, immediately downstream and the first of the SCORE projects, was commissioned ahead of Murum.

This case study highlights a project financed with a corporate bond, and the measures put in place to ensure the company maintained its credit rating. The construction of Murum was financially viable, taking into account key uncertainties, and using financial contingencies.

The ability of any project to sustain the provision of its wider economic benefits, and its management of social and environmental concerns, depend on financial viability. Cost overruns, especially at the implementation stage, are common.

SEB applied its well-developed financial management, analysis and monitoring procedures at corporate and project levels, and financial risks were regularly assessed with respect to the project.

Sophisticated risk analysis and monitoring against key performance indicators played a key role in effective cost control

SEB undertook a full assessment of the Murum project's financial viability, including an analysis of costs and revenue streams, and the revenue implications of obligations in the power purchase agreement.

The company also carried out a detailed risk analysis, identifying risks such as: financial responsibility for provisional sums in the EPC contract; impoundment date obligations not being met or other sources of delays in impoundment; off-takers' abilities to develop their infrastructure in a timely manner; and higher-than-anticipated costs.

Maintaining the company's high credit rating was established as an internal target



Construction of the Murum project

To keep a regular check on costs, SEB monitored the project's financial situation on a monthly basis. Updates on costs and project delivery risks were set out in monthly reports. The reports compared project milestones with actual progress, cost overviews, progress analysis and risk management.

The company's planning and strategy department was responsible for financial optimisation, reporting to the CEO on key performance indicators. This included maintaining the company's external credit ratings, which was established as a target.

Board-level oversight of updated analysis ensures financial viability is kept on track

SEB applied cost tracking and control measures using systematic processes. Uncertainty around provisional sums in the EPC contract were resolved through board-approved renegotiation and the higher contract price included in financial planning and viability assessments.

A CCE (current cost estimate) process was incorporated into the project execution team's responsibilities. For example, it was on the basis of the second CCE that the board approved the renegotiation of the EPC contract.

Updated CCEs incorporating firmed-up revenue streams, such as power purchase agreements, were made during

implementation. Maintaining the company's high credit rating was established as an internal target, prompting active management of financial indicators to ensure this was achieved.

Monthly financial data were modelled to understand any implications for project viability, and the analysis was reported to the CEO, together with an assessment of impacts and solutions.

Spend-to-date analyses were included in monthly project reports, and any serious cost overruns were highlighted by the project manager, and escalated to board level.

The planning and strategy department runs monthly risk tests for the whole business, including Murum as one of the factors. With this corporate financial backing and with the right systems in place, the project was able to cope with financial issues in a broad range of scenarios.

This case study is based on an assessment of Murum using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. This was conducted in 2012, with an on-site assessment in April 2012, when construction was 66 per cent complete.

Topic case study 11:

Governance: Santo Domingo, Colombia

Policy and practice lessons

- Governance issues and opportunities for improvement are identified at corporate and project levels
- Requirements for contractors are set out in the corporate governance model
- Corporate governance procedures are transparent and information is publicly disclosed

Key project features

Project stage: preparation

Developer/operator: Empresas Públicas de Medellín (EPM)

Capacity: 56 MW

Annual generation: 240 GWh

Reservoir area: 0.012 km²

Head: 11.5 m (concrete gravity weir structure)

Purpose: power generation

Contractors must sign up to a code of conduct before their contract can begin

The Santo Domingo project is subject to EPM's comprehensive corporate governance and external management processes. This case study describes how these procedures are implemented to ensure transparency, legality, compliance and quality in project development.

The project is set to be developed on the Santo Domingo river, in the eastern part of the department of Antioquia. It will be situated 97 km from the department's capital city, Medellín, where the Empresas Públicas de Medellín (EPM) headquarters are located.

Antioquia is a hub of hydropower development, where 45 per cent of all planned projects registered with the Colombian Ministry of Energy and Mines can be found. The project area has been one of the worst affected areas in Colombia in terms of violence between armed groups and coca cultivation. The restoration of law and order and the peace process have prompted farmers to return to the area and has resulted in an intensification of agricultural land use.

EPM is Colombia's largest generating company, with a market share of 22 per cent and an installed capacity of 3,258 MW, most of which comes from 25 hydropower stations. EPM is a public company, owned by the municipality of Medellín. It was founded in 1955 as an independent public institution



and later transformed into an industrial and commercial state company. EPM is the parent company of a business group of 56 companies (22 based in Colombia and 34 internationally), in which it has a majority stake and management control through

presence on their boards. The EPM group provides electricity, natural gas, water, sanitation, collection, recycling and disposal of waste, and telecommunications services.

As a leading public utility in Colombia, EPM has comprehensive corporate governance and external management processes. These cover key areas such as: occupational health and safety; sustainability; procurement; corporate social responsibility; transparency; ethics and corruption; human rights; stakeholder engagement; grievance mechanisms; risk management; and audits.

EPM has a solid understanding of corporate and external governance issues; identifies corporate risks and opportunities through partnerships; and actively manages these as part of its continuous improvements.

The company makes information relating to corporate governance, projects and sustainability available publicly on its website. It also has a number of external initiatives focusing on improving policies within the energy industry and in Colombia, particularly on human rights. External stakeholders rank EPM highly in its governance practices.

Governance issues and opportunities for improvement are identified at corporate and project level

Political and public sector governance issues, and corporate governance requirements and issues, are comprehensively assessed across the EPM group. EPM's integrated risk management system underpins business and project compliance and internal and external auditing processes. EPM has used the results of internal audits to implement between 200 and 300 improvement plans across the company. The system makes it possible to identify and address opportunities for improvement.

For example:

- EPM has improved its internal processes to minimise the risk of corruption during land acquisition;
- an ethics line was set up in 2013, available on EPM's webpage;
- EPM has developed guidelines on human rights to support the development of public policy in Colombia. The company also sent a representative to a UN discussion on human rights in Geneva;
- the company uses a balanced scorecard as a tool for improvement, including assigned responsibilities; and
- the company has improved its response times to community requests, claims and land issues.

EPM also identified project-level issues relating to the Santo Domingo Action Plan, and risks associated with the project moving from the planning to construction phase, and from construction to operation. This was important for ensuring commitments to provide power are met.

Requirements for contractors are set out in the corporate governance model

EPM has a corporate governance model establishing clear processes to manage corporate, political and public sector issues and risks. The model provides a balance between company growth and investor rights, and stakeholder access to information, transparency and ethics.

Practices implemented include:

- a corporate governance model, setting out political risk guidelines for corporate group management;
- a corporate governance code establishing provisions, practices and measures for the municipality of Medellín and EPM to work together, and a code of conduct for EPM;
- a balanced scorecard reporting process at institutional and group level;
- assessment of issues and associated risks is undertaken using EPM's integrated risk management policy and system (GIR). The GIR method, developed for EPM, complies with national and international best practice risk management practices;
- a compliance unit monitors legal and regulatory compliance, and oversees procedures for the control and prevention of money laundering, corruption and financing of terrorism;
- a corporate audit department undertakes internal audits across the business and coordinates external audits;
- a grievance mechanism and official phone line for issues, complaints and (anonymous or identifiable) claims; and
- transparency is managed through internal audits, the communications policy, and external reviews by Transparencia Colombia and Medellín controlling office.

EPM has a code of conduct for suppliers and contractors, requiring them to have policies and standards consistent with the EPM group in the areas of human rights, labour standards (including occupational health and safety), environment, corruption and bribery, and information management and security. All contractors are required to register with EPM prior to working with the company, which includes signing up to its code of conduct. EPM contracts clearly outline the company's expectations from contractors



Confluence of Santo Domingo and Melcocho valleys

in terms of meeting corporate policies and legal requirements. Where contractors use subcontractors, they must also be able to demonstrate that their policies and standards are consistent with those of EPM.

Corporate governance procedures are transparent and information is publicly disclosed

EPM's annual sustainability report is compiled from data collated from across the business. The report is reviewed externally and published on the EPM external website. EPM also publishes important project reports. EPM created a dedicated web page for one of its large projects under construction, giving access to the EIA and EMP, monitoring reports, the public utility declaration, environmental licence, contingency plan, management contract, integral plan, project summary brochure, and regular project newsletters.

EPM reports against sustainability indices from project level up to institutional level. External reviews by Transparencia Colombia, Deloitte and Dow Jones Sustainability Index rank EPM highly in its governance practices.

This case study is based on an official assessment of Santo Domingo using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in November-December 2014.

Topic case study 12:

Hydrological resource: Jostedal, Norway

Policy and practice lessons

- **Use of climate trends and climate change scenarios provides comprehensive predictions of water availability**
- **Long-term perspective, including attention to climate change, meets dual purposes of flood control and spill avoidance, with flexibility to adapt to future changes**

Key project features

Project stage: operation

Developer/operator: Statkraft

Capacity: 288 MW

Annual generation: 874 GWh

Purpose: power generation, flood protection

Commissioning: 1989

The Jostedal project demonstrates how comprehensive monitoring of hydrological resource and analysis based on climate trends and climate change scenarios provides reliable assessment of medium- and long-term water availability.

Jostedal PP is located on the east side of the Jostedalen valley, in western Norway. The Jostedøla river runs through the valley, emptying into a fjord, Sognefjord, at the settlement of Gaupne. The project utilises the run-off from a 144 km² catchment area, situated at an elevation of 1,200 m. Water is stored in two reservoirs.

The main reservoir is Styggevatn, at the northern end of the Jostedøla valley. This reservoir can store one and a half years of average inflow. It is fed by another reservoir further upstream, Kupvatn, which can store three years of average inflow. From Styggevatn, an underground penstock carries water down the eastern side of the valley to the power plant, taking in additional water from a further 18 intakes.

Kupvatn and Styggevatn, and streams to the west of the valley, are fed by Jostedalsbreen, the largest glacier on the European mainland.

Jostedal is a multipurpose project, built to manage damaging summer and autumn floods resulting from glacier melt and rain. Flood protection is a serious concern in the valley, which has been hit by two



devastating floods, the first in 1898 and the worst on record in 1979.

The project licence requires that Jostedal shall not make any flood worse than it would have been without the plant. There is also a requirement to utilise 1 m of regulation amplitude as extra flood

protection in the main reservoir, Styggevatn, during the period up to 1 September each year. This 1 m is required to be gradually reduced during September.

The power station is located 1,200 m inside the mountain on the eastern side of the valley, 40 km from Styggevatn and 15 km from Gaupne. The project head, at 1,186 m, is one of the highest of any hydropower scheme in Europe. The power station is equipped with a single 288 MW Pelton turbine. A second power station, Leirdøla, is located in the south-west of the valley. It discharges to Jostedal power plant's discharge tunnel, prior to both discharging to the Sognefjord at a depth of 46 m.

Statkraft carries out comprehensive monitoring of the hydrological resource, with measurements of river flow, reservoir levels and inter-seasonal storage in the form of snow and ice. Generation planning is aided by sophisticated models, one for hydrological forecasting and another for determining a 'water value'.

There is also a flood prediction model and a modern control system with on-site access to the entire Nordic operations of Statkraft.

Statkraft assesses the future availability of water in the medium- to long-term both through traditional trend analyses and climate change studies.

Use of climate trends and climate change scenarios provides comprehensive predictions of water availability

Jostedal's inflow is provided by rainfall, snowmelt and glacial melting. The Jostedøla valley's catchment is 29 per cent covered by glaciers, and run-off is at its highest in the summer when melting and rainfall occurs. Just over 60 per cent of annual run-off occurs from June to August. Meanwhile, in winter, precipitation is stored as snow and runoff is minimal. The average run-off is around 37 m³/s.

As part of routine medium- to long-term planning, Statkraft uses climate change scenarios in addition to the standard trend analysis tools.

Statkraft's understanding of the river's hydrology is based on 80 years of field

measurements. The company also operates several hydrological gauges in the Jostedøla catchment. In addition to this data, there are shorter time series for some of the smaller tributaries, and hydrological, sedimentological and glaciological measurements of the glacier feeding these tributaries.

The storage of the reservoirs and historical data series are used in a hydrological model to simulate a range of water availability scenarios. They are also used for a separate flood prediction model.

Climate variability and climate change are key issues affecting water availability, with an impact on the amount and seasonality of precipitation, and on glacial mass balance. Statkraft's hydrological staff carry out snow and glacial mass balance measurements around the catchment during the late winter to predict water availability for the coming year. The sampling stations are located at various altitudes and different aspects in order to provide representative data.

Climate variability is comprehensively factored into Jostedal's hydrological analysis, including evaluation of scenarios over the short and long term. Modelling yields a range of possible scenarios for short-term water availability. Traditional hydrological trend analysis and a scaling factor are used, based on the statistically proven increase in runoff seen over the last decade.

Climate change is identified as one of the most important business drivers for Statkraft. As part of routine medium- to long-term planning, Statkraft uses climate change scenarios in addition to the standard trend analysis tools.

Long-term perspective, including attention to climate change, meets dual purposes of flood control and spill avoidance, with flexibility to adapt to future changes

Generation is managed through a power system production model called EMPS, a well-established market analysis tool.

This is run in two steps: the first is for the whole Nordic system, including its interconnectors to central Europe, giving the price of electricity; the second is for the more detailed level, with higher resolution (over time), resulting in water values.

The water value for each coming week is set in a weekly meeting, based on results from model runs. The plant managers hold daily meetings in which the water value can be adjusted in response to unexpected and



Styggevatn reservoir with dam in the foreground, and the calving Austdalsbreen glacier in the far background

rapid changes in price or availability.

The EMPS model and Statkraft's weekly and daily planning gives flexibility to adapt to future changes. Trend analyses, continuously updated hydrological statistics and climate change scenarios are fed in to provide a long-term perspective. Run-off forecasting, serving the dual purpose of flood control and spill avoidance, has been very efficient.

When the models show inflow that will fill the reservoir, the response is to generate at full capacity to avoid the risk of spilling.

Spilling occurs when the Styggevatn reservoir exceeds 1,200 m above sea level. This has only happened once since commissioning. Flood prevention measures require the level to be kept below 1,199 m in the summer, up until 1 September. Generation is highly efficient and has great flexibility to adapt to variable conditions.

This case study is based on an official assessment of the Jostedal project using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in August 2012.

Topic case study 13:

Indigenous peoples: Keeyask, Canada

Policy and practice lessons

- The project took a comprehensive approach to incorporating local knowledge
- Consent was achieved through community benefits including revenue sharing plus continuous engagement and involvement of indigenous peoples in decision-making
- Agreements addressed impacts beyond compensation and legacy issues
- The project provided support to manage revenues and maximise benefits

Key project features

Project stage: preparation

Developer/operator: Manitoba Hydro

Capacity: 695 MW

Annual generation: 4,400 GWh

Purpose: power generation

The KCN conducted their own environmental assessments based on the Cree worldview

The Keeyask project was developed by Manitoba Hydro (MH) in partnership with four Cree Nations communities affected by the project. This case study demonstrates best practices in engaging and working with indigenous peoples, respecting culture and livelihoods, achieving consent and providing significant benefits.

The proposed Keeyask hydropower project is located on the lower Nelson river, at Gull Rapids, upstream of Stephens Lake in northern Manitoba.

Project construction is projected to take approximately eight and a half years, from June 2014 to November 2022. It was estimated that the first of seven units would begin generating power in November 2019.

The reservoir will cover an area of 45 km², and was predicted to expand by 7 to 8 km² over the first 30 years of operation. This would be due to erosion of mineral soil shorelines and peat-land disintegration. The project is designed to operate in either base loaded or peaking modes, using 1 m of available operating range.

The project design included a 25 km north access road, a 35 km south access road, and a 22 km construction power transmission line and substation. The construction of the north access road began in 2012.

The project was developed by MH in partnership with four Cree Nations



communities affected by the project: Tataskweyak Cree Nation and War Lake First Nation (acting as the Cree Nation Partners); York Factory First Nation; and Fox Lake Cree Nation. MH is to own least 75 per cent of the partnership equity and the Keeyask Cree

Nations had the right to own up to 25 per cent of the partnership.

Keeyask is located in the ancestral land of the four aboriginal partner communities (comprising around 5,500 people), known as the Keeyask Cree Nations (KCNs).

Affected aboriginal communities were given the option of becoming investing project partners and receiving revenues. These communities decided to become partners through referendums in each community. The project partnership agreement was developed between 1998 and 2009, and involved extensive negotiations and inclusive and participatory consultations with directly affected aboriginal communities. The project provided legal and advisory support and capacity-building throughout this process.

Environmental and social studies took a comprehensive approach to considering the views and local knowledge of the affected aboriginal communities. MH also reached agreements with the communities to address the adverse impacts of the project. These agreements address impacts of the project from a community-based perspective, and build on previous agreements to address legacy issues from earlier hydro developments.

The project took a comprehensive approach to incorporating local knowledge

MH provided financial support to the KCNs to participate in the assessment, regulatory licensing and agreements. The process involved establishing a number of processes and committees, such as: a partners' regulatory and licensing committee; an assessment coordination team; and a number of working groups involving multilateral stakeholders and representatives of MH and each of the KCNs. These committees and processes guaranteed the appropriate representation of indigenous points of view and cultural sensitivity. Each of the KCNs also conducted their own environmental assessments based on their Cree worldview. These assessments were filed in the licensing process along with the technical regulatory assessment required by the provincial and federal authorities.

Consent was achieved through community benefits including revenue sharing plus continuous engagement and involvement of indigenous peoples in decision-making

The project partnership agreement was developed between 1998 and 2009, and involved extensive negotiations and consultations between MH and KCNs. Engagement included a range of processes, including: working and reference groups, convened for the environmental and social aspects; regular open community meetings; off-reserve meetings; and websites created by the communities and the project. Consultations considered the aboriginal traditional knowledge and cultural practices.

All four First Nations approved the partnership agreement and the agreement to address adverse effects through a democratic referendum process.

The project partnership agreement was public and legally enforceable, and addresses aspects of project development, potential income opportunities, and training, employment and business opportunities for the KCNs. The project also provides financial support to implement the partnership and maximise anticipated benefits.

Agreements addressed impacts beyond compensation and legacy issues

The partnership agreement provides benefits that go well beyond simply providing mitigation and compensation for adverse effects.

For example, the agreement includes a provision for the KCNs to enter into a project-ownership arrangement by investing their own money according to a defined plan. Each KCN is able to choose between two different investment options, with different levels of potential risk and possible reward. One of these options provides a guaranteed minimum return on investment. A KCNs investment option is chosen at the end of construction when final capital costs are known.

Each KCN signed an adverse effects agreement with MH in 2009. These agreements aimed to avoid, mitigate, replace and compensate project impacts on KCNs with a focus on improving KCN livelihoods and living standards. The adverse effects agreements also provided elements beyond compensation, for strengthening cultural identity, lifestyle, values and aboriginal traditional knowledge and skills.

Depending on community, the agreements contained programmes related to resource access, the Cree language, land/environmental stewardship, gravesite restoration, traditional life and knowledge, and oral histories and cultural sustainability.

In addition, each of the four KCNs had separate agreements with MH to provide compensation for legacy issues in relation to previous hydropower developments in northern Manitoba.

The project provided support to manage revenues and maximise benefits

The revenue generated through the partnership is to be deposited into individual KCNs' trusts, and each KCN will decide on how it is invested. This was stated in the partnership agreement.

Revenues could be invested in priority activities, such as new infrastructure. The project revenues are to provide a sustained source of income that contributes to each KCN's development. The compensation payments set out in the adverse effects agreement are also deposited into a trust fund, and used for mitigation programmes intended to strengthen the KCNs' culture and traditional practices.

The project also provided training and work experience in construction activities for KCN members. This would allow them to find other stable jobs in the future. This was facilitated through the 'Hydro Northern Training and Employment Initiative', a multi-year training programme designed by MH, affected aboriginal communities and the provincial and federal government to prepare northern aboriginals for employment on hydro and community projects.



An artistic rendering of the final station at Keeyask

This case study is based on an official assessment of the Keeyask project using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in December 2012.

Topic case study 14:

Infrastructure safety: Sogamoso, Colombia

Policy and practice lessons

- Infrastructure and public safety issues are assessed and monitored according to a wide range of scenarios
- Efficient emergency preparedness and response measures proved successful when tested unexpectedly
- Project makes a positive contribution to improving public safety

Key project features

Project stage: implementation

Developer/operator: ISAGEN (acquired by Brookfield in 2016)

Capacity: 820 MW

Annual generation: 5,056 GWh

Reservoir area: 69.6 km²

Height of dam: 190 m

Purpose: power generation

The Sogamoso project was designed and implemented to ensure that people, property and the environment are protected from the consequences of dam failure and other significant infrastructure risks. This case study presents best practices in managing infrastructure and public safety.

The project is situated in north-east Colombia, in the department of Santander. The dam and its reservoir are located in the municipalities of Girón, Betulia, Zapatoca, Los Santos, Lebrija and San Vicente de Chucurí.

Sogamoso consists of a 190 m concrete-faced rockfill dam and an underground powerhouse. The mean river discharge at the dam site at the time of the assessment was 471.5 m³/s.

The project requires the construction of 50 km of roads and associated bridges and tunnels, and is located in a region of high seismic activity. There is a population of around 17,000 people exposed to project-related infrastructure risks around the reservoir and below the dam. This population is scattered in small settlements and dispersed along the riverbanks.

Sogamoso was designed to deliver both base and peak power. The operating modes will significantly alter flows and water levels downstream of the dam. Public safety around the site is also being affected by an increase in road traffic during construction.



This case study presents best practices in managing infrastructure and public safety. Issues of importance in this field relate to quality control processes to ensure that infrastructure design and measures specifically address the risk of dam failure. They also address risks associated with other

infrastructure, such as the power station, roads and transmission lines.

Sogamoso was designed and implemented to ensure that people, property and the environment are protected from the consequences of dam failure and other significant infrastructure safety risks.

Emergency and contingency plans in the event of a potential dam break were developed in line with ISAGEN's standards, using state-of-the-art modelling and scenario mapping techniques.

Contingency planning both for the contractors and the community at risk were developed in close cooperation with all relevant authorities and communities, and supported by training and re-training programmes. These plans included a division of responsibilities for emergency preparedness and response measures.

The effectiveness of the plan was put to the test twice in 2011, when extreme floods threatened to overtop a coffer dam. Overtopping did not happen, but the plan was nevertheless implemented successfully, proving its efficiency and design across all responsible parties.

Infrastructure and public safety issues are assessed and monitored according to a wide range of scenarios

The project addressed a range of safety issues set out in regulatory requirements and ISAGEN's own policies. It identified and assessed potential dam failure scenarios, such as leakage, overtopping, structural instability, earthquakes and logjams. These were incorporated into the project design during preparatory studies.

ISAGEN assessed hydraulic conditions through both mathematical and physical scale models. Each contractor was required to appoint a licensed industrial safety inspector. The project was fitted with instrumentation to monitor the drainage and structural stability at the dam. There was continuous monitoring of hydrological and seismic conditions, and the quality of construction and equipment.

Manual monitoring of the dam was carried out in case of instrumentation errors. ISAGEN staff accompanied the industrial safety inspectors on their rounds to identify opportunities for safety-related improvements. Relevant staff took part in committee meetings every two weeks, focusing on safety risks and opportunities. Any issues that could not be resolved at these meetings were passed on to a construction works committee.



The site of the Sogamoso hydropower plant

Efficient emergency preparedness and response measures proved successful when tested unexpectedly

ISAGEN used state-of-the-art modelling to develop an 'emergencies and contingencies procedure'. This procedure was based on scenario mapping, model flood wave movement and simulations of dam break impacts downstream.

The company worked with local municipalities, the regional governor's office, the regional committee for disaster prevention and care, national police, the Red Cross, and the army and civil defence to prepare a community contingency plan. The plan clearly defined the information flow chain, from the police to the communities, and assigned clear responsibilities. It also included a contact list identifying each person/position to be alerted at particular alert levels. Specific evacuation sites and routes were also identified.

The project's contingency plan was updated every one to two months, depending on the issues. Sirens were installed, taking care that they made a different sound to the blasting alarms to avoid confusion. There was also a continuous training and re-training programme for officials and communities.

Emergency plans were unexpectedly put to the test during construction in 2011. Rainfall was so intense over a prolonged period that the coffer dam threatened to overtop twice, in April and May.

The contractor and community contingency plans were activated, and people living downstream were relocated. This occurrence demonstrated that the information and decision-making chain for

managing an emergency was adequate, and that the relevant stakeholders were ready to take the necessary responses.

In 2015, ISAGEN was awarded the National Engineering Award by the Colombian Society of Engineers, in recognition of its management of Sogamoso.

Project makes a positive contribution to improving public safety

In addition to effectively managing its impacts and risks, the Sogamoso project has had a positive impact on public safety conditions by investing in road relocation with improved standards.

The Bucaramanga–Barrancabermeja road was partly rebuilt through the project, as a large stretch of the old road will be inundated by the future reservoir. This section runs through two tunnels, and has been rebuilt to a higher standard than the original road, with better road safety.

Other secondary roads not affected by the project were also improved as a result of the development of Sogamoso.

The emergency response plan was put to the test twice in 2011

This case study is based on an assessment of Sogamoso using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in October 2013.

Topic case study 15:

Integrated project management: Trung Son, Vietnam

Policy and practice lessons

- Multiple levels of monitoring and review ensure timely construction and correction of delays
- Identification and monitoring of interface issues avoids costly delays
- Implementation plans addressing anticipated risks reduce construction delays
- Independent technical review provides further check on quality of construction

Key project features

Project stage: implementation

Developer/operator: EVN and Trung Son Power Company

Capacity: 260 MW, with four Francis units

Annual generation: 1,019 GWh

Reservoir area: 13 km²

Height of dam: 84.5 m roller-compacted concrete dam

Purpose: power generation, flood protection

Commissioning: 2017

The Trung Son project demonstrates how regular and detailed monitoring can ensure projects progress according to schedule, and enables early identification of emerging risks.

Trung Son is located on the Ma river, the fifth largest river in Vietnam. The Ma rises in the north-west of the country, running through north-eastern Laos and re-entering Vietnam just upstream of the project site. The power station is located in the province of Thanh Hoa.

Three main contracts were used in the development of the project:

- The main construction works, implemented by a consortium of Samsung (South Korea) and CC47 (Vietnam), with five principal subcontractors, including design of works drawings, drilling and consolidation grouting for the dam foundation, excavation of the emergency spillway, hydro-mechanical equipment installation, supply of instrumentation and technology transfer;
- Hydro-mechanical equipment, delivered by a Vietnamese consortium, with four subcontractors; and
- Design, supply and installation of the electro-mechanical equipment by a joint venture between HydroChina and Toshiba.



AECOM New Zealand was contracted as the supervision consultant.

Associated facilities include a 20.4 km project-constructed access road connecting the project to the public road system, and a 57.5 km 220 kV transmission line.

The transmission line was handled separately to the main construction

works by the National Power Transmission Company (NPT).

Trung Son is owned and constructed by the Trung Son Hydropower Company (TSHPCo), a wholly owned subsidiary of the state-owned Vietnam Electricity (EVN). The World Bank provided a loan for a large part of the project cost.

Project management at Trung Son was based on a project operation manual and detailed sub-plans. Monitoring was conducted daily, weekly, monthly, bi-monthly and annually, including a main monthly report with detailed progress chart. The project had a comprehensive construction quality control plan with clear assignments of responsibilities.

TSHPCo and the supervision consultant oversaw the integrated management of the project in cooperation with the main contractor, Samsung/CC47. This ensured that the works were generally progressing according to schedule and within budget. Government authorities also monitored construction progress and quality.

Emerging risks, and their associated management responses, were the focus of regular meetings between TSHPCo, the supervision consultant and the contractor.

Each contractor and sub-contractor was required to have their own construction plan, based on the overall plan and approved by TSHPCo. A technical panel appointed by TSHPCo was also in a position to identify risks.

Multiple levels of monitoring and review ensure timely construction and correction of early delays

Monitoring of all construction-related issues, including budget and interface issues, was carried out by multiple parties: the main contractor, the supervision consultant, TSHPCo, government departments and the technical panel. Annual, bi-monthly, monthly and weekly reports were delivered in both English and Vietnamese, incorporating detailed progress charts for all works components.

External monitoring by the supervision consultant, government departments and the technical panel provided for the identification of emerging risks.

TSHPCo, assisted by the supervision consultant, monitored licences for machinery, the standard of equipment and materials, the contractor's laboratory and facilities for the manufacturing of materials, components and engineering products.



Diversion finished and operating with prominent work safety message (January 2014)

This reduced the risk of violations or shortcomings affecting the project schedule.

The Thanh Hoa province Department of Industry and Trade (DIT) and Department of Construction (DC) were responsible for supervising industrial management and quality control respectively.

The DIT carried out biannual inspection trips to the project site to check progress and control quality, reporting to national ministries on a quarterly or annual basis. A team of four from the DC visited the site four times a year for quality control.

Identification and monitoring of interface issues avoid costly delays

The project construction plan and general schedule identified all interface issues for the entire project lifespan, including intensity charts for key activities such as rock excavation. These helped ensure that slow implementation of one component did not negatively affect the implementation of another component, or indeed the entire project schedule.

The most important interface issues were the excavations, ancillary infrastructure (power supply, power evacuation, access and construction roads and bridges), the resettlement programme, and preparation of the reservoir for filling. All key interface issues were monitored on a weekly basis.

The supervision consultant could recommend the reduction of payments to the contractor in the event of delays. This was in order to incentivise prompt recovery of the schedule. For example, this measure was used in relation to unsatisfactory erosion prevention at a spoil dump.

The supervision consultants regularly identified non-conformances. Early delays to the excavations, due to limited power supplies for construction, were recovered.

Implementation plans addressing anticipated risks reduce construction delays

Monitoring addressed internal and external risks. Numerous risks were identified and addressed, such as problems with the construction power supply, spoil dumps, and late excavations.

Whenever a new risk was identified, measures for its control were set out in a work programme and implementation schedule, setting out short-term targets including monitoring.

Opportunities to speed up progress were taken in some cases, such as during the excavation works. Contractors were also required to monitor external risks, for example meteorological risks.

Independent technical review provides further check on quality of construction

TSHPCo appointed a project technical advisory panel based on terms of reference agreed with the World Bank, which was a continuation of the dam safety review panel used during project preparation. The panel provided external advice and monitoring of issues affecting construction, focusing mainly on safety issues, but also encompassing broader construction management risks and the avoidance of construction interface risks.

This case study is based on an official assessment of the Trung Son project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in January 2014, and was financed by the World Bank.

Topic case study 16:

Labour and working conditions: Santo Antônio, Brazil

Policy and practice lessons

- Risk-mapping and operational analysis provide a basis for specialised safety procedures
- Unified system facilitates health, safety and environmental management
- Human resources managers provide multiple levels of oversight
- Strict standards applied equally to all contractors and sub-contractors
- Workers' commission provided regular forum for communications
- Variety of training opportunities fosters employee satisfaction
- Loyalty incentives promote staff retention

Key project features

Project stage: implementation

Developer/operator: Santo Antônio Energia (SAE)

Capacity: 3,568 MW

Annual generation: 21,236 GWh

Reservoir area: A total of 422 km² at full supply level, not including backwater effects, out of which 142 km² is the original river

Head: 14.7 m

Purpose: power generation

Commissioning: 2012–16

The Santo Antônio project required up to 20,700 workers during its construction phase, but faced strong competition for qualified labour in the region. This case study demonstrates how the project provided excellent worker satisfaction and retention.

The Santo Antônio project is located on the Madeira river, 7 km upstream of the city of Porto Velho, the capital of Rondônia state in north-west Brazil. The Madeira river is a major tributary of the Amazon, the world's largest river in terms of run-off volume.

The Santo Antônio project is designed to make maximum use of the water resource potential, with minimal negative impact on the Amazon region.

The project required a large number of workers – up to 20,700 in 2011. However, other large hydropower projects being developed in the Amazon region, combined with a construction boom across various sectors, meant fierce competition for qualified labour. The potential consequences of this included higher staff turnover and upward pressure on salaries.

Construction on Santo Antônio began in September 2008, when the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) issued an installation licence. The dam was closed and reservoir filling began in September 2011, following



IBAMA's issue of the operational licence. The first two turbines became operational in 2012, but the plant was only completed only in 2016, following an extension that added additional capacity.

Santo Antônio Energia (SAE) appointed an engineering-procurement-construction

consortium for the construction of Santo Antônio. This consortium, Consórcio Construtor Santo Antônio (CCSA), consisted of three main components: a civil works consortium, Consórcio Santo Antônio Civil (CSAC), made up of Odebrecht (leader) and Andrade Gutierrez (both part-owners of the plant); an electro-mechanical equipment consortium, Grupo Industrial do Complexo Rio Madeira (GICOM), consisting of Alstom Power, Alstom Grid, Andritz, Bardella, Siemens and Voith; and Odebrecht, responsible for electro-mechanical installations. SAE, CCSA and CSAC all had designated human resources and HSE (health, safety and environment) managers.

The Acreditar programme was an important tool for the planning and supply of qualified staff for the project (please see page 88 for more details). Up until 2013, safety was proving to be a challenge at Santo Antônio. In response, CCSA established a set of targets on the reduction of accidents, comprising:

- 40 per cent reduction of accidents without absence
- 25 per cent reduction in lost time accidents
- 40 per cent reduction in cumulative days lost due to severe accidents

These targets were progressively on track for success throughout 2013 and 2014. For example, the rate of accidents without leave fell from 10.1 per million work hours in 2012 to 6.3 in 2013, and down to 4.6 in the first four months of 2014.

Lost time accidents (i.e. hours of lost working time) fell from 7.8 to 5.4 to 4.4 per million work hours, respectively, over the same period.

The project suffered a total of 10 fatalities (seven on site and three off site), but there have been no fatalities at the project since October 2013.

40%
reduction in
cumulative
days lost due to
severe accidents



Safety signage on the construction site

SAE and the consortium members focused intensively on workers' needs and safety. They put in place systems for continuous monitoring and auditing by external parties. Implementation of safety requirements was delivered through a project-wide health, safety and environmental management system (SSTMA). The SSTMA standards applied to everyone, including sub-contractors. Each new contractor was given a risk assessment and constantly followed up and scored on performance.

A specific programme for staff retention included a workers' commission of representatives and an ombudsman system.

The project's policy was to focus on quality rather than cost when hiring staff. The workers' facilities were world-class, offering good, healthy food, excellent and well-staffed medical facilities, air-conditioned lodging and plenty of clean showers and toilet facilities. Workers remarked that the leisure and social facilities were the 'best' they had ever experienced.

A specific programme for staff retention was put in place. This included a workers' commission of representatives and an ombudsman system, through which workers could report grievances.

Risk-mapping and operational analysis provide a basis for specialised safety procedures

SAE initially assessed occupational safety risks on the construction site using a methodical risk-mapping process.

This consisted of mapping 10 risks, each of which were evaluated in terms of the dangers involved and the importance of the risk.

Combining this with the number of people involved, and the seriousness of potential outcomes, produced a probability–consequence risk rating for each activity.

Higher ratings required an additional round of assessment, with an operational analysis conducted by a health, safety and environment team.

This led to the definition of special procedures for specific risks, such as electrical work, work in confined spaces and work at height.

Unified system facilitates health, safety and environmental management

SAE, CCSA and all contractors were required to use a unified system (SSTMA) to manage occupational safety risks. The system is guided by a policy document and described in a fully detailed manual.

It covers aspects such as, but not limited to: legal documentation; risk assessment and management; sanitary conditions; preventive health care; personal protective equipment (PPE); accident prevention; work at height; work in confined spaces; work with electricity; safety signage; blasting; emergency procedures; training; safety inspections; and investigations of accidents. Safety themes for the day were discussed at morning meetings each day.

Human resources managers provide multiple levels of oversight

SAE's and CSAC's special purpose human resources and HSE staff monitored the application of systems and the emergence of issues.

They analysed trends in accident and turnover rates, and identified opportunities on other projects for demobilised workers.

A range of organisations were involved in auditing personnel and safety practices: government bodies, i.e. the national electrical energy agency (ANEEL), the Ministry of Labour and the regional superintendent for labour; an independent auditor, as part of the SSTMA, every six months; and auditors assessing compliance with the IFC performance standards, appointed by financiers.

Strict standards applied equally to all contractors and sub-contractors

SAE's and CCSA's safety standards were applied equally to all contractors and sub-contractors. Each new potential contractor was subject to a comprehensive risk analysis before contracting.

An initial meeting was held once the contract had been signed to conduct detailed analysis and definition of critical risk vectors for which management measures would be necessary.

Each employee was given four hours of initial training and a set of performance criteria to be evaluated on a monthly basis. Each contractor knew their employees' results and areas for improvement. Workers had to show evidence that they had passed the safety training in order to gain access to the project site.

CSAC carried out monthly checks to ensure that contractors were conforming with their contractual obligations, using a system of 0–5 performance scores.

Workers' commission provided regular forum for communications

There were three main channels through which workers could report any grievances:

- the worker's immediate supervisor;
- an anonymous ombudsman system, giving responses within a maximum of 48 hours; and
- a workers' commission, i.e. a group of workers' representatives.

The commission coordinators met three times a week to discuss day-to-day issues, and any issues reported to line managers for immediate action. If this did not yield a satisfactory resolution, the issue would then be escalated to the next level. If still not resolved at that stage, it would then be raised to the CCSA ombudsman. The aim was to create good conditions for all workers.

Typical issues raised included workers' accommodation (e.g. quality of light, cleanliness of bathrooms), transport, interpersonal relationships and bureaucratic issues.



Construction workers at the Santo Antônio project

Every first Wednesday of the month, members of the workers' commission met company representatives including the HR department. This approach had a significant positive impact on communications, and on workers' safety.

Variety of training opportunities fosters employee satisfaction

Workers were offered a number of different training opportunities, in areas such as: work safety; personal health; technical skills; health and safety courses related to the worker's function; and technical courses appropriate to the worker's function.

Whenever a worker was promoted, they were offered 45 days of preliminary training, after which the promotion was either approved or rejected. Programmes for leadership were offered at all levels.

There were also special campaigns in areas such as sexual health, combating violence against women, and sexual abuse of minors and adolescents.

Loyalty incentives promote staff retention

Stiff competition for qualified workers in Brazil prompted the project to develop a special programme for labour retention.

The programme included benefits linked to a worker's period of employment, including salary increments after every six months of employment (up to 18 months).

The living and recreational facilities provided to workers were also a major factor in employee satisfaction.

The project was careful to support workers in the demobilisation phase, offering an interview to evaluate performance and identify interests in other project opportunities.

This case study is based on an official assessment of Santo Antônio using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. This was conducted in 2014, with an on-site assessment in April–May 2014.



Each employee was given four hours of initial training and performance criteria to be evaluated on a monthly basis.



Examples of best practice:

- the HR policy included a statement to "hire the best" - cost was considered secondary and candidates were often handpicked;
- the project was involved in a Brazil-wide initiative to improve conditions of work in the construction industry, providing access to experience from other companies and sectors;
- suggestion boxes were placed around the construction sites and workers' accommodation to identify potential improvements;
- the project had a commitment to avoid rules or defined practices that restrict equal opportunities in terms of race, gender, etc.;
- a special programme was established for a group of Haitian refugees to assist with their adaptation to Brazil;
- a special programme enabled prisoners to work on site during the day, in order to assist with their rehabilitation and re-adaptation to society; and
- a professional nutritionist was employed to manage the kitchen and plan meals.

Topic case study 17:

Procurement: Sogamoso, Colombia

Policy and practice lessons

- **Rigorous processes ensure equitable, efficient, transparent, accountable, ethical and timely procurement**
- **Dedicated programmes create opportunities for local suppliers and capacity development**
- **Incorporation of anti-corruption measures in pre-qualification criteria enables screening of suppliers**

Key project features

Project stage: implementation

Developer/operator: ISAGEN (acquired by Brookfield in 2016)

Capacity: 820 MW

Annual generation: 5,056 GWh

Reservoir area: 69.6 km²

Height of dam: 190 m

Purpose: power generation

Progress and spending was monitored every two weeks and adjusted where necessary

Construction of Sogamoso involved around 150 companies providing goods and services. This case study demonstrates how well planned and implemented processes can support efficient and effective procurement and boost local employment.

Sogamoso is located in north-east Colombia, in the department of Santander. The dam and its reservoir are located in the municipalities of Girón, Betulia, Zapatoca, Los Santos and San Vicente de Chucurí.

The project's area of influence extends into the lower Sogamoso river area, until it flows into the Magdalena river. Sogamoso's development required the construction of 30 km of access roads, replacement of some infrastructure located in the reservoir area, and construction of over 60 km of transmission lines and a switchyard.

The power plant has three vertical-shaft Francis turbines, each with a capacity of 278.8 MW. The construction required an investment of approximately USD 2.3 billion, 40 per cent financed by shareholders' equity and 60 per cent by commercial financing.

The plant started operations in December 2014, increasing ISAGEN's share of total generation to 60 per cent. The project provides 8.3 per cent of annual energy consumption in Colombia.



This case presents best practices in procurement and processes that can be applied to construction works, goods and services. Important issues within this topic relate to the implementation of fair and transparent procurement and supplier

selection processes, measures to avoid corruption and unethical practices, and procuring quality goods and services that are delivered on time and budget.

Construction of Sogamoso involved around 150 companies providing goods and services, including equipment suppliers, contractors and subcontractors. The major contracts that governed the project included: construction of the main civil works, undertaken by ICT Group; construction of the new Bucaramanga–San Vicente de Chucurí road, undertaken by CONALVIAS; assembly of the electromechanical equipment, undertaken by the Consalfa-Hidrosogamoso Consortium; design and manufacturing of the turbines, undertaken by Andritz Hydro; detailed design and advisory services, provided by INGETEC S.A.; and manufacturing of electromechanical equipment by Mutsui and Toshiba (generators), Siemens (electrical), Consalfa and ABB (control systems).

Rigorous processes ensure equitable, efficient, transparent, accountable, ethical and timely procurement

ISAGEN has a dedicated procurement management unit, responsible for implementing its corporate procurement policy and maintaining and updating methodologies for quality management. ISAGEN's policy is based on the principles of equality, morality, effectiveness, promptness, fairness, publicity, efficiency, supervision, self-control, corporate responsibility and integrity. Open tenders are published on the ISAGEN website and a national newspaper for a fixed period, and feedback on tender clarifications is given to all bidders. ISAGEN has a supplier relations policy based on the principles of diversity, coherence, collaboration and openness. The company also respects the minimum requirements set out by the International Labour Organisation (ILO).

ISAGEN's audit team reviewed the project contracts every three months. Owners and engineers prepared a balanced score card for ISAGEN's management committee on a monthly basis. ISAGEN's procurement management team monitored the progress and spending within the project contracts every two weeks. This process meant that risks could be identified and adjustments made, such as extending the end dates of contracts or increasing the budget and resources for key milestones.

Any contract requiring extension or modification must undergo a management committee review process, and ISAGEN documents any decisions or recommendations made.

Incorporation of anti-corruption measures in pre-qualification criteria enables screening of suppliers

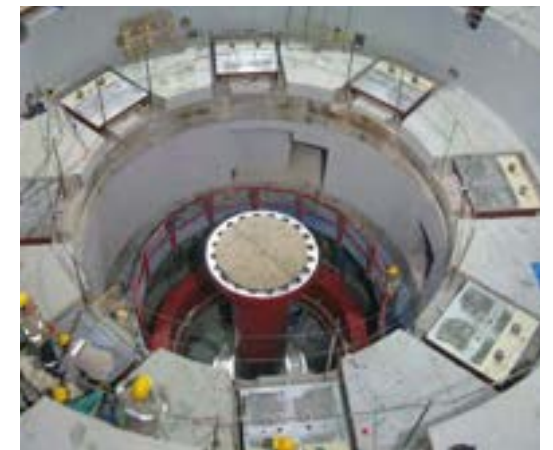
ISAGEN's procurement processes include anti-corruption measures and criteria specified in pre-qualification screening. Prior to the start of any contractual relationship, ISAGEN commissions an independent company to undertake screening to ensure companies have not been blacklisted for terrorism, money laundering, human rights violations, or environmental issues. The same company manages a database and registration record of suppliers. ISAGEN used an internal system to prevent money laundering and employed a safety model for IT to ensure information was shared securely with suppliers. Another company carried out a risk assessment for fraud, which prompted ISAGEN to develop a fraud risk management policy.

ISAGEN developed a fraud prevention programme and strategy, which included developing an anti-corruption strategy in 2013. These initiatives helped the company to achieve a number of objectives, including: conducting a policy review of the risk-assessment methodology, following International Institute of Internal Auditors standards; reviewing the risk management system; training internal auditors; incorporating international standards such as the Sarbanes-Oxley (SOX) into the review process; and an online course for employees on human rights, corruption and fraud risk management.

The company implemented a number of other anti-corruption measures, including: inserting clauses into contracts to prevent money laundering and terrorism-related activities; a corporate anti-corruption plan; and a corporate statement of ethical practices. ISAGEN's ethical phone line was in use for the project, and no corruption issues were reported.

Dedicated programmes create opportunities for local suppliers and capacity development

ISAGEN developed a 'local labour-involvement programme' to prioritise local and regional employment for the project



A machine being installed at Sogamoso

construction. Under this programme, contractors were contractually obliged to offer opportunities to local suppliers where possible. The programme was included in the environmental and social management plan.

ISAGEN established an employment committee to receive and organise applications for unskilled positions, and to maintain direct and timely communications with the employers. This committee was made up of representatives from the project's area of influence. When contractors were unable to obtain resources or goods locally, they were required to propose alternatives to ISAGEN for approval. The company also developed a programme for supplier capacity development, with the aim of boosting the capacity of local suppliers to enable them to access project contracts. Six suppliers participated in this programme out of the 25 invited.

ISAGEN evaluated contractor performance based on a number of criteria: technical, billing, timing, knowledge transfer, and environmental and occupational health and safety (OHS). This evaluation is intended to promote improvements from suppliers and contractors. The company can issue the results to any supplier or contract with a score of less than 80, in order to identify areas for improvement.

This case study is based on an assessment of Sogamoso using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in October 2013.

Topic case study 18:

Project-affected communities: Itaipu, Brazil–Paraguay

Policy and practice lessons

- Ongoing and effective communication processes over 30 years ensure good relations with affected landowners
- Multiple uses of the reservoir benefit local economies in two countries
- The project contributed to better long-term living standards

Key project features

Project stage: operation

Developer/operator: Itaipu Binacional

Capacity: 14,000 MW

Annual generation: 103,098 GWh

Purpose: power generation for two countries

Itaipu is an example of an operating project developed in the early 1980s that has fulfilled its commitments to economically displaced people, delivered additional benefits to landowners and farmers neighbouring the reservoir area, and promoted new business opportunities in affected municipalities.

Itaipu hydroelectric project is located on the Paraná river, on the border between Brazil and Paraguay. The Paraná river is among the largest in the world, by length and discharge. In 2014, the project provided 79 per cent of Paraguay's and 14 per cent of Brazil's energy supply. The Itaipu dam was built between 1975 and 1983. The 170 km reservoir reached its operating level in 1984, and covers an area of 1,350 km² over 16 municipalities in Brazil and five municipalities in Paraguay.

The land cover in the inundated area included fruit trees, timber, crops (e.g. corn, rice, manioc, coffee and soya), cattle farming, and riparian forest. Land acquisition affected landowners, tenants, and occupants in the reservoir area, construction areas and work camp sites, reservoir protection areas and other ancillary facilities. In the long term, the project developed a number of public infrastructure facilities, such as ports, schools and churches, used by affected people.



The 'Itaipu Binational Treaty' and laws promulgated in the 1970s set out the procedures for land acquisition and compensation. In addition, the project prepared a reservoir masterplan in 1982 which is intended to promote recreation, tourism and other uses in the reservoir area.

Itaipu Binacional kept paper records of land acquisition, valuation and compensation cases, with a total of 922 compensation cases in Paraguay, and 9,002 in Brazil.

The compensation process included a formal method of complaints and revision of compensation values. Compensation for landowners was fair, and in the long term, their livelihoods and living standards improved. Over its 30 years of operation, Itaipu Binacional has developed good engagement mechanisms with affected landowners and municipalities. The project also supported local economies and multiple uses of the reservoir through a number of voluntary programmes.

Ongoing and effective communication processes over 30 years ensure good relations with affected landowners

Affected landowners received fair land compensation based on comprehensive topographic surveys, an inventory of affected land and infrastructure, land and assets valuations, and regional market research.

Landowners received compensation for 100 per cent of the land in cases where, for example, only 70 per cent of land was affected, and the remaining land was insufficient for providing a permanent livelihood. Landowners had the opportunity to negotiate and express disagreement with the initial compensation proposal. Valuation prices were higher than market value prices, and Itaipu resolved any land title issues prior to compensation.

Since project development, engagement with affected neighbouring landowners continued around issues such as water use permits and maintenance of land boundaries. In both countries, there is a grievance mechanism in the form of an ombudsman, and a phone line/email for reporting issues. Itaipu provided relevant and prompt feedback to any queries raised.



Beach at Santa Helena



Old camp site at Belavista, now private homes

Multiple uses of the reservoir benefit local economies in two countries

The Reservoir Master Plan identified the need for studies to address regional development and Itaipu identified and implemented opportunities to meet this objective. Itaipu Binacional promoted multiple uses in the reservoir using similar permitting procedures in the two countries. Neighbouring landowners and communities benefited from these activities.

Some uses, such as recreation, ports and aquaculture, require a permit without a fee. Public recreation is the most popular use, followed by ports/boat landings, domestic water supply and aquaculture uses.

Aquaculture is promoted and controlled to avoid negative impacts on water quality. Aquaculture areas received significant support, such as training and facilitation from Itaipu.

Fish production reached 145 tonnes in 2014, and around 63 people worked with fish tanks. Fishermen who belonged to local fishing associations were the only group who could use nets on the reservoir. There were approximately 4,500 active recreational fishermen. Itaipu also supported competitions and other events associated with sport fishing.

Itaipu put a strong focus on tourism. For example, the tourism complex on the Brazilian side generated 100 direct jobs, through a visitor centre, tours, night tours, the biological reserve, zoo and eco-museum. Itaipu had ongoing communications with tourist associations and regular meetings.

Farmers reduced the use of water for cattle watering through the establishment of wells away from the reservoir.

The project also generated significant royalties for affected municipalities,

which perform relatively highly in human development indicators (longevity, education and income) and health indicators.

The project contributed to better long-term living standards

Improvement of living standards was not an established practice at the time of project development, but over the long term Itaipu has contributed to improved regional indicators and living standards.

Itaipu monitored the amount of land purchased by landowners compensated for land acquisition. Data indicated that for every hectare that was acquired by the project, an average of 1.6 hectares were purchased with the land compensation payments in the Paraná state of Brazil.

Paraná is one of the most prosperous states in Brazil, and land prices are very high. Alto Paraná and Canindeyú provinces are also quite prosperous compared to other provinces in Paraguay.

This case study is based on an official assessment of the Itaipu project using the operation stage tool of the Hydropower Sustainability Assessment Protocol and it is focused on issues related to landowners that were economically affected by the project. The assessment was conducted in 2015, with an on-site assessment in August 2015.

Topic case study 19:

Project benefits: Miel I, Colombia

Policy and practice lessons

- Legislative requirements on benefit sharing are complemented by local capacity-building
- Corporate policies and voluntary initiatives drive regional development through project implementation
- Measurable project benefits and programmes are implemented to reduce dependency on project investment

Key project features

Project stage: operation

Developer/operator: ISAGEN (acquired by Brookfield in 2016)

Capacity: 396 MW

Annual generation: 1,460 GWh (Miel I); 308 GWh (Guarinó); 104 GWh (Manso)

Reservoir area: 5.71 km²

Height of dam: 188 m

Purpose: power generation

3%



fall in extreme poverty in the project area in 2011

The Miel I project has made an important contribution to improving the livelihoods of project-affected communities and to regional development. This case study demonstrates how a project can deliver significant and sustained benefits to the surrounding area.

The project is located in the municipality of Norcasia, on the Miel river. It includes two river diversions: Guarinó on the Guarinó river, operating since 2010; and Manso on the Manso river, in operation since 2013. Hydropower projects in Colombia are legally required to pay 3 per cent of gross sales to any municipalities with jurisdiction over the reservoir area and project catchments. Operating plants are also legally required to pay 3 per cent to regional authorities with jurisdiction over the project area and the catchment, to be invested in catchment protection activities.

There are directly affected communities located in over 50 districts within the municipalities of Norcasia, Victorias, Samaná, and La Dorada. They include communities downstream of the hydropower plant, adjacent to the reservoir, adjacent to the Guarinó and Manso diversions, and downstream of the diversions. Other beneficiaries are more widely distributed across the Caldas and Tolima regions. The population of the beneficiary municipalities is roughly 150,000.



The Miel I project has made some important contributions to regional development, for example by: paying royalties to affected municipalities; establishing a support programme to improve the capacity of municipalities to manage royalties; committing to job creation; and developing investment programmes. The company publicises its commitments to project benefits, monitors royalties paid and reports to the national environmental authority.

The project identified and managed risks through the financial control of co-financing and oversight from committees of community representatives. The project has extended benefits through its expanded environmental management plan (EMP) programmes and through a broad range of voluntary programmes.

Directly affected communities, excluding those downstream, have received royalties amounting to COP 5–7 billion (USD 2.7–3.8 million) from the project. All communities have benefited from job creation. The project appears to have delivered significant and sustained benefits to the area, which has undergone rapid development since the plant's construction.

Legislative requirements on benefit sharing are complemented by local capacity-building

ISAGEN was aware that local authorities needed to be better prepared to manage royalties. It was important to ensure these were invested transparently, and in priority activities to drive community development.

The company implemented a capacity-building programme to maximise the use of royalties generated by the operating plant. By February 2014, the project had generated COP 820 million (about USD 440,000) in royalties, benefiting around 150,000 people.

Each municipality is notified of all the royalties paid, with the amounts published in bulletins and wallcharts on a monthly basis. The project keeps records of the amounts paid dating back to the start of operations. Municipalities aim to use the royalties for environmental projects (rural and urban catchment management, reforestation, recovery and ecological rehabilitation, solid waste management and basic sanitation), and a large proportion is spent on road maintenance. ISAGEN has published a brochure explaining the royalty system and how communities can get involved.

Corporate policies and voluntary initiatives drive regional development through project implementation

All of ISAGEN's projects must follow a system of corporate responsibility. As a result of ISAGEN's 'complementary management policy' and 'social management criteria guidelines', there are numerous voluntary environmental and social programmes that have been implemented to contribute to regional development. ISAGEN contributed



Moscovita community hall, an example of community investment by the project

more than COP 8.7 billion (USD 4.7 million) to voluntary projects over 2013–14.

Voluntary programmes include: supporting the Peace Development Programme (PDP); river Integrated Action Plans (PAI) for Miel I; and ISAGEN's 'good neighbours' programme, which supports local districts, mostly in basic water provision and sanitation.

ISAGEN was one of the founding partners of the PDP, established in 1995. The programme works with over 70 community-based organisations in 17 municipalities, spending COP 2–billion per year. ISAGEN provides 20–30 per cent of core funding and funding for specific projects. The PAI extends project benefits to downstream communities not eligible for royalties, and partly addresses the impacts of downstream flows.

Other voluntary initiatives supported by the project include:

- the Foundation Apoyar programme to provide training to rural youth, including young victims of armed conflict;
- subsidies for ICETEX (the Colombian institute of educational credits and technical studies abroad) to provide educational credits for people seeking vocational training;
- a programme for agricultural business promotion, rubber production and basin management in Victoria municipality;
- additional support to a regional environmental authority for basin management and to support basic sanitation projects;
- reconstruction of a footbridge over the Tasajos river, in response to requests from the local community;
- construction of a cultural house in the Norcasia municipality;
- construction of a new old people's home in Norcasia;
- support to the Norcasia youth choir; and
- rural feeder roads in the Guarinó area.

Measurable project benefits and programmes are implemented to reduce dependency on project investment

Royalties can amount to more than 10 per cent of municipalities' total expenditure. The project also provides financing for more than 20 per cent of specific projects implemented in some municipalities. Socio-economic indicators for the Caldas region reflect the contributions made by the project. For example, the rate of extreme poverty fell from almost 13 per cent to less than 10 per cent in 2011.

Local communities and municipalities regard the project's contribution to regional development as highly significant. An opinion poll revealed that 22 of 34 respondents agree the project has brought benefits to the region, while 21 of 32 respondents disagree that the region has been adversely affected by the project.

ISAGEN and its partners in the local communities are aware of the potential risk of dependency on project investment, and have prioritised empowerment and capacity-building in the programmes.

This case study is based on an official assessment of Miel I using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in June 2014.

Topic case study 20:

Public health: Mangdechhu, Bhutan

Policy and practice lessons

- Involvement of public health authorities facilitates identification and monitoring of public health issues
- Measures were introduced to manage health risks associated with contractors and migrant workers
- Public health conditions have been enhanced with better infrastructure and prevention campaigns

Key project features

Project stage: implementation

Developer/operator: Mangdechhu Hydroelectric Project Authority (MHPA)

Capacity: 720 MW

Annual generation: 2,925.25 GWh

Purpose: power generation and export to India

Quality of health services delivered to local communities has improved significantly

The Mangdechhu project has been successful in improving public health conditions in surrounding districts. This case study demonstrates how comprehensive health management plans and involvement from health authorities and contractors can have a positive impact on healthcare in local communities.

The project is located on the Mangdechhu river in the Trongsa district of central Bhutan. The Mangdechhu river is a major tributary of the Manas river, which is itself a tributary of the Brahmaputra river in India. The project operates as a run-of-river, with a 13.5 km headrace tunnel leading to an underground powerhouse that discharges back into the Mangdechhu river.

The project affects three sub-districts within Trongsa: Nubi, Drakten and Langthel. The project area is very close to Trongsa town, the district capital. Trongsa town is located about 1 km upstream from the dam site and has a population of about 13,000. The town has a government district hospital, while provision of healthcare in the sub-districts is driven by a national policy of equitable service provision based on accessibility.

Prior to project construction, public health infrastructure in the three sub-districts consisted of: four basic health units (one in Nubi, two in Langthel, and one in Drakten);



and 15 outreach clinics (six in Nubi, six in Langthel, and three in Drakten).

The project directly affected 158 households, as a result of the acquisition of 42.4 hectares of private land and associated economic displacement. Livelihoods were dependent on agriculture (e.g. rice, wheat, maize, millet,

potatoes and vegetables). The project did not affect indigenous peoples and did not require physical displacement. Pre-project water quality was generally good.

The health situation and the need for public health interventions in the project area were assessed as part of the project's environmental impact assessment, and then by the Ministry of Health. The project health issues included: the introduction of malaria by migrant workers; sexually transmitted diseases (STDs) including HIV/AIDS; poor water supply infrastructure and sanitation; the need of improved infrastructure; and awareness-raising.

The project's health management plan addressed these issues and prevented overloading of existing public health infrastructure.

The project also implemented several innovative solutions to key health-related issues in collaboration with contractors and public health authorities.

Involvement of public health authorities facilitates identification and monitoring of public health issues

A comprehensive assessment of existing public health conditions was carried out at the start of project construction. This was done by the Bhutanese Ministry of Health, led by the director of the Department of Public Health.

The assessment anticipated the following project-related needs:

- measures to avoid the introduction of malaria by infected migrants working or seeking to work for the project;
- measures to avoid a potential rise of STDs and hepatitis incidences;
- sanitation and water supply facilities at labour camps to avoid risks for nearby communities;
- health awareness programmes
- improved water supply facilities in local communities; and
- improved public health infrastructure.

During project implementation, the chief medical officer of the medical division of the Mangdechhu Hydroelectric Project Authority (MHPA) assessed public health issues and needs and prepared a health management and monitoring plan. This was done in collaboration with the Trongsa District Hospital and the local community. All clinics and the MHPA reported regularly

to the provincial health officers on any new cases or trends. MHPA, working closely with Trongsa Hospital, monitored potable water quality twice a year. Antibiotic use was also monitored to avoid contributing to the development of resistant strains.

The project experienced a large influx of migrant workers, which had the potential to put pressure on existing public health facilities. Risks included: infectious diseases; vehicle-related accidents; and air, noise and waste pollution from labour camps. These risks were monitored periodically. Monitoring involved constant evaluation of health statistics and follow-up on screenings and check-ups of workers and communities.

Measures were introduced to manage health risks associated with contractors and migrant workers

MHPA and contractor personnel had to undergo initial health screenings. Annual mass screenings were carried out in 2012, 2013 and 2014 for malaria, STDs and HIV.

Project and provincial health staff put in place successful measures to encourage contractors to adapt to Bhutanese standards.

New public health facilities created by the project were integrated into district infrastructure from the start of construction. This facilitated the handover of facilities from the project to the district.

Other hydropower projects in Bhutan have faced water contamination during construction. However, on this occasion the company's medical division introduced an improved water treatment method to prevent this from occurring.

New public health facilities created by the project were integrated into district infrastructure.

The project also identified the need for blood supplies at the clinics to address the huge influx of workers. MHPA collected blood from project staff to avoid a burden on the district supply. Workers with HIV have traditionally been dismissed by contractors, which discourages them from being tested. MHPA's medical staff made great efforts to convince contractors to provide local treatment and allow workers to remain on the job.



The authority office at Mangdechhu

Public health conditions have been enhanced with better infrastructure and prevention campaigns

The project delivered a number of new health facilities:

- a basic health unit at Dangdung, offering medical services to MHPA staff and villages around Dangdung;
- a health information service centre at Kuengarabten to provide information, advice, testing and treatment for HIV/AIDS and other STDs;
- provision of ambulances in the area;
- ultrasound equipment and an electrocardiogram machine for Trongsa Hospital;
- screening campaigns on and off site; and
- contractors' clinics with qualified medical staff.

The project supported the Bhutanese Ministry of Agriculture and Forests with an anti-rabies campaign to raise public awareness. The campaign involved vaccination of 708 dogs and sterilisation of a further 592 dogs.

Caseload records indicate that there have been no significant increases in public health problems due to the project, and that the level of service extended to affected communities has improved significantly.

This case study is based on an official assessment of the Mangdechhu project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2016, with an on-site assessment in January 2016.

Topic case study 21:

Resettlement: Chaglla, Peru

Policy and practice lessons

- Comprehensive studies and plans facilitate compliance with international standards
- Significant efforts made to restore and improve livelihoods and living standards of resettled communities
- Continuous two-way engagement mechanisms ensure successful resettlement

Key project features

Project stage: implementation

Developer/operator: Empresa de Generación Huallaga S.A. (EGH), a subsidiary of Odebrecht Energía S.A.

Capacity: 456 MW

Annual generation: 2,736 GWh

Reservoir area: 4.74 km²

Head: 202 m

Purpose: power generation

Specialist studies were commissioned to understand issues affecting local communities

The Chaglla project required the physical displacement of nine families, and had a direct influence over around 3,000 people. This case study demonstrates how engagement with local people led to successful resettlement.

Chaglla is located on the upper Huallaga river and named after the municipality of Chaglla, in the department of Huánuco, on the eastern slopes of the Peruvian Andes.

The project's area of influence is divided between the district of San Pablo de Pillao, in the province of Huánuco, and Chaglla, in the province of Pachitea.

About 3,000 people were living in the project's influence area (excluding the transmission line) in 2010. This is mostly an area of traditional collective ownership. The department is also one of the least developed in Peru, and has experienced some outmigration. Chaglla required the physical displacement of 33 families, most of whom were relocated before the end of 2012. Nine of the 33 families opted for a replacement house.

The number of families to be resettled as part of the project was relatively small, and most were relocated within their own community. This reduced the burden on both the relocated families and the host communities. Families were given the choice between a replacement home or cash compensation, and the compensation and transition



process was generally well handled. Post-resettlement assistance was the same as for families who were economically displaced due to land acquisition.

The resettled families that remained in the area were closely monitored, with most reporting improvements in their living standards and livelihoods.

Comprehensive studies and plans facilitated compliance with international standards

An initial environmental impact assessment (EIA) did not address the physical displacement of families. The project is financed by international institutions, so was required to comply with international performance standards on involuntary resettlement. Empresa de Generación Huallaga S.A. (EGH) commissioned a Compensation and Involuntary Resettlement Plan to fulfil those requirements.

A number of additional specialist studies were commissioned to better understand the issues affecting local communities. Resettled families were among the 96 families whose land was affected. All were considered 'priority stakeholders' and have been closely monitored. The surveys of 'priority stakeholders', covering most of the resettled families, were exemplary in their level of detail. These look at a range of indicators that would allow risks and opportunities to be identified, such as income generation. Nine of the 33 physically resettled families moved elsewhere or did not permanently live in the area, and therefore were not monitored. However, their primary residence and occupation were known, and the families were not considered vulnerable or at risk of impoverishment. Monitoring revealed no noticeable impacts on host communities, and social monitoring instruments were regularly updated.

Continuous two-way engagement mechanisms ensure successful resettlement

The resettled families were invited to choose their preferred means of compensation and, where applicable, the locations and designs of replacement homes. In addition to the three rounds of workshops required by the EIA process in Peru, the project delivered additional workshops, and liaison officers performed monthly community visits to address any concerns. Centres for information and citizen services were also available to resettled people and host communities. Feedback to the resettled families was thorough and timely, and no concerns were left unaddressed.

Landowners who were unsatisfied with the valuation of their land or other aspects of the compensation process could access a "claims resolution committee". There have been no expropriations or legal cases,



New home provided to a resettled family by the Chaglla project

very few complaints from the resettled people about the process and outcomes of resettlement, and no complaints from host communities. Surveys conducted among priority stakeholders reveal high levels of satisfaction with living arrangements.

Significant efforts made to restore and improve livelihoods and living standards of resettled communities

The project developed a series of land acquisition plans covering resettlement requirements. Owners could choose between rebuilding a home in a similar style, at least the same size and of better quality, or cash compensation. Only five of the 33 families opted for a replacement house, with 28 preferring cash compensation. Most were resettled within their own plots or their own villages. They were monitored closely and given priority in negotiations and employment opportunities. The lenders accepted the cash compensation option after demonstrating how agricultural income would be maintained.

All families received logistical support with their move, including transport, disassembly or demolition of their existing homes and transport of salvageable parts and, in two cases, temporary rental of homes. The valuation and land acquisition principles were publicly disclosed and clearly communicated to affected people.

Resettled families reported significant improvements in their living standards, and generally, in their livelihoods. All resettled families were invited to participate in an agricultural technical assistance programme, which most accepted. The package of assistance measures was designed to encourage self-sufficiency.

The nine families that moved out of the project area generally reported using their compensation money to buy additional productive land, build homes, develop small businesses, cover education costs, or purchase property in Tingo María.

There were two cases where the resettlement process was more complex:

- a small community of 15 houses was established at Nueva Chulla on the left bank, resulting from fraudulent subdivision and sale of parcels; and
- seven Agua Nueva landowners remained in the reservoir area after the settlement of compensation; they were treated separately from the resettlement plan.

Their intention was most likely to obtain additional compensation payments or benefit from their position close to construction traffic. EGH resolved the conflict in close cooperation with community leaders. The company paid compensation to move those households away from the reservoir area, even though this was not a requirement.

This case study is based on an official assessment of the Chaglla project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. This was conducted in 2015, with an on-site assessment in June 2015.

Topic case study 23:

Waste, noise and air quality: Santo Antônio, Brazil

Policy and practice lessons

- A dedicated centre at the project facilitates waste management
- Comprehensive monitoring facilitates identification of emerging and unforeseen pollution risks
- Thorough assessment of pollution and noise sources enables effective management
- Programmes for worker and community responsibility improve waste management

Key project features

Project stage: implementation

Developer/operator: Santo Antônio Energia (SAE)

Capacity: 3,568 MW

Annual generation: 21,236 GWh

Reservoir area: A total of 422 km² at full supply level, not including backwater effects, out of which 142 km² is the original river

Head: 14.7 m

Purpose: power generation

Commissioning: 2012–16

The Santo Antônio project produced a wide range of solid waste from both the construction site and workers' camps. This case study demonstrates how regular monitoring, proper treatment facilities and training programmes can improve waste management, including beyond a project's own impacts.

The project is located on the Madeira river, 7 km upstream of the city of Porto Velho, capital of Rondônia state in north-west Brazil. The Madeira is a major tributary of the Amazon, the world's biggest river in terms of run-off volume. The project is designed to make maximum use of the water resource potential, with minimal negative impact on the Amazon region.

Construction began on the project in September 2008, after the installation licence was issued by the Brazilian federal environmental agency (IBAMA).

The dam was closed and reservoir filling began in September 2011, following the issuing of the operational licence by IBAMA. The first two turbines started operations in 2012, but the plant was only completed in 2016, following an extension to add additional installed capacity.

The project produces a wide range of solid waste, from both the construction site and the workers' camps. The camps are the



primary source of domestic wastewater and the concrete and crushing operations also produce industrial wastewater. Vehicles, blasting and crushing are the main sources of noise and air pollution.

A construction consortium, Consórcio Construtor Santo Antônio (CCSA), was appointed for the project. This consists of a civil works consortium, an electromechanical equipment consortium, and Odebrecht for electromechanical installation.

The civil works consortium (Consórcio Santo Antônio Civil, CSAC) consisted of Odebrecht and Andrade Gutierrez.

Waste, noise and air quality pollutant sources and volumes were carefully and analytically identified during the project preparation phase. Regular monitoring was set up for all sources of pollution. Monitoring of issues took into account any possible linkages, for example by looking for a relationship between wastewater effluent monitoring and aquatic macrophytes monitoring.

The project provided environmental and waste management education to project-affected communities and project workers.

Monitoring was adapted according to emerging risks and opportunities during the implementation phase. For example, noise monitoring was increased during blasting, and additional water quality monitoring was established to cover a new treatment process.

A dedicated waste treatment area was set up to process solid waste; ponds and treatment facilities were used for wastewater; and vehicles were checked regularly to ensure they complied with noise and air requirements.

The project also provided environmental and waste management education to project-affected communities and project workers,

88%
recycling rate
achieved for all
project waste



Composting of organic waste

thus contributing to addressing waste management issues beyond its own impacts.

A dedicated centre at the project facilitates waste management

The civil works contractor established a dedicated waste management centre on the project site where solid waste was segregated, classified, quantified and processed.

The different types of waste included: burnt oil, contaminated oil, contaminated soil, sawdust, industrial wood, metal scrap, paper and cardboard, plastic and rubber, oil filter, cloth, paper and cotton waste, used and contaminated PPE, batteries, fluorescent lamps, tyres, incineration ashes, non-recyclable waste and organic waste.

Third-party companies were appointed to recycle the materials. This process achieved a recycling rate of 88 per cent of total waste.

Organic waste was composted on site and used for land rehabilitation. Contaminated soil was composted separately, allowing bacteria

to break down contaminants, before being combined with other compost.

Material that could not be recycled or composted – approximately 9 per cent of the total amount collected – was disposed of in an on-site sanitary landfill facility.

Comprehensive monitoring facilitates identification of emerging and unforeseen pollution risks

Comprehensive monitoring was carried out at the project site across a range of parameters.

The civil works contractor, for example, was responsible for:

- recording volumes of solid waste on a monthly basis;
- monitoring effluents from the washing and lubrication ramp's oil and water separation traps, and outflow from the camp's wastewater treatment lagoon on a monthly basis;
- monitoring water from the settling ponds of the concrete plant, water from the

- concrete curing of the powerhouses, and leachate from the landfill every six months;
- monitoring air quality on an annual basis, in and around the project site, for particulate matter, carbon monoxide, carbon dioxide, sulphur dioxide, ozone, nitrous oxides, hydrogen sulphide, hydrofluorocarbons and CFCs;
- monitoring 'black smoke' from vehicles on the construction on a monthly basis; and
- monitoring noise levels annually in the nearest communities or more frequently when higher noise was expected

- carrying out weekly checks to ensure vehicles complied with noise standards.
- Monitoring was adjusted according to new risks that became apparent during the construction phase. For example:
- when the treatment of iron pipes with a new chemical presented a water pollution risk, the civil works contractor developed a treatment station for wastewater and put in place a monitoring procedure to ensure the treatment was working;
 - noise monitoring was conducted during periods of intense blasting in response to

- concerns that the activity could disturb local communities; and
 - river turbidity was monitored when silt from dredging was released.
- The project implemented a number of broader environmental monitoring programmes, on issues such as water quality, sediment loads, and macrophytes in the Madeira river.
- This enabled SAE to identify links between the monitoring results for wastewater effluents from site treatment plants and those from broader programmes.



Each year, Odebrecht offers awards for employees' innovation. This led to one of the project's employees proposing to replace the use of aluminium sulphate in wastewater treatment in favour of a new system using tree bark.



Water treatment ponds

Thorough assessment of pollution and noise sources at the project enables effective management

The project adopted an analytical approach to the identification of the sources and volumes of wastewater, solid waste and noise. For example, it identified sources of wastewater from: industrial effluents from the workshops; washing ramps; vehicle lubrication areas; crushing and concrete plant areas; and wastewater containing fuels and lubricants from storage areas.

Through its environmental education programme, the project offered workshops, lectures and meetings with local communities to improve knowledge on environmental protection.

Before work on the project began, the civil works contractor calculated the amount of domestic wastewater the project would generate based on the estimated

number of workers on site. An estimate was also made of the volumes of industrial wastewater to be treated, based on an assessment of the amount of concrete to be used, the processing volume of the crushing plant, and use of vehicles.

The civil works contractor also assessed the potential noise impact from equipment, blasting, transport and the crushing plant. The assessment considered how each source could impact the surrounding environment and communities.

During the project preparation stage, potential sources of air pollution were examined, including site vehicles, crushing and blasting.

Programmes for worker and community responsibility improve waste management

The civil works contractor trained staff to identify emerging pollution risks by offering a wide range of waste management education courses.

These courses addressed topics such as:

- identification of environmental impacts;
- dealing with oil or chemical product spillage to soil or water;
- solid waste management;
- handling of chemicals;
- incineration of hazardous waste; and
- composting of organic waste and cleaning of grease traps.

Each year, Odebrecht offers awards for employee innovation. As a result, one of the project's employees came up with a proposal to replace the use of aluminium sulphate in wastewater treatment in favour of a new system using tree bark.

Aluminium sulphate is a toxic reagent which, when discarded, accumulates in the food chain. The replacement of this reagent with the bark of the Veta tree eliminated the impact that the disposal of aluminium sulphate would have caused.

In addition, sludge generated by the project was used as organic fertiliser in a land rehabilitation programme.

Through its environmental education programme, the project offered workshops, lectures and meetings with local communities to improve knowledge on environmental protection, including waste management, appropriate practices for burning waste, proper use of pesticides and water management.

This case study is based on an official assessment of Santo Antônio using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in April–May 2014.

Topic case study 24:

Water quality: Semla IV, Sweden

Policy and practice lessons

- Regional stakeholders join forces to monitor water quality in the catchment area
- National-level systems promote long-term water quality improvement
- Online monitoring results provide water quality data, transparently, for all
- Water-lubricated turbines eliminate spill risks during operation

Key project features

Developer/operator: Sydkraft Hydropower AB, which is part of the Uniper Group

Capacity: 3.5 MW

Annual generation: 14.8 GWh

Reservoir area: 34 km² (Lake Barken)

Head: 10.5 m

Purpose: power generation

Water quality issues were assessed during the preparation of the Semla IV project, but what makes this case study particularly interesting is the level of water quality information that was available for the area. This offers lessons for the development of water quality monitoring systems elsewhere.

The project will replace Semla III, which in turn replaced two plants, Semla I and Semla II, built in 1887 and 1902. The project is located on the Kolbäcksån river in the north-west of Fagersta municipality in southern Sweden. The nearby Strömsholm canal has been in operation since the 1700s.

Upon completion, Semla IV should have a capacity of 3.5 MW. The project is a combination of replacement and rehabilitation of Semla III. The modernised project will use the same flow and head as its predecessor, but will increase generation from 10.1 to 14.8 GWh/year by replacing the turbines and penstocks.

The existing Semla dam creates a small headpond, which connects immediately upstream to the Vevungen lake, and is maintained by a natural barrier, raised slightly in the 18th century to facilitate boat traffic into the canal. The lake is connected to the much larger southern and northern Barken lakes, with a total surface area of 34 km².



Sydkraft Hydropower AB has a total capacity of approx. 1,700 MW. The Uniper Group operates 178 plants in Germany and Sweden, with a total capacity of approximately 3,600 MW.

An online platform makes water quality data transparent and accessible

Water quality in the project area is mixed, with a number of pollution sources unrelated to hydropower. The environmental impact assessment for Semla IV included an assessment of water quality issues. Results showed the project would have no impact on water quality during regular operations, and only temporary minor impact during construction primarily related to turbidity.

The most interesting aspect of this case study, however, is the depth of the water quality information that was available for the area. This offers lessons for the development of water quality monitoring systems elsewhere.

Regional stakeholders join forces to monitor water quality in the catchment area

Water at Semla IV flows from a 2,200 km² catchment area. This is predominantly forest, but includes some towns, historic and current industrial sites, and agricultural areas. As with many parts of Sweden, the surface waters in the upper catchments are nutrient-poor and therefore have little buffer against acidification, so lakes are limed regularly.

Water quality in the area is generally moderate to good, although the consequences of contamination would be serious. People staying in nearby cabins use drinking water directly from the lakes above Semla, with filtration as the only treatment.

To maintain local water quality, stakeholders in the region formed a water management association, the 'Kolbäcksån Vattenförbund'.

The Kolbäcksån river is also one of the tributaries to Lake Mälaren, Stockholm's main source of drinking water. To maintain local water quality, stakeholders in the region formed a water management association, the 'Kolbäcksån Vattenförbund' (<http://bit.ly/2n5IApR>), in 1986. The association brings together 53 municipalities, public sector organisations and private businesses that are authorised to use, or whose activities have an impact on, the river. Most are mandatory members by law. The association has a board and holds



Penstocks of the existing Semla plant, which are leaking badly and will be replaced by one new penstock with the construction of Semla IV

an annual general meeting at which Uniper is represented. The secretariat is provided by the county administration.

The association finances water quality monitoring and other joint efforts, such as flood management studies. Water quality monitoring is comprehensive: the association contracted the Swedish University of Agricultural Sciences (Department of Aquatic Sciences and Assessment) to monitor 11 lakes and 10 watercourses in the basin between 1997 and 2010. The programme comprised physical, chemical and biological parameters, with sampling carried out monthly in the watercourses and twice a year in the lakes.

Online monitoring results provide water quality data, transparently, for all

The results of the water monitoring are accessible to everyone online [<http://bit.ly/2nutvhN>]. In 2011, the association contracted a private company to continue the water monitoring programme, publishing all results online.

National-level systems promote long-term water quality improvement

Sweden has an exceptionally thorough system for nationwide, long-term programmes to monitor and respond to problems in water quality. Water management associations across Sweden have joined forces to establish a country-wide water quality monitoring system.

This enables them to guide and track progress towards their European Union Water Framework Directive (WFD) commitments. For example, stretches of the Kolbäcksån river system upstream of Semla (the southern and northern Barken lakes), were downgraded to "moderate chemical status" in the WFD action plans for 2015–21. This was mostly due to contamination with polycyclic aromatic hydrocarbons (PAHs) and heavy metals (primarily zinc). However, their WFD commitments meant 'good chemical status' was required by 2015.

Water-lubricated turbines eliminate spill risks during operation

All the turbine runners currently operated by Uniper on the Kolbäcksån river are oil lubricated, and the two of the oldest – in the Semla III powerhouse – do not have oil collectors. With Semla IV, the three units of Semla III will be replaced with a single water-lubricated turbine, eliminating the risk of spills.

This case study is based on an official assessment of Semla III using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in November 2014.

Projects



Project case studies

1.	Blanda, Iceland	66
2.	Kabeli-A, Nepal	70
3.	Keeyask, Canada	74
4.	Miel I, Colombia	78
5.	Romanche-Gavet, France	82

Hydropower projects from around the world that have demonstrated overall good practice in sustainable development.

Project case study 1:

Blanda, Iceland

Policy and practice lessons

- **Certified asset management systems deliver almost 100 per cent reliability and profitability**
- **Continuous monitoring is used to assess meteorological trends and develop models of glacial ablation**
- **Community cooperatives facilitate sustained benefits for community members**
- **Partnerships provide a practical mechanism for benefit-sharing**
- **Retrospective environmental assessment at operation stage can promote new, systematic approaches to environmental management**
- **Certified management systems deliver transparency, integrity and accountability**

Key case study features

Project stage: operation

Developer/operator: Landsvirkjun

Capacity: 150 MW (three 50 MW units)

Annual generation: 800 GWh

Reservoir area: 56 km² (Blöndulón) and 5 km² (Gilsárlón)

Head: 287 m

Purpose: power generation

Commissioning: 1991

Whilst Blanda is a relatively small project in a sparsely populated, developed context, it sets an example of excellence in technical, financial, environmental and social sustainability.

Located in north-western Iceland, Blanda harnesses the Blanda river as it flows north from Hofsjökull glacier, to meet the sea at the town of Blönduós. It lies on the fringe of the Iceland's highland plateau, with gentle hills and heathland on shallow soils.

The Blöndulón reservoir is formed by two dams, on the Blanda river and the Kolkukvísl river, and water is diverted through 9,800 m of diversion canals and four lakes to an intake reservoir, Gilsárlón.

From Gilsárlón, water runs through a 1,300 m canal and a 347 m headrace tunnel, before dropping vertically through a 236 m penstock to the underground power station. From the turbines, the water flows through a 1,700 m tailrace tunnel into the Blanda river.

Certified asset management systems deliver almost 100 per cent reliability and profitability

Blanda's asset maintenance is managed through a management system guided by the new ISO 55001 standard. It uses software that provides good linkages between task scheduling, performance tracking, and higher-



level corporate objectives and requirements. Key performance indicators are set regarding system failures, job completion, the balance

between monitoring and maintenance attention, and attention to unsafe issues. The Blanda power station is one of the most reliable in Landsvirkjun's asset portfolio, with reliability greater than 99.9 per cent outside scheduled outage periods.

Generation scheduling decisions are based on state-of-the-art simulation and optimisation models, integrated across all power stations in the country.

Continuous monitoring is used to assess meteorological trends and develop models of glacial ablation

Blanda is managed with a detailed sense of the availability and reliability of resources, based on long-term historic flows and climate observations and modelling. Landsvirkjun has also undertaken extensive research into future water availability, which is expected to improve due to glacial retreat.

Landsvirkjun carries out extensive hydrological and glacial monitoring, weather and run-off modelling and medium and long-range forecasting of hydrological changes.

Short-term forecasting is made difficult in Iceland by frequent changes between snow and rain around 0°C. Climate change is predicted to significantly increase water resource availability over many decades on glacier-fed rivers in Iceland.

Predicted seasonal changes include: earlier springs and snowmelt; lower flows in early summers but higher flows in late summers due to glacial melt; and more frequent small winter floods. The historical flow series indicates an average inflow into Blöndulón

reservoir of 41.6 m³/s, but the forecasted average – based on changes already realised up to 2010 – increases to 44.1 m³/s and is expected to increase further.

The meteorological office, Landsvirkjun and the Iceland Glaciological Society are monitoring the mass balance and retreat of Hofsjökull, a 850 km² ice cap that delivers meltwater to several large glacial rivers, including Blanda and Þjórsá. They take snow cores at 30 locations, between elevations of 700 m and 1,800 m during the winter, and record summer mass balance from ablation stakes. The monitoring results feed into seasonal run-off forecasts.

For long-term monitoring, the surface of the ice cap has been mapped with high-resolution airborne lidar, and as part of Nordic cooperation projects, the impacts of climate change on Iceland's glaciers have been modelled. They are predicted to largely disappear over the next two centuries.

Increased annual inflows and changing seasonality caused by climate change may alter optimal storage and installed capacity values at Blanda, and across Landsvirkjun's system.

Scenario analyses show that potential energy in the total river flows to Landsvirkjun's power system is expected to increase by 20 per cent (2.8 TWh) until 2050. This can be mainly attributed to added run-off in glacial rivers, ranging from 27 per cent to 84 per cent for individual rivers.

There may not be the flexibility to adapt to greater variation in flows without additional storage, resulting in a reduced load factor.

Community cooperatives facilitate sustained benefits for community members

When Blanda was developed, Landsvirkjun reached an agreement with farmers who grazed sheep in the lands lost for the reservoir.

The agreement was to create new grassland as compensation. Practically, this involved delivering a fixed amount of fertiliser to a compensation area over the project's lifetime.

The work is being delivered in partnership with the Icelandic Soil Conservation Service and two farmers' cooperatives, for the west and east banks of the river (further details are provided in the case study on page 30).

Local community members have developed a number of cooperative organisations to manage financial compensation paid by Landsvirkjun.

When Landsvirkjun offered both cooperatives a one-off cash payment to end the fertilisation programme, the west bank cooperative, which had become less reliant on sheep, took the offer and invested the proceeds in a fund to subsidise the community's energy costs on an ongoing basis.

Local community members have developed a number of cooperative organisations to



The Blanda reservoir

manage financial compensation paid by Landsvirkjun. These include, on the west bank: fencing and roads; angling; and grazing. On the east bank, they include: fences and roads; angling; and a joint cooperative concerning sheep, huts (cabins) and grazing rights.

The approach has been so successful that it extends beyond compensation for impacts of the project, to deliver real benefits to communities.

Partnerships provide a practical mechanisms for benefit-sharing

Icelandic law requires the payment of property tax to the municipality in which the power station is located. Blanda's payment increases the local municipality's annual budget by approximately 15 per cent, and will continue to do so. Since commissioning, Landsvirkjun has

also established grant-based partnerships to deliver additional benefits.

The company has established the Landsvirkjun Energy Research Fund and the Landsvirkjun Community Fund to distribute grant funding.

Landsvirkjun has developed numerous partnerships with educational institutions, landowners, fishing associations and other stakeholders.

Landsvirkjun has developed numerous partnerships with educational institutions, landowners, fishing associations and other stakeholders. Examples of projects supporting Blanda communities are:

- new roads and bridges in the highlands;
- an airstrip to the south of the reservoir;
- a programme, 'Many hands make light work', which employs around 30 young people each summer and provides training in first aid, and health and safety;
- maintenance of a fish ladder to benefit the angling association;
- a fishing lodge for visiting anglers;
- a salmon museum and research centre (the 'Laxa Centre');
- construction of three new huts (cabins) in the highlands for use when collecting



Emerging environmental and social risks and opportunities are identified and addressed through partnerships with environmental organisations working in the area, and the project's strong links with local communities.

99.99%
reliability outside scheduled
outage periods makes Blanda
one of Landsvirkjun's most
reliable power stations



- sheep, which now generate income for the municipality from tourism;
- additional fencing in the highlands to contain sheep, and stables for sheep and horses in the highlands;
- connection of some farms to fibre optic cable for internet access;
- allowing the meeting rooms at the power station to be used by the community; and
- support for a storyteller to record and distribute an historic story about the area (an Icelandic saga; a good example of intangible heritage).

Retrospective environmental assessment at operation stage can promote new, systematic approaches to environmental management

Partnerships are also used to monitor and manage environmental issues. For example, Blanda has partnered with the Icelandic Institute of Freshwater Fisheries on research and consulting services for freshwater fish, and with the Soil Conservation Service of Iceland on its programmes to combat desertification and sand encroachment, and reclamation and restoration of degraded land.

Blanda was designed and constructed before legislation requiring environmental and social impact assessments was introduced in Iceland in 1993. However, in response to a stakeholder enquiry, Landsvirkjun commissioned a retrospective assessment of operations in 2004, referred to as the 'Blanda Environmental Report'. Another study, carried out in 2006 by the University of Akureyri, examined Blanda's social impact.

Numerous studies fed into the environmental report and Blanda continues to monitor key issues. Landsvirkjun uses a company-wide ISO 14001 certified environmental management system to address all environmental and social issues, including those at Blanda.

Emerging environmental and social risks and opportunities are identified and addressed through partnerships with environmental organisations working in the area, and the project's strong links with local communities.

Every job undertaken within the project has its own safety and environmental risk assessment.

In a notable approach, Landvirkjun makes the reporting of any risks or opportunities an explicit responsibility of all employees. Employees must use a form (part of Landsvirkjun's quality management system) to describe any environmental, social or labour issue or incident, and the remedial action required. This is processed, analysed and remedial works scheduled, and the manager responsible for the issue must take steps to prevent reoccurrence.

Every job undertaken within the project has its own safety and environmental risk assessment. This provides a comprehensive overview of the job and is regularly updated. Site inspections have a checklist to identify opportunities for improvement, such as fixing paths or lighting, and reducing waste or noise. The social responsibility department maintains an "ideas bank" where new opportunities are logged.

Landsvirkjun uses an integrated management system that meets the requirements of ISO 9001, and an environmental management system that meets the requirements of ISO 14001.

The company is also planning to integrate the requirements of ISO 26000 (guidance on how businesses and organisations can operate in a socially responsible way) into the management system. Blanda was the first Landsvirkjun project to become ISO 9001 certified, and Landsvirkjun has also been certified as a producer of green electricity by the German company TÜV SÜD.

Certified management systems deliver transparency, integrity and accountability

Landsvirkjun applies systematic corporate business structures, policies and practices. This is developed through and reflected in its certification to a comprehensive range of standards: ISO 9001, 14001, 27001, OHSAS 18001, and other external certifications.

Policies and procedures apply across all business areas, and are proactively implemented through the quality system processes. Transparency, integrity and accountability are addressed through the adoption of a social responsibility policy and mapping of performance against the UN Global Compact and ISO 26000.

This case study is based on an official assessment of Blanda using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2013, with an on-site assessment in September 2013.

Project case study 2:

Kabeli-A, Nepal

Policy and practice lessons

- Iterative siting and design evaluations bring social and technical benefits
- Specialist hydrological methodologies and independent review contributed to improved design and safety
- Specialist studies enhance the validity and completeness of impact assessments
- An adaptive management approach allows unforeseen risks to be addressed
- Providing benefits in the preparation stage builds confidence among communities
- Targeted programmes promote the representation of indigenous and vulnerable groups

Key case study features

Project stage: preparation

Developer/operator: Kabeli Energy Ltd (KEL), a majority-owned subsidiary of Butwal Power Company (BTC)

Capacity: 38 MW

Annual generation: 206 GWh

Purpose: power generation

A decade of armed insurgencies has made infrastructure development difficult or even impossible in much of Nepal. Kabeli-A is one of the first projects to be developed in a list of options identified prior to this time, and meets proven best practice in a wide range of technical, social and environmental areas.

The project is located approximately 800 km east of Kathmandu, and would be a peaking run-of-river plant. With a small diversion dam, it would use a head of 118 m, and a reservoir covering an area of only 10 ha (of which 9.1 ha is the existing river or its flood zone) would allow for short-term storage.

The main project components are a 14.3 m dam, intake and settling basin, a tunnel over 4 km in length, powerhouse and tailrace. It will divert water from the Kabeli river, discharging it downstream following Kabeli's confluence with the Tamor river as it loops from an east-west direction to west-east. The Tamor flows into the Koshi river, which crosses the border with India and enters the Ganges.

Kabeli-A would be financed through a mix of loan financing, including from the World Bank (International Development Association), International Finance Corporation (IFC) and commercial banks, and shareholder equity.



Iterative siting and design evaluations bring social and technical benefits

The project design was iteratively improved and optimised. Initially, a sequence of studies through the preceding three decades concerned the identification of project options and their screening and ranking, through the 'Medium Hydropower Project' in the mid- to late 1990s.

When Kabeli Energy Limited (KEL) won international competitive tendering to develop the project, it was required to update the feasibility study and environmental impact assessment as a condition of the project development agreement. The focus of the design team has been to prepare as simple a design as possible, in order to reduce potential construction, operation and maintenance problems, whilst avoiding or minimising environmental, social and technical risks.

As would be expected, the updated feasibility study investigated alternative locations for project components such as the dam, powerhouse, access roads, tunnels, construction camps, quarries and spoil disposal sites.

Some of the key issues and innovations were:

- moving the powerhouse site to protect it from flooding;
- moving the intake 500 m upstream, because of engineering constraints, but with the added benefit of increased head

- the addition of a desander, with a so-called 'serpent sediment sluicing system' (S4) for flushing the sediments at least hourly, to maintain downstream sediment transport while removing aggressive hard sediment to avoid turbine damage;
- re-alignment of the road to the intake, increasing the distance from 2 km to over 7 km, in response to community requests to route the road through their settlements (the community provided the land for the road free of charge); and
- avoidance and mitigation of impacts on cremation sites and a temple located downstream from the intake (more details of which are provided in the topic case study on page 18).

Specialist hydrological methodologies and independent review contributed to improved design and safety

Flows in the Kabeli river were not measured until March 2010, when KEL established a gauging station to develop a rating curve. This required the use of data from elsewhere in the basin, and various methodologies to develop flow duration curves. KEL used hydrological data from four official gauging stations in the Tamor basin, which have been in operation for between 11 and 41 years.

Working with a hydrological specialist consulting company, KEL used a range of methodologies to determine the hydrology of the project site.

These included the HYDEST method developed by the Nepali Department of Hydrology, correlation with the Tamor river at Mulghat, and the MSHP method developed by the Nepal Electricity Authority. They used five different methods to estimate precipitation in the Kabeli basin based on the available rainfall data, including the arithmetic-mean, Theissen-polygon, inverse-square-distance, inverse-distance-weight and the iso-hyetal methods. This allowed the design in the updated feasibility study to increase the design flow, based on a flow duration of 35 per cent.

Additional work by KEL's hydrology consultants later increased the design flow even further, based on the standard Nepal Electricity Authority recommendation of using the 40 per cent duration.

KEL also used the consultants to assess dam safety risks, reviewed by the owner's engineer, lenders' engineer and a panel of experts (PoE).

The studies covered most conceivable infrastructure safety issues, and looked at a number of opportunities.

These included: increasing the design flood to the 1,000-year flood; expanding the scope of monitoring to cover seepage and uplift; and an assessment of opportunities to use new technologies, which led to a number of automated safety features and extensive



Overview of the powerhouse site at Kabeli-A

monitoring instrumentation, and a supervisory control and data acquisition (SCADA) system to monitor water levels and control operation.

Specialist studies enhance the validity and completeness of impact assessments

An initial environmental examination (IEE) is required for projects of less than 50 MW under Nepalese law. This was augmented by an environmental impact assessment, social impact assessment, and management plan to meet World Bank and IFC standards, and a range of specialist studies.

The additional studies focused on areas of uncertainty identified in the impact assessments, covering downstream flow in the dewatered stretch of the Kabeli and Tamor rivers, potential risks of fish entrapment at the head works, impacts from fluctuating daily flow downstream of the tailrace, and cumulative impacts.

Checks were also made to confirm the conclusions of the social impact assessment, particularly the support from local communities, focusing on women, Dalits and indigenous people.

The project assessed numerous opportunities for socio-economic development, including rural electrification, local employment, schools and health centres, as well as the preservation of local traditions and cultural heritage.

A catchment management plan, including provision to train local people to improve their management of the forest in the river basin, will seek to reduce sediment load.

An adaptive management approach allows unforeseen risks to be addressed

KEL and its partners developed a range of management plans for different issues and phases. For example, the construction phase EMP addressed issues such as: constructing a fish passage; putting in place infrastructure for cremation sites; protecting sacred trees during the construction phase; ensuring slope stability of earth cuts; and maintaining minimum downstream flows.

The contractor will be required to produce management plans to address construction-related waste, noise, air quality, land disturbance and rehabilitation. Specific plans will cover construction camps, traffic, land acquisition, pollution abatement, terrestrial and aquatic ecology, erosion and public health. Outlines for these were provided in the EMP. A catchment management plan, including provision to train local people to

improve their management of the forest in the river basin, will seek to reduce sediment load.

In addition, a social action plan was developed, incorporating a resettlement compensation and livelihood assistance plan, indigenous and vulnerable community development plan, resettlement policy framework, gender action plan, public consultation and participation strategy, and benefit-sharing mechanisms.

A number of ongoing studies will investigate emerging risks and opportunities in more detail as part of an adaptive-management approach. These studies include an improved understanding of the aquatic biodiversity and community water uses of the Tamor and Kabeli rivers, a fish-hatchery planning study, a catchment area treatment plan and the new cumulative impact assessment (CIA).

Providing benefits in the preparation stage builds confidence among communities

KEL began a social responsibility programme during preparation. Activities included establishing a seedling nursery, a free dental campaign, support to local youth clubs and improving local school facilities. This generated confidence among communities, and created an “entry point” for the project, facilitating genuine participation in the planning of ongoing management plans and benefit sharing.

Kabeli-A plans two benefit-sharing mechanisms for the funding of local development, one of which will be generated by the Kabeli-A hydroelectric project (KAHEP). Firstly, by law royalties will be paid to central government over the 30-year licence period, and 50 per cent will be channelled into the project-affected region. Secondly, KEL will establish a project fund to finance activities in the four affected villages through the construction stage.

Targeted programmes promote the representation of indigenous and vulnerable groups

Nepal has considerable cultural, linguistic, religious and ethnic diversity. There are 59 officially recognised indigenous groups, referred to collectively as Adivasi Janajati. They make up 37 per cent of Nepal’s population, and each

There are 59 officially recognised indigenous groups in Nepal, known as the *Adivasi Janjati*



has its own territory, language, traditional rites and customs, distinct cultural identity, social structure, and history. They are traditionally outside of the Hindu caste system. More than 50 per cent of people in the project area are Adivasi Janajati (for more information please see page 21).

An indigenous and vulnerable community development plan (IVCDP) sets out plans to provide additional development opportunities for vulnerable groups, including indigenous peoples. It comprises a women’s programme (for example, including microcredit, and support for small businesses), a capacity-building programme through a local NGO, loan assistance, and measures to build meaningful participation of vulnerable people.

The plans include measures that, based on ethnicity, provide support that is additional to compensation for impacts and wider benefit-sharing measures. It defines actions to maintain and improve the livelihoods of indigenous peoples in the project area, for example through agricultural initiatives, employment, skills and capacity-building, drinking water, health and sanitation support.

Indigenous people will be represented on the implementation structures for the social action plan.

Training and employment schemes will target indigenous people. For example: employment of at least one member from each affected indigenous-community household will be guaranteed in project construction and maintenance work; at least one member from each of the affected indigenous-community households will be involved in livelihood enhancement activities, such as skills training

for income generation and other livelihood improvement activities; preference will be given to qualified indigenous-community individuals in recruitment of community facilitators who will maintain frontline contact with the community in implementing IVCDP activities; supplementary infrastructure facilities will be developed for Majhi households near the power station site, such as latrine construction and drinking water facilities; a small-loan assistance programme will be developed, to promote income-earning opportunities for vulnerable indigenous households; and indigenous people’s organisations will be supported to protect and preserve their indigenous cultures, knowledge, oral literature, language and traditions.

Indigenous people will be represented on the implementation structures for the social action plan. KEL will use a range of communication and information dissemination mechanisms to promote awareness of indigenous peoples’ entitlements, including written documents (information sheets and newsletters), FM radio broadcasts through local radio stations, community meetings, focus group discussions, participatory appraisal techniques, household interviews and social-mobilisation techniques.

This case study is based on an official assessment of the Kabeli-A project using the preparation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2014, with an on-site assessment in August–September 2014.



An indigenous and vulnerable community development plan (IVCDP) sets out plans to provide additional development opportunities for vulnerable groups, including indigenous peoples.

Project case study 3:

Keeyask, Canada

Policy and practice lessons

- Partnerships require long-term commitment and formal agreements
- In-depth and broad-ranging public involvement during preparation requires planning
- Public scrutiny and support is facilitated through a stakeholder-focused assessment of the need for the project
- Complex preparation and implementation require a range of procedures for interface and risk management
- Technical detail and indigenous values underpin comprehensive environmental management planning

Key case study features

Project stage: preparation

Developer/operator: Keeyask Hydropower Limited Partnership (KHLP; consisting of Manitoba Hydro and four First Nations)

Capacity: 695 MW

Annual generation: 4,400 GWh

Reservoir area: 93 km² reservoir upstream of the powerhouse. The project will flood 45 km² of land and the reservoir is predicted to expand by 7–8 km² during the first 30 years of operation

Purpose: power generation

Commissioning: 2022

In an area of Canada where the development of hydropower has a historical legacy of displacing indigenous peoples, the Keeyask project demonstrates best practice of stakeholder involvement in project preparation.

The province of Manitoba in central Canada is developing new sources of renewable generation and a more integrated grid as part of its Clean Energy Strategy initiative, seeking a fossil-free future. A key aim is to export clean energy to neighbouring provinces in Canada, and across the border to the mid-western states of the US.

However, the historical legacy of hydropower for the displacement of indigenous people (First Nations in Canada) is particularly pertinent in the north of the country, where Keeyask will be developed. This case study highlights the preparation of a project through public involvement in the assessment of needs, top-class project management, thoroughness in environmental assessment and a co-owner partnership with indigenous peoples.

Keeyask is the latest in a number of hydropower developments in the Nelson river catchment. The Nelson catchment has been significantly altered in order to generate power, with diversions and the regulation of Lake Winnipeg. Most recently, Manitoba Hydro has brought forward two projects – Wuskwatim

and Keeyask. The construction of Wuskwatim was completed in 2012.

Keeyask will be located at Gull Rapids on the lower Nelson river, immediately upstream of Stephens Lake amid boreal forest in northern Manitoba. Its name, “Keeyask”, is the local Cree



word for gull. At its widest, the river spans approximately 2.5 km across Gull Rapids, and consists of three large channels.

Three dams (the north, central and south dams) will be constructed across the channels, creating a 93 km² reservoir, approximately half of which is the original river channel. A number of earth-fill dykes will be built on both riverbanks to contain the reservoir, 11.6 km on the north and 11.2 km on the south banks. With a full supply level of 159 m above sea level and a minimum operating level of 158 m, the project will provide either base-load generation or peaking generation drawing down this 1 m of regulation.

Development of Keeyask is a collaborative effort between Manitoba Hydro, Tataskweyak Cree Nation and War Lake First Nation (acting as the Cree Nation Partners), York Factory First Nation, and Fox Lake Cree Nation. These partners have formed the Keeyask Hydropower Limited Partnership (KHLP).

Partnerships require long-term commitment and formal agreements

Manitoba Hydro and the chiefs and councils of the Keeyask Cree Nations engaged in discussions and agreements over more than a decade. They proceeded through agreements-in-principle, and various process agreements. Ultimately, the parties negotiated the Joint Keeyask Development Agreement (JKDA) and various adverse effects agreements in 2009.

The JKDA establishes that Manitoba Hydro will own at least 75 per cent of KHLP equity, and will provide project administrative and management services. The four First Nations, known collectively as the Keeyask Cree Nations (KCNs), together have the right to own up to 25 per cent of the partnership.

The JKDA governs how the project will be developed, as well as setting out agreements on potential income opportunities, training, employment, and business opportunities. It also establishes a number of planning and decision-making bodies, such as the ‘partners’ regulatory and licensing committee’, the ‘monitoring advisory committee’, a dispute resolution mechanism and a number of mediation measures.

In-depth and broad ranging public involvement during preparation requires planning

The JKDA sets out the approach to engagement between the KCNs and Manitoba Hydro within the KHLP, including responsibilities for public announcements by the partners. A further committee, the



Floating ice upstream from Gull Rapids

‘pre-hearing consultation committee’, met every one to two months to review plans for communications prior to hearings. Manitoba Hydro and the Keeyask Cree Nations jointly developed a public involvement programme (PIP) in 2007, specifically for project preparation. Its aim was to guide engagement activities with First Nations and stakeholders beyond the KCN communities. The PIP sets out the purpose and principles of public involvement, target audiences, consultation stages, documenting consultation, methods and schedule.

At a higher level of governance, the provincial and federal governments and each of the KCNs also developed agreements, setting out the principles, objectives and means of consultation between the governments and each community for the Keeyask project.

A Keeyask project communication plan was developed for ongoing communications through preparation and implementation. This sets out the purpose, objectives and means for external and internal communications, and responsibilities for communication within the partnership. It included a ‘public announcement framework’ and a protocol for communications related to the regulatory process. Some of the activities included were: ‘future development’ team offices in each community; regular open community meetings; a KHLP website, phone line and email address; and community liaison officers based at the construction camp.

Public scrutiny and support is facilitated through a public assessment of the need for the project

Manitoba’s provincial government has conducted strategic planning for both the energy and water sectors. It has also developed a clean energy strategy initiative, focused on demand-side management (the highest priority), and renewable, fossil-free power. A ‘power resource plan’ document, which was made public, presented the results of Manitoba Hydro’s evaluation and prioritisation process.

An in-depth process addressing the need for the project became the chosen approach for involving the public and stakeholders in the provincial government decisions on whether to allow Keeyask (and earlier Wuskwatim) to proceed. This was called the ‘Need For and Alternatives To’ (NFAT) process. Stakeholders are involved and consulted (as well as through other processes such as environmental licensing, and Clean Environment Commission hearings). The NFAT process for Keeyask also addressed all the other potential demand and supply side options, as well as major new transmission within the province and to the USA.

NFAT includes a component described as a ‘multiple-account cost–benefit analysis’ (MACBA). This expands on financial analysis by factoring in costs and benefits accruing to parties, including affected communities, citizens, taxpayers and customers. It looks at the distribution of costs and benefits across the different parties, and incorporates analysis of sensitivity to parameters such as the social discount rate.

Complex preparation and implementation require a range of procedures for interface and risk management

Keeyask has a relatively complex sequence of construction, with cofferdams on three channels of the river. Preparation of Keeyask also paid close attention to the risks affecting licensing and support for the KHLP partnership among Cree Nations.

To organise preparation and construction, Keeyask is managed, and was licensed, as three separate projects: Keeyask Generation Project (KGP); Keeyask Infrastructure Project (KIP, mainly the north access roads and first phase of the main camps); and Keeyask Transmission Project (KTP). Several units within Manitoba Hydro are responsible for Keeyask: a pre-construction project team; the transmission planning and design division (TPD); and the Keeyask Project Division.

Manitoba Hydro developed the Keeyask Project Execution Plan (PEP), setting out means, methods, tools and techniques, and assigning responsibilities. It includes descriptions of

a Joint Keeyask Development Agreement and adverse effects agreements, licensing, an integrated control plan, and schedule management. It describes work-breakdown structures, each of which is given a number in the company's project and financial management system.

Other measures include: a 'project charter'; project schedules; risk identification; monthly reports to the senior management team, including the top three risks; and change management request forms to identify, manage and approve changes to the schedule.

The pre-construction project team developed a pre-construction risk register and risk registry tables for the preparation of KGP and KIP. A detailed risk register is maintained for project risks.

Effective interfaces between departments, as well as with and between contractors on site, were critical.

For example, the pre-construction project team was responsible, via their project charter, for the delivery of licenses and the technical memorandum to the construction team. The strategic direction of the preparation of Keeyask

is highly focused on risks related to local community support affecting project licensing. Signed agreements, including the Joint Keeyask Development Agreement and the adverse effects agreements, were instrumental to project relationship with the local peoples, with significant effort to generate local employment and business opportunities.

Effective interfaces between departments, as well as with and between contractors on site, were critical.

Manitoba Hydro developed and discussed a paper with each partner to refine roles and responsibilities in the regulatory process. A pre-hearing coordination group was established with lead witnesses from each of the partnering Cree Nations.

Interfaces with and between contractors are managed by consideration of the best



View of the main camp at Keeyask

contracting vehicle, contract stipulations, interface activities identified in schedules, and day-to-day coordination on-site. In addition, detailed construction environmental protection plans (EPPs) were developed for all components, including the generation station, transmission line and access roads. These comprehensively identified risks and measures required to manage them.

Technical detail and indigenous values underpin comprehensive environmental management planning

Environment assessment of Keeyask was conducted over years, resulting in a highly robust assessment. The assessments covered the physical, terrestrial, aquatic and socio-economic environments, as well as cultural issues around resource use and heritage. Risks and opportunities were analysed comprehensively, for example:

- in the case of aquatic biodiversity, macro-invertebrates, phyto- and zooplankton and macrophytes were extensively studied, and the effects of impoundment on their populations were assessed during construction and operation, and overlaid with other influences such as rising temperatures and shorter ice cover periods;
- water quality studies, undertaken over a ten-year period, covered a spatially broad area beyond the hydraulic zone of influence, and integrated the impact of climate change;
- shoreline erosion was mapped for 205 km of the Nelson River likely to be affected by the project, and modelled for the 264 km shoreline of the Keeyask reservoir, using peatland-disintegration modelling for northern Manitoba (not

undertaken before), and climate change also integrated into the analysis;

- a human health impact assessment, based on Health Canada, WHO and US EPA guidance, peer-reviewed by a leading academic, and overseen by a technical working group; this even involved assessing the movement of fish to determine whether those that would have raised mercury levels from the reservoir moved upstream to areas outside the hydraulic zone of influence; and
- An innovative feature of the assessment process was that the Keeyask Cree Nations undertook and disclosed their own parallel assessments. These were based on their own Cree worldview, and used as a basis for their own decisions on compensation and partnership agreements.

A series of plans were developed for all project components: environmental protection plans (EPPs); environmental management plans; and environmental monitoring plans.

These placed special emphasis on impacts on valued environmental components (VECs), defined on the basis of the technical and indigenous studies.

This case study is based on the findings of an official assessment of the Keeyask project using the Preparation Stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was carried out during preparation of the project, from November 2012 to May 2013, with an on-site assessment encompassing a visit to the project site and interviews with stakeholders in December 2013.



Examples of communications activities during preparation:

- a comprehensive Public Involvement Program that involved three rounds of consultation throughout the assessment process with partners, other interested or affected communities and organisations, and government agencies;
- the "overview of water and land" (OWL) working group, and community-level reference groups convened for the Keeyask Cree Nations' own separate environmental studies;
- referenda on the project within each community (please see page 38);
- websites created by the Cree Nations Partnership, in addition to the KHLP website;
- dissemination of a partnership video, "Keeyask: our story", and regular project newsletters;
- consultation for the transmission line using aboriginal traditional knowledge, and two rounds of open house meetings;
- federal- and provincial-level public consultation by regulatory agencies, including calls for public comment on the assessment, with funding available through a participant assistance programme; and
- a technical advisory committee involving a wide range of agencies, meeting to consult with provincial government.



An innovative feature of the assessment process was that the Keeyask Cree Nations undertook and disclosed their own parallel assessments, based on aboriginal traditional knowledge, as a basis for their own decisions on compensation and partnership agreements.

Project case study 4:

Miel I, Colombia

Policy and practice lessons

- **Good understanding of available hydrological resource optimises water use**
- **Water diversions increased project generation by almost 30 per cent**
- **Plans contribute to addressing issues beyond the project impacts**
- **Adaptive processes enable successful management of unexpected environmental and social issues**

Key case study features

Project stage: operation

Developer/operator: ISAGEN (acquired by Brookfield in 2016)

Capacity: 396 MW

Annual generation: 1,460 GWh (Miel I); 308 GWh (Guarinó); 104 GWh (Manso)

Reservoir area: 12.8 km³

There is a high degree of climate variability in Colombia, where the Miel I project is located. This case study shows how a hydropower project can carry out comprehensive hydrological studies and monitoring to explore different scenarios and optimise water use, as well as delivering environment, social and financial objectives.

The project is located in the municipality of Norcasia in Colombia. The plant generates a portion of the hydroelectric power in west Caldas, where major water sources include the Guarinó, Miel, Moro, Manso and Samaná Sur rivers, and minor tributaries such as the Pensilvania and Tenerife rivers. The plant has an installed capacity of 396 MW across three units. Commercial operations started in December 2002.

The underground powerhouse uses three generation units powered by Francis turbines of 132 MW each. The Miel I dam, known as the Patángoras dam, is a gravity dam and the second highest roller-compacted concrete (RCC) dam in the world. A ski-jump type spillway is located at the centre of the dam.

Miel I facilities include two river diversions: Guarinó and Manso. The Guarinó diversion has been in operation since 2010. It consists of a concrete dam on the Guarinó river with an approximate height of 7 m, and a diversion tunnel to the Miel river.



The Manso diversion structure consists of a 5 m concrete dam on the Manso river and a diversion tunnel from the Manso river to the Santa Bárbara stream, and ultimately, to the Amaní reservoir.

This case study shows how a hydropower project can make significant contributions to addressing issues beyond the impacts caused by the project itself. It also demonstrates the importance of carrying out comprehensive hydrological studies to explore different scenarios, including climate change, and to optimise water use, taking into account environmental, social and financial objectives.

Good understanding of available hydrological resource optimises water use

Colombia has an installed electricity generation capacity of 14,400 MW, 64 per cent of which is in hydropower plants.

There is a high degree of climate variability in Colombia, both temporally and spatially. Rainfall varies considerably and is difficult to predict, due to the rugged topography.

Storm cells and flash floods are regular occurrences. The Miel river basin has an area of 1,105 km², and is located across six municipalities in the Caldas department.

ISAGEN has a good understanding of the hydrological resource available to Miel I.

A hydrological model guides the analysis of data at 40 hydrometric stations, and any issues that could impact on the availability of water due to climate variability are identified at a range of timescales.

Hydrological forecasting reports consider both short and long-term scenarios. Precipitation and flow information is analysed in relation to macroclimatic phenomena, such as El Niño Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), and Madden-Julian Oscillation (MJO) influences.

In parallel to ISAGEN's own modelling, a distributed hydrological model is currently under development. This aims to simulate flows in real time at points of interest in the catchment, and then forecast flows using hydrological and weather data.

The model uses information from a meteorological radar installed by ISAGEN, in partnership with local public agencies, as part of an early warning system. The radar measures reflectivity, which is correlated with precipitation data to enable a more comprehensive alert system than the hydrometric stations alone.

Water diversions increased project generation by almost 30 per cent

The two diversions were built to further maximise the use of available water and

The Manso diversion was the first project in Colombia to have its minimum flow release determined using a method developed by the National University in Bogotá in 2008

power generation potential. The Manso diversion increased generation by 11.3 per cent, and Guarinó by 17 per cent. This was



View of the Amaní reservoir

only possible with sound knowledge of the hydrological conditions, climate variability, and sediment dynamics, supported by adequate hydrological and sediment models. These diversions contribute to making Miel I financially sustainable.

The diversions operations did not only take into account generation and financial objectives.

ISAGEN manages flows down three rivers (Miel, Manso and Guarinó) with the aim of meeting social and environmental objectives. The minimum flow release for Miel (17 m³/s) was determined as part of the project's environmental impact assessment (EIA), and was one of the first downstream flow releases provided in Colombia.

Detailed studies were later completed for the Guarinó (2002) and Manso (2006, 2012)

diversions, based on economic, environmental and social objectives to determine seasonal minimum flow releases (6–7.2 m³/s for Manso and 10.5–17.3 m³/s for Guarinó).

The Manso diversion was the first project in Colombia to have its minimum flow release determined using a method developed by the National University in Bogotá in 2008. This method has been approved by the National Environmental Licensing Authority (ANLA).

Plans contribute to addressing issues beyond the project impacts

ISAGEN has made considerable efforts to address issues beyond its own impacts, especially in terms of biodiversity conservation, water quality and public safety. Broader

biodiversity conservation measures are demonstrated by the extent of protected areas compared to the project's area of impact.

Broader water quality measures are demonstrated by improvements to drinking water supply and wastewater treatment.

Monitoring data shows improvements over time in the condition of flora and fauna in the protected areas. Research, for example on vegetation succession, provides important

information to other stakeholders, and contributes to a global network that aims to establish benchmarks. Seed collection and dispersion activities aid reforestation efforts.

As part of ISAGEN's conservation strategies, the area surrounding the reservoir was nominated as an 'important area for bird conservation' by the Alexander Von Humboldt Institute in Colombia. Information and biological records dating back to 2012 have been published in association with the Von Humboldt Institute, according to the Colombia Biological Information System.

Education activities further demonstrate the project's contributions beyond managing its own impacts. The 'Miel flora guide' and other associated publications are important information resources about the region, which have been distributed for free. Education efforts have also focused on seeds and ecological agriculture.

These activities have helped share the knowledge gained from monitoring with the local communities.

There has also been promotion of ecological tourism, such as hiking and birdwatching. Visitors can see the vegetation succession research plots, which supports education and awareness raising.

Broader water quality measures are demonstrated by improvements to drinking water supply and wastewater treatment in the local community.

ISAGEN has supported several basic sanitation programmes in partnership with institutions such as Coffee Committee, municipal administrations and NGOs. These efforts have supported the installation of over 796 septic systems and the construction of more than 732 toilets in the four downstream villages, and in the San Diego and Berlín townships. Water supply systems for drinking water are also being improved.

Broader public safety measures are driven by ISAGEN's procedures for engaging with the police, military and private security companies. The company has organised a number of events and training courses on human rights and environmental education for army personnel. It has also implemented voluntary peace programmes in the region.

Materials and equipment have been provided by ISAGEN to the local fire brigades, and the company has collaborated closely with safety brigades and local communities.

These activities have contributed to improving public safety and bringing stability to the region since operations began at the plant.



Catchment above the Manso tunnel

Adaptive processes enable successful management of environmental and social issues

Miel I was able to respond to and manage unexpected project impacts using adaptive management processes.

Construction of the diversions did not initially require resettlement, but a number of households had to be resettled as a result of unexpected impacts of the diversions. These included severe erosion and landslides.

The ongoing delivery of ISAGEN's responsibilities under the Miel I environmental management plan (EMP) programmes provides a management structure for anticipating and responding to environmental and social risks and opportunities.

Since Manso started operations, the project began implementation of an additional programme, 'Community Care and the Management of Unforeseen Impacts'. The aim of this programme is to ensure timely responses to ongoing damage to property arising from construction or operation.

Specific examples of managed risks include:

- negotiations with landowners for the sale of land affected by erosion above the buffer zone around the reservoir; and
- provision of support to farmers on reservoir shores, whose crops were initially affected by increased relative humidity.

Engagement with affected stakeholders has been a key aspect in overcoming unexpected challenges of the project. ISAGEN has set up a range of partnerships with universities, stakeholders and communities to assist with managing environmental and social issues.

For example, it has set up partnerships to: manage downstream issues as well as adjusting its operation as required; acquire land and create protected areas; use forest rangers and guides from local communities; provide capacity-building and education within local communities; collaborate with municipalities and other institutions and landowners; create and support conservation zones; and collaborate with NGOs, for example the WWF water stewardship project.

This case study is based on an official assessment of the Miel I project using the operation stage tool of the Hydropower Sustainability Assessment Protocol. This was conducted in 2014, with an on-site assessment in June 2014.

Miel I was able to respond to and manage unexpected project impacts using adaptive management processes.



Romanche-Gavet, France

Policy and practice lessons

- Increased power generation and restoration can be achieved through ambitious modernisation projects
- Detailed corporate management processes deliver excellence in project management, on time and budget
- Comprehensive environmental management procedures promote contractor compliance
- Local communities benefit from restoration and a range of additional benefits

Key case study features

- Project stage:** implementation
- Developer/operator:** EDF (Électricité de France SA)
- Construction start date:** 2012 (access roads in 2010)
- Commissioning date:** 2020
- Capacity:** 94 MW
- Annual generation:** 560 GWh
- Reservoir area:** run-of-river project with a reservoir contained within the existing river channel
- Purpose:** power generation; restoration of the Romanche river through the decommissioning of six old small-scale facilities

The Romanche-Gavet project addresses the need to reduce the adverse impacts of hydropower in the Romanche valley. This case study demonstrates how ambitious modernisation projects can deliver increased power generation and better conditions for recreation and tourism in the surrounding area.

The 94 MW project is located on the right bank of the middle section of the Romanche river, in the Isère department in the French Alps, south-eastern France. It replaces six facilities with a total capacity of 82 MW, built in the early 20th century, and increases average annual generation by over 30 per cent.

The project has relatively limited adverse environmental and social impacts, and has the potential to deliver long-term benefits for the local community. The valley is a route for tourists making their way to the skiing and recreational areas of the nearby Alps.

Romanche-Gavet consists of a new intake structure with a maximum capacity of 41 m³/s; a 9.3 km headrace tunnel; an underground power plant with two Francis turbines, excavated 160 m below ground; and a new transmission line. It will use a head of 270 m and will be operated as a run-of-river plant.

Apart from the intake and outlet structures and the transmission line, all of the project's structures will be located underground.



EDF is part of the multinational EDF Group, which also owns or has holdings in transmission companies in France and utilities across Europe and internationally. EDF Group is 80 per cent owned by the French state.

The group holds two concessions for Romanche-Gavet: one for the construction and operation of the new project; and another for the operation and decommissioning by 2020 of the six existing plants.

Increased power generation and restoration can be achieved through ambitious modernisation projects

The design of Romanche-Gavet directly addresses the need to reduce the adverse impacts of hydropower generation in the Romanche valley, by removing the old plants and water transport infrastructure. This should improve conditions for recreation and tourism, and repurposing some of the decommissioned plants for cultural heritage conservation or economic uses.

The facilities that will be decommissioned are, from upstream to downstream: Livet, Les Vernes, Les Roberts, Riouperoux, Les Clavaux, and Pierre Eybesse.

Through removal of five dams, the project will improve the ecological connectivity of the affected stretch of the river. Fish ladders are being installed at both the new Livet intake

structure and at the Les Clavaux intake (which will not be decommissioned). The Gavet dam, just below the new project's tailrace, will not be decommissioned either; therefore, full downstream connectivity to the sea will not be restored at this moment. However, since the priority species of this river stretch – trout and Chabot (bullhead) – do not require access to the sea during their life cycle, the presented solution is acceptable to local stakeholders and legislators.

EDF will be obliged to ensure connectivity though the remaining barriers as part of its commitments under the requirements of the EU Water Framework Directive.

EDF assessed whether it was necessary to vary the minimum flow released downstream of the intake throughout the year.

In addition to improving ecological connectivity, the focus of the project is as much, if not more, on restoring aesthetic quality in the valley. The project will remove a range of old and unsightly structures, including intakes, galleries, headrace channels, penstocks, powerhouses, generating units and transmission lines.

EDF assessed whether it was necessary to vary the minimum flow released downstream of the intake throughout the year. Legal requirements call for a minimum downstream release of 10 per cent of annual inflow, which in this case equates to an average of 4 m³/s. However, the law only requires that this target be met as an average over the course of the year.

The local community favoured a constant flow for safe recreational use of the river between the intake and tailrace. Modelling was used to confirm that this would be sufficient from an ecological perspective.

Detailed corporate management processes deliver excellence in project management, on time and budget

EDF managed Romanche-Gavet through quality-controlled, documented organisational structures. A national-level 'Directoire' was formed, consisting of the deputy director of the Hydropower Generation and Engineering Division, the director of the Hydro Engineering Centre within this division, the regional director, a regional project manager, and separate project managers for the construction and decommissioning projects.



Livet II (left) and Livet I (right)

The regional division internally contracted the Hydro Engineering Centre (CIH) to prepare and deliver the project.

Within the Directoire, a management team was formed to provide regional-level management. This team consists of the regional director, regional project manager and project managers.

EDF used a range of plans to set out organisational requirements jointly for the construction and decommissioning projects, and for risks and interface issues. All documents were quality-controlled and compiled in an internal database, ensuring integrated management of both the construction and decommissioning projects.

Local communities played an active role in assessing issues of importance to them.

Contractors used detailed plans that were reviewed and integrated by the construction

project manager. These identified critical interfaces between design and construction, and between construction components.

Progress was monitored through monthly management team meetings, and quarterly Directoire meetings monitored risks for implementation. These meetings were an opportunity to review milestones and budgets.

Weekly meetings with each contractor were minuted through quality-controlled documents. Three site managers, supported by three additional supervisors, reported to project managers through a quality-controlled reporting structure.

Meetings of a “project validation committee” (a technical review committee) and a safety committee from a central level in EDF were held to scrutinise engineering studies.

Comprehensive environmental management procedures promote contractor compliance

EDF assessed and managed a range of environmental issues in a demanding regulatory context. Plans and processes are embedded within a centralised environmental management system, certified to ISO 14001.

EDF carried out an initial assessment to examine issues for all phases, including construction of the new project, decommissioning of the old plants, and operation of the new project.

The project’s environmental and social impact assessment addressed the impacts of construction of the intake, new bridge, and powerhouse on surface water, wildlife, flora and the aquatic ecosystem. It also examined the social impacts in terms of economic activities and employment, cultural heritage, property, transport, noise and dust.

The assessment of the impacts of operation included operational impacts on surface water in terms of hydrology, sediment transport, physical chemistry and groundwater, and on terrestrial and aquatic flora and fauna.

The long-term social impact of the project was looked at in terms of employment opportunities, tax revenue, impact on infrastructure, property, cultural heritage, tourism, health, education and security.

Environmental management plans were approved by the regulator and established in a prefectural decree. Plans included:

- an environmental assurance plan (EAP) to manage waste, discharge of pollutants to soil, air and water, noise reduction, integration of the site into its surroundings, compliance with legal and contractual environmental constraints, and preservation of environmentally sensitive areas;
- inclusion of an appendix on environmental requirements in all contracts, and ensuring all contractors’ environmental management plans clearly establish how they will meet their contractual requirements;
- checking contractual requirements on a weekly basis, or more frequently if required, by the EDF site manager using a specific QSSE (quality, security, safety, environment) visit sheet to record findings, lodged in EDF’s central environmental management system, part of the overall electronic project management system; and
- EDF environmental officers, with protocols and procedures for responding to an emerging risk of pollution, or a pollution event, which were regularly tested through simulated events.

Two staff members, one on site and one at the Hydro Engineering Centre, oversaw the monitoring of environmental parameters during project implementation. These staff were tasked with analysing and collating the environmental monitoring information.

A comprehensive risk assessment (initially highlighting environmental risks of hydrocarbon and cement discharge to the river, soil pollution from machinery, noise and air pollution) was regularly updated with new risks based on ongoing monitoring.

Each new phase of works required a new “execution procedure”, requiring the contractor to explain to EDF project managers how they would respond to environmental risks.

Local communities benefit from restoration and a range of additional benefits

Local communities played an active role in assessing issues of importance to them. They recognised the significant positive impacts the project brings in terms of employment, improved recreational access to the river and conservation of cultural heritage.

As a result of community consultation, EDF committed to delivering a range of additional benefits. These include: a new domestic

50%
of hours worked were by
employees from the region



water supply system; a permanent bridge in an affected village; the handover of the project office (Maison Romanche Energie) to the local municipality for community use; and permanent noise mitigation measures around a local school.

EDF committed to ensuring that 5 per cent of the project’s workforce (by working time) is sourced from local unskilled workforce. The company implemented this in close cooperation with a local organisation that supports young people aged 16–26. More than 25 per cent of total expenditure at the time of the assessment was on contracts from the southern part of Isère, and more than 50 per cent of hours worked were by employees from this region.

Challenges: decommissioning old plants whilst preserving heritage value

Some of the plants being decommissioned were of cultural heritage value, owing to their role in hydropower and mineral extraction in the industrial era. There was a significant risk that EDF would be required to dismantle and destroy structures to meet its concession requirements (which required decommissioning), despite the genuine heritage value of the plants. This required very careful stakeholder consultation and clarification of EDF’s responsibilities.

The Les Vernes plant was built in 1917 by an entrepreneur who pioneered calcium carbide production and hydropower in the Romanche valley. The building has a neoclassical design, and encompasses a stairway based on the architecture of a nearby château. It also includes the original penstocks and machinery. Les Vernes was classified by the French state in 1994, upon EDF’s request, and the plant and its penstocks are listed by the regional authorities.

The Livet plant consisted of two parts: two older buildings built between 1898 and 1902 (Livet I), and a structure built in 1904 (Livet II). The second structure is made of concrete and steel, in an industrial design rarely found in the region. The structure is even depicted

in a stained-glass window in the local church. None of the other plants have the distinctive architecture of Livet or Les Vernes.

EDF commissioned a series of studies to assess the cultural heritage value of the plants. The company assessed steps for their conservation, including a study to establish local communities’ and stakeholders’ requirements. It also obtained confirmation from the regulator that Les Vernes power plant could be conserved (overruling the concession requirements) and the company remains committed to its conservation on a voluntary basis.

Livet I and II, however, could only be omitted from the concession requirement if they were formally recognised, or if a commercial investor could be found to finance their conservation. There was no process led by the regulatory authorities to resolve this conflict and conserve this heritage, which could have an impact on economic development in the valley. At the time of the assessment it appeared that EDF, which was not the owner of the plants, would be obliged to demolish Livet I and II.

This case study is based on the findings of an official assessment of the Romanche-Gavet project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was carried out during implementation phase of the project, in May to July 2013, with an on-site assessment encompassing a visit to the project site and interviews with stakeholders in June 2013.



EDF commissioned a series of studies to assess the cultural heritage value of the plants. The company assessed the steps for their conservation, including a study to establish local communities’ and stakeholders’ requirements.

Initiatives



Initiative case studies

1.	Acreditar training and recruitment programme, Brazil	88
2.	Angostura hydropower plant, Chile	90
3.	Cultivando Água Boa/Cultivando Agua Buena, Brazil-Paraguay	94
4.	Regional initiative to promote sustainability in hydropower	96
5.	Reventazón, Costa Rica	100
6.	Tulila Hydroelectric Plant, Tanzania	104

Examples of broader schemes undertaken in relation to hydropower projects to address commonly problematic development challenges.

Initiative case study 1:

Acreditar training and recruitment programme, Brazil

Policy and practice lessons

- **Regional-scale training programmes contribute to regional development**
- **Local training programmes reduce migrant influx**
- **Ambitious programmes deliver benefits well beyond the project needs**
- **Broad programmes support inclusivity of women and young people**

Key project features

Developer/operator:

Santo Antônio Energia

Associated projects:

Santo Antônio (3,568 MW)

Region/basin:

Rondônia, north-west Brazil

Facing strong competition for qualified labour in the region, the Santo Antônio project developed the Acreditar initiative to train local people and develop skills that could be used beyond the needs of the project.

The Santo Antônio hydropower plant is located on the Madeira river, 7 km upstream of the city of Porto Velho, the capital of Rondônia in north-west Brazil. The Madeira is a major tributary of the Amazon, the world's largest river in terms of run-off volume. The plant has an installed capacity of 3,568 MW.

Santo Antônio was designed to maximise use of water resource potential in the region with minimal negative environmental impact.

An important challenge for large infrastructure projects in Brazil at the time of project development was strong competition for qualified labour. The presence of other large hydropower projects in the Amazon region, such as the neighbouring Jirau, contributed to high staff turnover and upward pressure on salaries.

The project workforce peaked in 2011, at 20,700 workers. An extension to the project led to further demand for construction workers. During the implementation stage, the project aimed to hire 70 per cent of workers from the state of Rondônia, in order to address local unemployment and avoid

an influx of migrants to the area in search of work. To deliver on this objective, the project developed the 'Acreditar' training programme, as well as providing training to local suppliers. Acreditar was a flagship initiative designed to plan for, and supply, sufficient qualified workers for the project. The initiative proved to be financially viable.



The project doubled the rate of women's employment compared to national norms

Regional-scale training programmes contribute to regional development

At the start of project construction in 2008, the EPC contractor evaluated the local supply of labour. They found that Porto Velho and surrounding areas in Rondônia could only provide around 30 to 40 per cent of the project's labour needs. However, at the time, around 30,000 Porto Velho residents were unemployed. The entire region was experiencing a high level of unemployment. This is because the federal government had promoted an ambitious settlement programme in Rondônia state in previous decades, which had little success in terms of industrial development.

Acreditar began by introducing a series of 15 different training programmes for unemployed people in Porto Velho and the surrounding areas of Rondônia state. However, the project needed to establish a more ambitious target in order to achieve its 70 per cent target.

In response, the project developed two programmes: Acreditar Profissional; and its extension, Acreditar Junior. Acreditar Profissional trained over 45,000 people, including through partnerships with highly regarded technical training institutions, including the National Industrial Apprenticeship Service (SENAI), National Rural Education Service (SENAR), National Commercial Education Service (SENAC) and the Brazilian Navy.

The training far exceeded the direct hiring and supply needs of the project, and has left a legacy of skills development in the region. It went well beyond more commonly seen programmes, which tend to promote employment in the nearest and most affected communities only, instead taking a regional-level approach.



'Acreditar' training

Acreditar is an outstanding example of a project taking the opportunity to make a long-lasting impact on the local community and region.

Thanks to the initiative, Porto Velho and Rondônia have experienced a notable increase in trained workers and workers with experience on large construction projects. These workers are now qualified to look for well-paid work on similar projects elsewhere.

Local training programmes reduce migrant influx

As a result of the Acreditar programme, approximately 80 per cent of the entire project workforce came from Rondônia state, and most were from Porto Velho itself.

This not only made an important positive impact on the region, but was also an important factor in reducing the risk of in-migration and camp-follower issues.

Ambitious programmes deliver benefits well beyond project needs

Almost 29,000 Acreditar trainees were employed on the Santo Antônio project over the course of its implementation. This figure shows that a significant number – over 16,000 – trainees benefited from the programme but used their new skills to seek employment elsewhere. This extends well beyond the needs of the project, and was one of the key benefits of the project for the region.

Broad programmes support inclusivity of women and young people

Major construction sites in Brazil employ few women, normally around or below 5 per cent of the total workforce. Acreditar actively

sought to address this, through activities to promote equal opportunities, especially in terms of gender.

The project established a commitment to not have any rules or defined practices that would restrict equal opportunities. Courses provided through SENAI included a programme to deliver training to approximately 1,000 women on tasks typically viewed as 'male' jobs. The project doubled the employment rate of women compared to national norms, achieving a proportion of 10 per cent of positions taken by women. In addition, the Acreditar Junior programme provided training for teenage children (aged 14–18 years) of project workers, with courses offered through SENAI.

Replicable programmes can be readily applied with significant benefits

The approach developed on Santo Antônio has been replicated by the developer on many other hydropower, and other, projects in 11 countries. These include Chaglla in Peru, and Teles Pires in Brazil. The benefits of the Acreditar initiative extend far beyond Santo Antônio and beyond the hydropower sector. In total, over 100,000 employees have received training through the initiative.

This case study is based on an official assessment of the Santo Antônio project using the implementation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in April and May 2014.

100,000 employees have benefited from the initiative

Initiative case study 2:

Angostura hydropower plant, Chile

Policy and practice lessons

- Continuous engagement with communities and local authorities was key to implementing the project and gaining support
- The integration of energy and tourism was achieved through a partnership approach
- The project supported the opening of an Entrepreneurial Centre to provide training, advice and financing to companies in the vicinity of the plant

Key project features

Developer/operator:
Colbún S.A

Associated projects:
Angostura Hydropower Station (316 MW)

Region/basin:
Biobío River, Biobío Region, Chile

Angostura is the largest hydropower plant to have entered into operation in more than a decade in Chile. Its model was designed to integrate energy and tourism into a single project. This case study demonstrates a successful multi-purpose project that has directly benefited regional economic development in the Biobío basin area.

Local communities were involved at an early stage of the project planning process, and mitigating environmental impacts and boosting local economic development were central to the preparation, implementation and operational stages of the project.

With an installed capacity of 316 MW, enough to provide power to approximately 400,000 people, the Angostura hydropower station uses the water resources of the Biobío and Huequecura rivers through a reservoir covering an area of 641 hectares.

The plant is located 63 km south-east of the city of Los Ángeles, and 18 km upstream from Quilaco and Santa Bárbara, in the Province of Biobío, Biobío region in Central Chile.

The environmental impact assessment (EIA) was submitted in September 2008 and was approved in November 2009. Construction of the project began in February 2010 with the first earthworks, and ended 48 months later, on schedule.

The plant began its commercial operation in April 2014 and is the third hydropower plant with a reservoir in the Biobío basin.

The Angostura plant has a minimal regulation reservoir, meaning that the reservoir level does not vary by more



than 1 m, and environmental impacts are minimised, enhancing the potential for tourist activity in its surroundings.

In addition, with an installed capacity of 44 W/m² of flooded area, plant efficiency at Angostura exceeds UN international standards for water management and low environmental impact.

An environmental monitoring plan was implemented. Specifically, it sought to ensure that the evolution of environmental variables was in line with those projected in the environmental impact assessment, and that mitigation and compensation measures were adequate. The scope of this plan covers the basins of the Biobío and Huequecura rivers, which are the project's area of influence.

In terms of water quality, the goal is to maintain the reservoir as a balanced and healthy body of water. Four annual monitoring campaigns that include the measurement of solid retention and aquatic ecosystem monitoring are carried out, the results of which are reported to the Superintendence for the Environment (SMA).

In addition, a fish management plan was developed. This plan sought to ensure the conservation and protection of native fish within the Biobío and Huequecura river basins, particularly in the project's area of influence, where the presence of 16 species in conservation status is maintained (six in the Huequecura river and 10 in the Biobío river).



The site of the Angostura hydropower plant

To date, monitoring has shown an abundance of these species. Moreover, in order to identify possible preservation areas for fish fauna, monitoring of the Quilme, Lirquén, Mininco, Queuco and Quillaileo rivers (tributaries of the Huequecura river) is also carried out, given that these have a similar composition.

Regarding the reforestation work associated with the development of the Angostura project, 210 hectares of native forest (with species such as quillay, oak, laurel, guindo santo and naranjillo, among others) have been replanted.

In addition, the plant curtain of eucalyptus in the southern parapet is being replaced by native trees. Considering the size of the trees, this activity is the first of a kind in Chile.

These measures and the associated learning are documented in a publication that has been delivered to public services, academia, and civil society.

Continuous engagement with communities and local authorities was key to implementing the project and gaining support

Consultation began in October 2007 and lasted nine months. As a result of this process, the project incorporated modifications. For example, the format for negotiating with resettled families changed from a collective format to an individual one.

In order to reach an agreement with the 46 families affected by the creation of the reservoir, Colbún implemented an individual resettlement plan, which considered a case-by-case package of compensation, psycho-social support and assistance in the development of vocational projects.

A team of 17 people worked exclusively over three years on this programme of support to resettled communities, who are now being provided with ongoing support.

Angostura Park is a prime example of a multi-purpose project which both boosts power generation and delivers economic benefits to the entire region



Results have shown the success of this initiative with more than **160,000** visits to Angostura Park during 2016

Another element that characterises Angostura is the outreach to local communities. The plant has a public affairs team in the field that is in permanent dialogue with local inhabitants, authorities and other stakeholders.

To date, Angostura has carried out two public reporting presentations, in 2015 and 2016. This is an open exercise in which social, environmental and operational performance is reported to all those living in proximity to the installation.

The project involved the replacement of social infrastructure. Los Notros school was built, as was a community centre, dressing rooms, two football fields, two public roads and three bridges.

Hiring a local workforce was prioritised during the construction of the plant. On average, about 65 per cent of the workers were from the Biobío region, and the 34 per cent came from the towns of Quilaco and Santa Bárbara. During the development of the project 900 workers were trained, of whom 750 were local.

The integration of energy and tourism was achieved through a partnership approach

Angostura Park is a tourism initiative that includes trails, a lookout point, three campsites, two free access beaches and a visitors' centre. Additionally, there are guided tours to the dam and the turbine hall.

To promote the development of tourism in the area, a full marketing plan has been developed, which includes a dedicated website and a Facebook page that now has more than 45,000 followers. These offer information on the tourist project developed around the reservoir and the surrounding area.

In addition to the development of Angostura Park, Colbún has sought to strengthen the area of Quilaco and Santa Bárbara as a new tourist destination in the region, under the name Angostura del Biobío.

The basis for promoting this new destination is through a public-private partnership under the aegis of the Angostura Tourism

Board. The partnership began operating in January 2011. This body is made up of representatives of the area's neighbourhood associations, local entrepreneurs, representatives of the chambers of commerce, the municipalities of Quilaco and Santa Bárbara, the regional national tourism service and Colbún.

All relevant decisions regarding the park have been made by this board, building a public-private governance for the tourism project.

In 2016, the centre provided training, advice and related services to 2,714 people.

Since it began its operations, the Angostura hydroelectric power station has received the recognition of FEDETUR, Cigré, AmCham (Chile-US Chamber of Commerce), Capital Goods Corporation (CBC), and has received a Latinoamerica Verde award.

The project supported the opening of an Entrepreneurial Centre to provide training, advice and financing to companies in the vicinity of the plant

In 2012, the Enterprise Centre of Santa Bárbara and Quilaco was opened by Colbún in partnership with the NGO Acción Emprendedora.

In 2016, the centre provided training, advice and related services to 2,714 people, 688 people attended their seminars and training programmes (workshops), 160 consultancy services were delivered and the centre gave financial support to 72 ventures. Nine of these projects corresponded to tourism development in the power station area. Tourism initiatives have contributed to the development of the region.

New offices are being built for the workers of the plant, which will be launched during 2017. Currently, they are under application to be certified as a sustainable building by CES (Certificación Edificio Sustentable), a national accreditation system.



Stakeholder engagement boosts economic development with minimal environmental impact

The Angostura project combines a highly developed environmental management plan with an ambitious plan for economic development through tourism that focuses on the involvement and empowerment of communities in proximity to the plant.

Environmental management measures include the protection of fishstocks in the Biobío and Huequecura rivers and tributaries and large scale reforestation of areas around the reservoir with native trees.

In addition, individual resettlement plans offered each family and individual who would be affected by the flooding caused by construction of the dam a bespoke package of financial, vocational and psycho-social support.

At the same time, a unique tourist attraction was developed that includes a visitor centre to the dam, and turbine hall and recreational facilities on and around the reservoir.

Angostura Park is managed by a public-private partnership that brings together local neighbourhood associations and chambers of commerce.

In addition to the development of tourist facilities, entrepreneurship in the region has been supported more generally through the opening of an Entrepreneurial Centre.



To date, Angostura has carried out two public reporting presentations, in 2015 and 2016. This is an open exercise in which social, environmental and operational performance is reported to all those living in proximity to the installation.

Initiative case study 3:

Cultivando Água Boa / Cultivando Agua Buena, Brazil–Paraguay

Policy and practice lessons

- Practical measures to minimise run-off can be taken in partnership with farmers
- Catchment management can provide a framework to deliver wider benefits
- A micro-catchment approach allows a large-scale problem to be managed in small parcels
- Micro-catchment managers and effective communications enhance catchment management programmes

Key project features

Developer/operator:

Itaipu Binacional

Associated projects:

Itaipu (14,000 MW)

Region/basin:

Paraná, south-west Brazil/east Paraguay

The “Cultivando Água Boa” (“Cultivating Good Water”) programme was set up by the Brazilian part of Itaipu Binacional in 2003. Concerned about siltation of the Itaipu reservoir and the risk of eutrophication due to agricultural run-off, the programme aims to minimise the run-off of silt, fertilisers and pesticides.

The Itaipu dam was built between 1975 and 1982, with the 170 km long reservoir reaching its operating level in 1983. The initial 18 units were commissioned between 1984 and 1991, with a further two added in 2006–07.

The Paraná River is among the largest in the world in terms of length and discharge. The Itaipu plant has generated almost twice as much electricity as any other power plant in the world. It provides 79 per cent of Paraguay’s total electricity and 14 per cent of Brazil’s total electricity.

Land on the Brazilian bank of Itaipu’s 1,350 km² reservoir has been intensively cultivated for decades. At the time of Itaipu’s development, farming was already widespread and modernised. The Paraguayan reservoir bank was largely forested at the time of project development, but has since become much more agricultural, with large-scale clearance of forest for soya crops.

The “Cultivando Água Boa” (CAB) programme has been successful in managing run-off, as well as extending to the provision of a wide range of benefits to local municipalities. Stakeholders in these municipalities report significant



environmental improvements, with less agricultural pollution, and better roads and water supplies.

Building on the success of the programme, the Paraguayan part of Itaipu Binacional has now instigated a similar programme, ‘Cultivando Agua Buena’ (the Spanish equivalent of ‘Cultivating Good Water’).

Practical measures to minimise run-off can be taken in partnership with farmers

CAB supports a wide range of measures to manage the quality of water entering the reservoir. These include physical measures such as: contour bunding; promoting zero-tillage approaches in farming; tree planting on contours and along water courses; constructing rural roads to meet high erosion-prevention standards; and recovery of degraded areas through reforestation.

The work of the micro-basin managers is supported through a range of CAB-branded communications materials.

A noticeable feature is the provision of washing stations, which provide free water to farmers for washing agricultural machinery.

This is important for ensuring that soil and other residues are collected and managed, rather than being washed into watercourses, and ultimately the reservoir. Many of these measures are being taken in partnership with farmers, who can see the benefits of avoiding soil erosion on the productivity of their farms.

A micro-catchment approach allows a large-scale problem to be managed in small parcels

CAB is planned and managed through micro-catchments, allowing the programme’s activities to be tailored to its objectives on a micro-catchment by micro-catchment scale.

Decision-making is largely decentralised, with a municipal-level steering committee determining priority activities in each municipality within their jurisdiction.

CAB is now being extended to municipalities beyond the initial reservoir shoreline. Itaipu Brazil is also discussing the opportunity to extend CAB upstream in Paraná state.

Catchment management can provide a framework to deliver wider benefits

CAB has evolved into the coordination framework for most of the benefits delivered by Itaipu to the municipalities around the reservoir. The catchment has become the key management unit for all sustainability-related work.

Through a highly participatory cooperation process with the municipalities, CAB is able to gather proposals for community benefits. These proposals have been identified by tens of thousands of stakeholders who are in contact with local CAB managers.

For example, CAB has provided community water supplies for domestic consumption, and a programme aimed at vulnerable people. This amounted to a budget of USD 431,000 in 2015. From 2005 to 2011, CAB also implemented a participatory water-quality monitoring initiative, involving local schoolchildren. The programme has brought added value by building municipality management capacity through the steering committees.

Micro-catchment managers and effective communications enhance catchment management programmes

CAB works with 29 municipalities and 150 micro-catchments, engaging with over 2,000 partners. More than 40,000 people have been directly involved in CAB, and outreach activities have engaged over 80,000 people through 400 activities.

Itaipu Brazil employs 11 micro-basin managers, who provide a highly effective channel for local stakeholders to raise issues.

They are also responsible for convening the municipal-level steering committees every 60 days, and organising the technical chambers when necessary.

The work of the micro-basin managers is supported through a range of CAB-branded communications materials, including:

- a website, www.cultivandoaguaboa.com.br;
- CAB ‘Informativo’ newsletters, and monthly newspaper;
- a CD highlighting the achievements of the programme; and
- another website, www.observatoriocab.org.br, offering information on the programme and an ombudsman.

Itaipu Brazil has also developed a procedure for liaising with indigenous communities, which has been incorporated into CAB.



Road upgraded through Cultivando Água Boa

CAB provides a replicable model

Expenditure on CAB in Brazil was over USD 2.35 million, or 13 per cent of its total expenditure on environmental and social programmes in 2015. At USD 220,000 in 2015, expenditure on the programme in Paraguay is much lower, but is growing.

A similar range of measures are underway through agreements of the Department of Reservoir and Protected Areas in Paraguay and the environmental regulator, together with project-affected municipalities.

CAB has been replicated in many other areas of Brazil and also in five additional Latin American countries: Argentina, Dominican Republic, Guatemala, Paraguay and Uruguay, as well as in Spain.

The programme was awarded the Water for Life prize by UN Water in early 2015, recognising it as the best water-management programme in the world.

This case study is based on an official assessment of Itaipu using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2015, with an on-site assessment in August 2015.

Initiative case study 4:

Regional initiative to promote sustainability in hydropower

Policy and practice lessons

- Embedding a sustainability assessment into a wider programme builds stakeholder awareness and buy-in
- A protocol assessment may help attract support of international financial institutions
- Locally focused information sharing supports wider-scale transboundary coordination
- Ongoing training initiatives promote wider informal and formal use of the protocol

Key project features

Partners:
Shardara Reservoir Division of the Ministry of Agriculture, Kazakhstan; Deutsche Gesellschaft Für Internationale Zusammenarbeit (GIZ); CAREC (the Regional Environmental Centre for Central Asia)

Associated projects:
Sharardara Multi-Purpose Project (100 MW)

Region/basin:
Aral-Syrdarya Basin (Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan)

When the Hydropower Sustainability Assessment Protocol was finalised in November 2010, GIZ's programme for Transboundary Water Management in Central Asia asked the International Hydropower Association (IHA) to apply it to the Shardara Multi-Purpose Project. The report was delivered in December that year, but the initiative didn't stop there.

The assessment led to steps to improve transboundary basin management, modernise the Shardara project, and promote sustainability in hydropower across the Central Asian region.

After the protocol was finalised in November 2010, the first assessment was carried out in Kazakhstan. It was an assessment of the Shardara Multi-Purpose Project, organised with the support of a GIZ (then GTZ) programme on transboundary water management in Central Asia.

The Shardara Multi-Purpose Project is located in southern Kazakhstan, near the border with Uzbekistan. The project is one of many reservoirs, weirs, barrages and hydropower plants on the 2,200 km Syrdarya river.

The purpose of the project is irrigation and flood regulation, with power generation as an additional benefit. It was built between



1964 and 1967 and has a 100 MW capacity. JSC Shardarinskaya GES, incorporated in

1998, is the owner and manager of the plant. The company is 100 per cent owned by Samruk Energy, a power sector subsidiary of the National Welfare Fund Samruk Kazyna.

Embedding a sustainability assessment into a wider programme builds stakeholder awareness and buy-in

The GIZ programme on Transboundary Water Management supports Central Asian states in establishing suitable water management structures.

The programme ran from 2009 to 2017, under the German Federal Foreign Office's Central Asia Water Initiative (the 'Berlin Process'), and with partial co-financing from the European Union. Its objective is to support Central Asian states in jointly developing practical approaches for sustainable regional water management.

A range of institutions interviewed during the assessment actively participated in the evaluation meeting.

Within this programme, the protocol assessment was embedded in a wider evaluation process, involving partners across Kazakhstan and the whole region. The final report, prepared by Dr Helen Locher (a protocol-accredited assessor), was translated



Shardara hydropower plant

into Russian and distributed to all involved institutions from Astana, Shimkent (the provincial capital) and Shardara, in March 2011.

An evaluation meeting was held in late March 2011, and minutes of the meeting were distributed to stakeholders. The national Kazakh Committee of Water Resources and Ministry of Environmental Protection delivered official responses in May of that year.

A range of institutions interviewed during the assessment actively participated in the evaluation meeting.

These included: the Ministry of Industry and New Technologies; the Shardara Hydropower Plant board; the Shimkent Committee of Water Resources; the Aral-Syrdarya Basin Inspection; and the Ministry of Agriculture.

A number of other stakeholders also participated, notably the EC IFAS – Executive Committee of the Fund for Saving the Aral Sea; and CAREC, the Central Asian Regional Ecological Centre.

CAREC is supporting on basin planning and Basin Council issues in the Kazakh

Aral-Syrdarya Basin Inspection (the main institution of the state Committee Water Resources in the lower Syrdarya basin), which is responsible for the inspection of water use, including water protection zones, within the GIZ programme.

Other stakeholders present included: other committees of water resources; the provincial Nature Conservation Department; the State Institute Hydroproject; the Kazakh Scientific Research Water Resources Institute; and the South-Kazakh State University, Shimkent.

The purpose of the evaluation meeting was to consider the findings of the assessment, as well as the suitability of the approach for the region. The overall response of the participants was positive, with many highlighting the value of the approach and promising to study the report.

The chairman of the Kazakh Committee of Water Resources noted in an official response that: "the results and recommendations are useful for the further development of reservoir management... and we recommend the Hydropower Sustainability Assessment Protocol be applied to the entire Syrdarya basin."

The chairman of the Kazakh Committee of Water Resources recommended the Protocol "be applied to the entire Syrdarya basin"

A protocol assessment may help attract support of international financial institutions

Some of the key findings of the assessment, on the topics of asset reliability and efficiency (O-5) and infrastructure safety (O-6), were that all assets, including generation, reservoir, and irrigation and drainage assets, still require considerable investment for rehabilitation works.

Whilst dam safety is closely monitored, and dam and plant rehabilitation works have safety as a strong priority, the need for a new emergency gate at Shardara, and it was also necessary to replace a second dam's gates and plant gates, and improve irrigation drainage.

JSC Shardarinskaya GES has since instigated a rehabilitation project, with loan finance from the European Bank for Reconstruction and Development (EBRD). A ten-year loan of up to EUR 75 million was agreed in 2012, for a EUR 96 million project to replace old equipment and improve efficiency.

Locally focused information sharing supports wider-scale transboundary coordination

One of the key recommendations of the assessment was that the chairman of the Committee of Water Resources (the state agency with responsibility for water resources) should establish a Shardara Reservoir Council.

This would be a more locally focused grouping within the Aral-Syrdarya Council, which could meet to discuss reservoir management issues and share information between agencies. The Shardara Reservoir Council would also provide a forum to address issues raised by stakeholders.

Conclusions under the communications and consultation (O-1) and governance (O-2) topics highlighted that, despite some mechanisms for coordination, such as the Syrdarya Basin Water Organisation and Aral-Syrdarya Basin Council, it was unclear how much lateral exchange of information occurs.

The conclusions also raised an absence of dialogue between Kazakhstan and

Uzbekistan operational staff on the Arnasai dam. The dam is located on the southernmost point of the Shardara reservoir, and releases water into Uzbekistan.

Transboundary information and negotiation problems (upstream with respect to inflows, and downstream with respect to the Arnasai Dam) were left unresolved, and presented a risk for operations.

The Committee of Water Resources acted upon this recommendation, establishing the Shardara Reservoir Council as a forum to discuss local issues of reservoir management between Kazakhstan and Uzbekistan.

Ongoing training initiatives promote wider informal and formal use of the protocol

The chair of the Shardara Reservoir Council participated in a series of training events organised by CAREC in Almaty in 2016. Other participants included representatives from EC IFAS and trainees from across all Central Asian countries.



The reservoir at Shardara



Participants at a training event wanted to understand how the protocol complements international lenders' requirements.

CAREC approached IHA in 2016 to ask for further training on the protocol and support for awareness raising of the protocol across the region. The resulting initiative comprised:

- a training event to raise awareness among decision-makers;
- The development of a dissemination brochure in Russian;
- an additional 'train-the-trainer' event; and
- the development of a scientific paper concerning the initiative ("The Hydropower Sustainability Assessment Protocol – its relevance and suitability for application in Central Asia").

One of the key questions raised during the training, which is also addressed by the scientific paper, is: 'Why use the protocol in Central Asia?'. Developers and operators of hydropower projects in the region have to follow detailed regulations and engineering standards for project development. Participants were interested in understanding how the Protocol compared to these standards.

Participants also wanted to understand how the Protocol complements international lenders' requirements.

The scientific paper, prepared in Russian, addressed these questions with the following answers:

- the protocol consists of a comprehensive range of topics, including technical and financial, as well as environmental and social issues;
- the protocol is focused entirely on hydropower (unlike lenders' requirements, which are general);
- a protocol assessment can be used as a tool for stakeholder engagement;
- a protocol assessment provides a rapid "check" on a project's sustainability; and
- Following the training events, IHA, CAREC and EC IFAS entered into discussion on the steps needed to promote the protocol further in Central Asia.

Potential actions under discussion are:

- the translation of one or two official assessments of projects in other locations into Russian, or summaries, as examples of assessment reports;
- developing training materials and delivering training courses at a national level, possibly in partnership with universities, targeted at teachers and students;

- providing the protocol brochure and presentations, for example to ministries and working groups, and annual regional meetings of water sector organisations, and development partners;
- disseminating materials in Russian, such as a website, standard presentations, case studies, and a video of the process of an official assessment; and
- developing an approach to using the protocol that is appropriate for rehabilitation projects.

This case study is based on an assessment of the Shardara Multi-Purpose Project using the operation stage tool of the Hydropower Sustainability Assessment Protocol, and ongoing work in the region in response to the assessment. The assessment was conducted in November-December 2010.

Initiative case study 5:

Reventazón, Costa Rica

Policy and practice lessons

- The offset programme was based on environmental and social criteria and designed and implemented with stakeholders
- A biological corridor was created to safeguard critical jaguar habitats
- The programme protects a free-flowing river and the perpetuity of intact ecosystems
- Offset measures address multidisciplinary objectives

Key project features

Developer/operator:
Instituto Costarricense de Electricidad (ICE)

Associated projects:
Reventazón (305.5 MW)

Region/basin:
Reventazón river, Limón province

The Reventazón Hydroelectric Project (RHP) is one of the first Latin American hydroelectric projects to use a river offset approach. This case study demonstrates how strategic basin planning can help develop the hydropower potential of a river whilst making a significant contribution to biodiversity conservation.

Instituto Costarricense de Electricidad (ICE), Costa Rica’s national power company, developed the Reventazón Hydroelectric Project (RHP) between 2012 and 2016. RHP was built on the Reventazón river in the Limón province, with a 130 m dam and an 8 km long reservoir.

The project is the fourth in a cascade of projects on the Reventazón river, and is designed to maintain a downstream flow of 40 m³/s. It comprises an additional small powerhouse, with a single 13.3 MW turbine, to utilise the environmental flow release. The project is located in an area of very humid tropical forest.

Reventazón was partially funded by the Inter-American Development Bank (IDB) and as such was required to meet international environmental and social safeguards.

Project studies anticipated that, in the absence of environmental management strategies, RHP would make a significant impact on migratory fish species and critical habitats and connectivity.

Studies indicated that the project would affect around 471 species of fauna, of which 34 are at risk of extinction and 58 are under threat. It would also affect 193 species of flora, of which 15 are at risk of extinction, and six are under threat.



ICE designed an offset plan that included protecting the perpetuity of the Parismina river, an intact river that joins the Reventazón river downstream of the dam on the coastal plain.

RHP is one of the first Latin American hydroelectric projects to use the river offset approach. The IDB estimated that the offset would cost USD 2.7 million over 2013–15, and USD 800,000 per subsequent year.

This case study is an example of how strategic basin planning can help develop the hydropower potential of a river whilst protecting and avoiding development in other free-flowing rivers in the same basin. It also demonstrates how effective mechanisms can be used to offset environmental impacts.

The project shows how hydropower projects can make a significant contribution to biodiversity conservation at regional and basin level through offset programmes designed with relevant stakeholders.

The offset programme was based on environmental and social criteria and designed and implemented with stakeholders

ICE, with assistance from IDB, designed and implemented a river offset programme to compensate residual and cumulative biodiversity impacts.

The programme was designed to:

- protect a free-flowing river with similar characteristics to the Reventazón river;
- improve water quality and riparian habitats;

The programme had to be implemented in a river stretch with similar ecological conditions and services to the Reventazón river.



Construction of the dam at Reventazón

- compensate the loss of critical habitat and impacts on terrestrial and aquatic connectivity, especially impacts on big cats and migratory aquatic species; and
- facilitate a possible net gain of critical habitats.

The offset programme had to be implemented in a river stretch with similar ecological conditions and services to the Reventazón river. The Parismina river and its tributary, Dos Novillos river, were selected for the implementation of the programmes (a total stretch of 105.5 km).

The selection process involved analysing nine river basins discharging into the Caribbean Sea. Three of the nine basins were selected due to their equivalent fluvial ecosystems meeting the following criteria: complex aquatic ecosystems and migratory species with high biodiversity; a continuous flow without barriers; good aquatic and terrestrial habitat conditions; and socio-economic services (e.g. eco-tourism, or sites of cultural heritage importance). Parismina was selected because it receives several tributaries and is key to fish migration. Dos Novillos was selected for offering the best aquatic and riparian environmental quality. The project carried out a feasibility study of the Parismina and Dos Novillos rivers in order to avoid the loss of, or ensure positive biodiversity gains, with respect to the residual impacts, and especially connectivity impacts.

About 16 communities had a direct influence on the Parismina and Dos Novillos rivers, with a total population of 6,787 in 2013. The feasibility study used recognised indicators to measure riparian habitats, hydro-geomorphological conditions and riparian forest quality. The study concluded that the rivers would be suitable for the programme and would enable a net gain of 40 per cent in riparian habitats.

ICE designed the Parismina–Dos Novillos water offset management plan, which included actions to reforest the riverbanks, reduce agrochemical water pollution, promote best agricultural practices, and improve water resource management.

The programme engaged local communities, who were involved in capacity-building activities and monitoring.

The feasibility study used recognised indicators to measure riparian habitats, hydro-geomorphological conditions and riparian forest quality.

ICE also worked with small farmers and other stakeholders in the basin to implement the planned environmental actions. Other major challenges to the offset programme's long-term sustainability included obtaining a site protection legal framework from Costa Rica's Environment and Energy Ministry, and ensuring financing for the management and operation.

The programme protects a free-flowing river and the perpetuity of intact ecosystems

The programme was the region's first river offset programme. ICE protected migratory routes for three fish species in the Parismina river. An offset agreement guaranteed the prohibition of artificial river or natural flow pattern modifications, including dams and other barriers to fish migration.

The programme involves ongoing work between ICE and landowners in the Parismina and Reventazón watersheds to reduce erosion, sedimentation and pesticide run-off. The effectiveness of protection measures would be verified through a permanent monitoring programme for water quality, biodiversity and key habitats.

A biological corridor was created to safeguard critical jaguar habitats

The reservoir location would have a significant impact on one of Costa Rica's most important biological corridors, the Barbilla-Destierro biological subcorridor. This corridor plays a key role in the migration of jaguars in the Mesoamerican biological corridor between Nicaragua, Costa Rica and

Panama. The Barbilla-Destierro biological corridor was identified as an area of importance for the connectivity of jaguar populations since 1990. The project performed studies on the effectiveness of the Barbilla-Destierro biological subcorridor management and the role of different stakeholders. This process contributed to strengthening the corridor's management structure. The project implemented habitat restoration measures to preserve the subcorridor's role in the movement of jaguars and their genetic flow. Measures included in the offset programme involve riverbank restoration that could create additional jaguar habitats and improve habitat connectivity from Tortuguero National Park on the coast up into the central mountain range.

The project aimed to restore degraded land and raise local awareness on the importance of protecting the biological corridor.

The offset measures will contribute to meeting a number of environmental and social objectives that will benefit the environment and improve the performance of the project.

The project also included payments to forest owners for environmental services, environmental education, and agroforestry technical support. For example, farmers were able to learn how to raise pigs in enclosures rather than letting them run free. This way, waste produced by the pigs can be converted into fertiliser and gas, and will not affect water quality in the reservoir. At the same time, the pigs will be less exposed to jaguar predation, reducing the potential for conflicts between farmers and conservationists.

Offset measures address multidisciplinary objectives

The offset measures will contribute to meeting a number of environmental



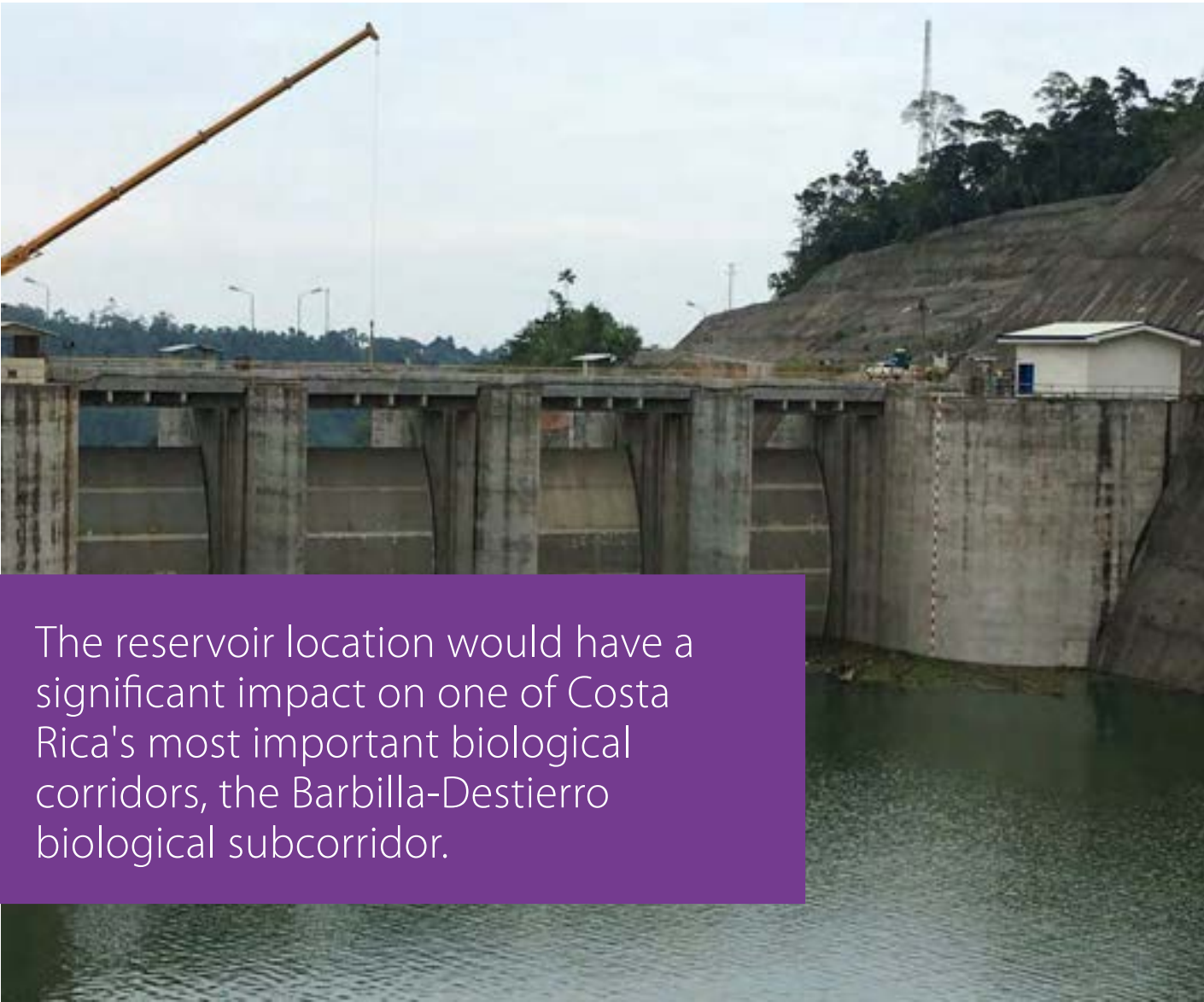
The powerhouse penstock and surge tower

and social objectives that will benefit the environment and improve the performance of the project.

For example, the reforestation of a buffer strip around the reservoir would help to:

- reduce erosion and sedimentation, increasing the useful life of the reservoir;
- reduce the risk of landslides; and
- create connectivity routes and new habitats for amphibians, reptiles, birds, insects, and mammals.

The project also prepared a reforestation plan using local tree and plant species and local nurseries.



The reservoir location would have a significant impact on one of Costa Rica's most important biological corridors, the Barbilla-Destierro biological subcorridor.



The reservoir location would have a significant impact on one of Costa Rica's most important biological corridors



Contributing to biodiversity conservation in Costa Rica

The programme contributed to meeting the policies and objectives on biodiversity conservation in Costa Rica. In addition to the protection of the Parismina river, the president of Costa Rica declared that the Savegre and Pacuare rivers would be protected from hydropower development from 2015 for 25 years.

This decision was made as part of a national framework for hydropower development. The Savegre and Pacuare rivers were selected for their ecological, biological, economic and social importance.

Initiative case study 6:

Tulila Hydroelectric Plant, Tanzania

Policy and practice lessons

- Plant supplies energy for load centres in Songea, Mbinga and surrounding rural areas
- Project supports services to local people and charity work
- Local jobs created for operation and maintenance of the power station

Key project features

Developer/operator:

Tulila Hydro-Electric Plant Company Limited (Albert Koch Foundation/ Benedictine Sisters of St Agnes, Chipole)

Associated projects:

Tulila Hydroelectric Plant (5 to 7.5 MW)

Region/basin:

Ruvuma region, Tanzania

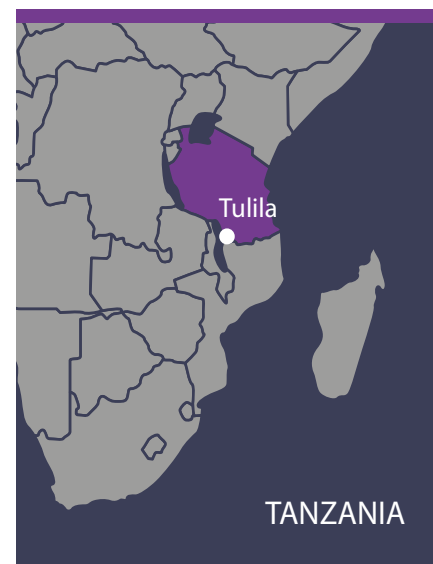
The Benedictine Sisters of St Agnes, based in the Ruvuma region of south-west Tanzania, have constructed a small hydroelectric plant on the Ruvuma river in Tulila. It supplies the load centres of Songea and Mbinga and rural areas in the vicinity of the plant, and delivers important benefits to the local community.

The Benedictine Sisters of St Agnes reside at the Chipole Convent, approximately 50 km west of Songea. They provide services for local people in this rural area, funded by farming and small companies run by the sisters. Their activities are limited by financial restrictions and dependence on donors locally and from abroad.

In 2004–06, Robert Fuchs from Switzerland built, through his Robert Fuchs Foundation, the Lupilo hydropower project (400 kW), located on the Ruvuma river. The Benedictine Sisters have the right of use of the Lupilo project to secure the convent with a long-term power supply, with the objective of developing the convent's social activities and small businesses. The plant provides reliable, cheap and renewable electricity for the convent.

Based on the positive experience of operating the Lupilo project, and with their understanding of the recently established rules and regulations for small (private) power producers (EWURA tariffs, SPPA, etc.), the Benedictine Sisters of Chipole decided

to construct the new small hydropower project at Tulila Falls. This will give the sisters a sound and sustainable basis for their social/public services and activities, and will enable them to extend these considerably, delivering multiple benefits to the local area.



View of the Tulila project site

In summer 2009 the entrepreneur Albert Koch from Switzerland launched an initiative 'Hydropower for Africa' in collaboration with the Benedictine Sisters of Chipole, with his first project: the Tulila hydroelectric plant.

To launch his activities, Mr Koch founded the Albert Koch Foundation and Tulila Hydroelectric Plant Ltd, both in Switzerland. Later, the local project company Tulila Hydro-Electric Plant Company Ltd. was founded in Tanzania. All engineering work

and support for licensing, financing and insurance for Tulila Hydro-Electric Plant Co. Ltd. was provided by AF-Iteco (formerly Iteco Engineering Ltd.). AF-Iteco carried out the complete technical project, from initial studies to successful commissioning, and allocated two resident engineers over two and a half years for project management and work supervision on the construction site.

The initial studies were carried out in 2010, and construction work began in October 2013. Following commissioning, the commercial operation started in mid-September 2015. All works were completed by end of August 2016.

Technical features

The Tulila HEP is a run-off plant with daily pondage. The damming structure consists of an earth-fill dam, including a concrete part in the middle with intake, overflow section with four weir blocks, a bottom outlet and wing walls.

The intake already has three inlet openings, where the inlet next to weir block one is closed (phase two). Inlet one and two lead water through two penstocks and then into the powerhouse.

The penstocks have two different diameters for each alignment (DN2300/DN2500). This

decision was made to reduce the transport costs because the DN2300 pipe was nested into the DN2500 pipe.

The powerhouse was designed for three identically constructed turbine and generator units, each of 2.5 MW.

In phase one, only two 2.5 MW units have been installed, due to electricity demand considerations and transmission line capacity of the mini-grid.

The third 2.5 MW unit and penstock alignment will be installed when the grid is connected to the Tanzanian national grid.

Plant supplies energy for load centres in Songea, Mbinga and surrounding rural areas

The Ruvuma region is home to between 300,000 and 400,000 inhabitants, and has a 5 per cent rate of electrification.

Furthermore, a major problem presented by the diesel-powered generators was the unreliability of the electricity supply due to frequent power outages and load shedding, especially in the morning. Rural areas were not connected at all.

During the rainy season, Tulila can also supply the evening peak but support depends on seasonal water availability.

2,000 schoolchildren receive an education through schools provided by the convent

The remaining power demand is covered by diesel generators. In order to increase power supply in rural areas, villages along the 85 km transmission line were connected to the mini-grid. Diesel usage has been considerably reduced since the Tulila project came into operation.

Tulila HEP is helping to stabilise the network by supplying the bulk of the load. One 4 MW diesel generator park may now be shut down. The Tulila project and Songea Power Station (operated by Tanesco) are cooperating closely and exchanging experience, as Tulila is currently synchronising onto the regional mini-grid.

Project supports services to local people and charity work

The Benedictine Sisters of St Agnes deliver important education, healthcare, nutrition and orphanage services in Chipole Convent and in 45 remote stations. In line with Benedictine tradition, almost all basic daily needs are met by the sisters themselves.

All the sisters' services for the Tulila project were made available with limited own contributions. After repayment of the debt financing, and once proof is established that the sisters are able to undertake the commercial and technical management of the Tulila project on a sustainable basis, the project will be handed over. The convent will also need to demonstrate that it can direct the generated profits to a sustainable use for their charitable purposes. Today, around 2,000 pupils receive education

through the sisters' guided schools. Classes are held from kindergarten through to 12th grade. The focus is on preparing children for advanced studies and/or skills for self-sufficiency and independent living.

Trade schools are also guided by the sisters, where children receive education in tailoring, shoemaking, electrical engineering, mechanics, carpentry and plumbing. These services will be increased in the region, and more children will receive a school education. Since the foundation of Chipole Convent, many of the sisters have been given placements to provide healthcare services.

High demand for medical assistance in the area prompted the sisters to establish a health centre in Tulila.

The sale of electricity supports the sisters' services and charity work, and provides a solid and sustainable basis for their activities. The sisters fill an important gap as they offer the only healthcare facility for the eight villages in the Chipole area.

During the project's construction, it was agreed that the sisters would provide medical assistance to workers.

A skilled nurse was assigned to the Tulila project, and news spread to villages up to 20 km from the project.

High demand for medical assistance in the area prompted the sisters to establish a health centre in Tulila, which continues operating even after commissioning of the power station.

Local jobs were created for operation and maintenance of the power station

Project operation requires skilled personnel. Five sisters and two local electricians operate the power plant.

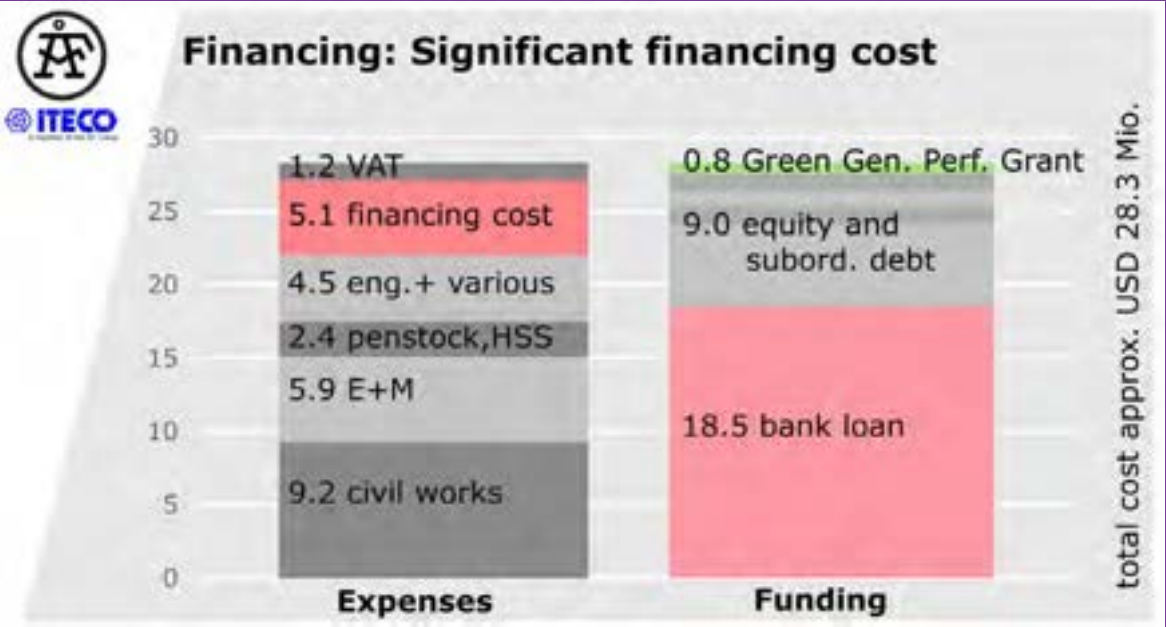
Over the first two years of operation, Tanesco, the energy supply company, has provided two expert staff to operate the plant and provide training to the Tulila staff. Additional personnel have been hired for the maintenance of structures and operational matters, such as shutting down the intake, bottom outlet and powerhouse outlet.

All personnel were trained by experts, such as the suppliers of the hydraulic steel structures, turbines and generators, and electrical installations.

Local construction companies were also involved in project construction. This means that any general repairs and maintenance works can be carried out by local contractors.



Operators of the Tulila plant (l-r, back to front): Moyo (electrician); Oscar (electrician); Sister Upendo OSB; Sister Doreen OSB; Sister Rechardis OSB (nurse); Sister Saburi OSB (electrician); Christopher (Tanesco, chief of staff); and Sister Veritas OSB (electrician)



How was the project financed and insured?

The total project cost of approximately USD 28.3 million was financed by a bank loan (65 per cent, USD 18.5 million), subordinated loans and equity (32 per cent, USD 9 m) and a Green Generation Performance Grant through REA (3 per cent, USD 0.8 million).

Despite sufficient equity funds, attractive site conditions, low technical risks, high feed-in tariffs and a favourable economy, financing was a challenging aspect of the project. The uncompromising commitment of the main stakeholder and the sisters' excellent reputation were important factors in convincing creditors and insurers.

Furthermore, the issuance of an export risk policy was a precondition for credit. From the kick-off meeting at the bank, it took 16 months to conclude the credit contract.

An export risk insurance covering pre-shipment/supplier loan combined with a buyer credit insurance has been concluded with Swiss Export Risk Insurance (SERV). While technical risks were considered to be quite low, the commercial risks associated with a non-recourse project financing in a Sub-Saharan country was quite a challenge for the financing community.

The existence of a well-designed framework for small hydroelectric power projects in Tanzania was a very positive factor.

The procedure to obtain the required export risk insurance policies took more than six months and was very well supported by SERV. As shown above, overall financing costs (including fees, interest during construction and SERV insurance premium) amounted to USD 5.1 million, which represents approximately 18 per cent of the total project cost.

Another hurdle in connection with the financing was finding an insurance company for technical risks during the construction and operating period, including delay-in-start-up, marine and business interruption insurance. The Tulila hydropower project proved rather small for international insurance companies. Yet, with the strong support of a Swiss insurance broker, this hurdle could be overcome, as a Swiss insurance company was identified and provided the required insurance package.