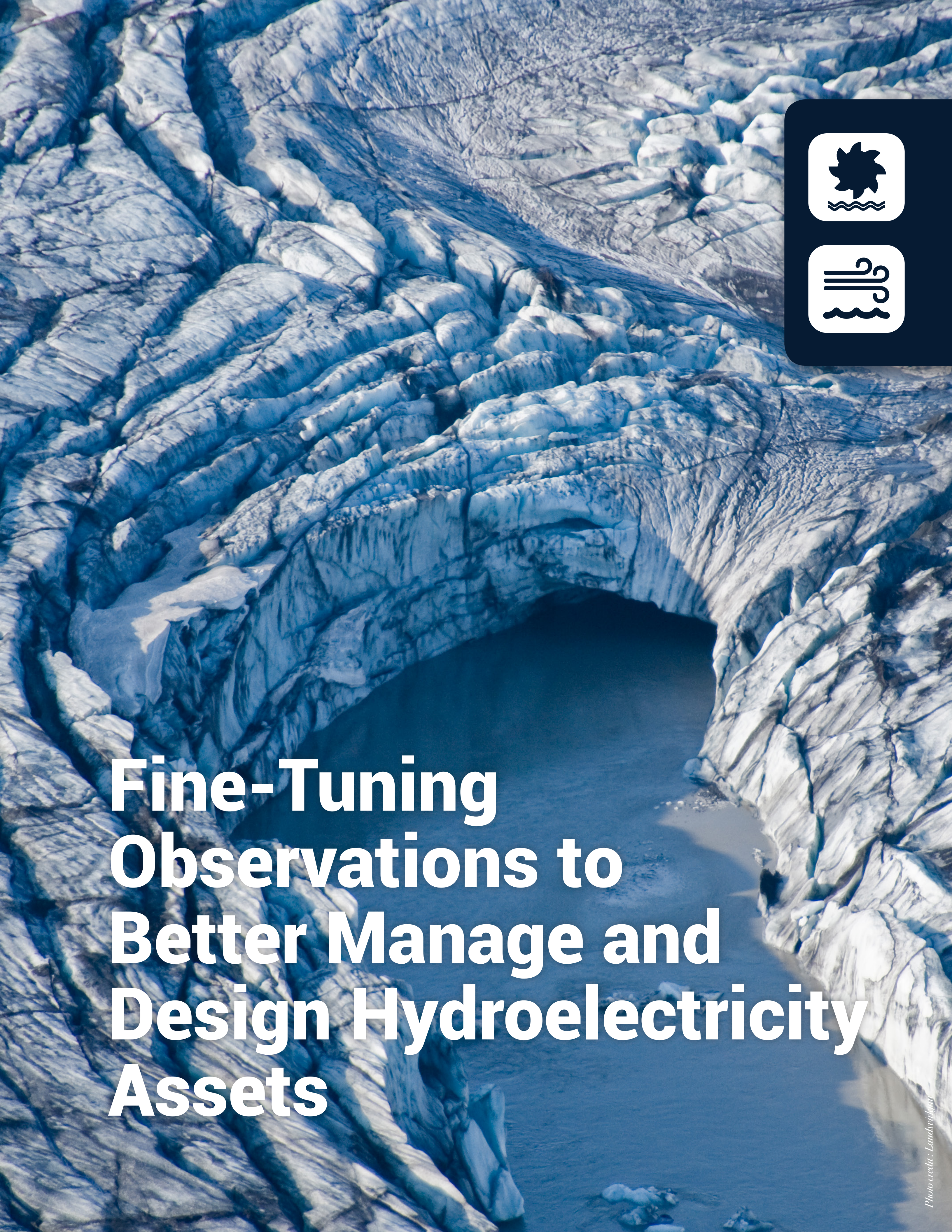

Fine-Tuning Observations to Better Manage and Design Hydroelectricity Assets

Photo credit : Landsvirkjun

"When we first considered expanding the Búrfell power plant, it was not economically feasible. Once we factored in expected increases in flow, however, it became more than feasible."

Óli Grétar Blöndal Sveinsson, Executive Vice-President of Research and Development, Landsvirkjun[1]

SUMMARY

The hydroelectric sector stands to benefit from some aspects of climate change, such as increased flows due to melting glaciers. To take advantage of these potential opportunities, however, requires considerable knowledge of climate change projections and hydroelectric generation. Landsvirkjun, the National Power Company of Iceland, has become a leader in this field during the last 15 years. In collaboration with other power companies, universities and meteorological services across Scandinavia, Landsvirkjun has produced data on river flows that incorporate climate trends. Every five years, the company uses the data to adjust its reservoir-management plans. Landsvirkjun also uses the long-term perspective provided by climate projections to design and adjust existing and proposed new assets to take advantage of anticipated increases in flow rates.

CONTEXT

While climate change remains one of the world's biggest issues, it also creates opportunities for the hydroelectric sector. Rising global temperatures cause glaciers around the world to melt. In some of the watersheds fed largely by glacial melt, climate change is expected to accelerate glacial melting and increase flow rates. In watersheds fed by glaciers that have already lost significant mass, flow rates may decrease. Projected changes in precipitation—and whether they will create opportunities for hydroelectric generation—vary by region; water availability will increase in some regions and decrease in others. Along with water availability, regional demand for electricity is also likely to vary due to climate change. A warmer climate could reduce demand for electric heat in winter, for instance, and increase usage of air conditioning in summer.

To take advantage of potential opportunities, hydro projects must adapt to new and changing conditions. In some cases, existing hydro resources, such as dams, turbines and reservoirs, are able to cope with changes in flow rates, water availability and demand through careful management strategies. In other cases, though, changes in management practices will not be enough. A common reason is that the capacity of the reservoir and/or turbines is too small to handle significantly larger volumes of water. In these cases, asset modifications are needed. Few companies around the world have justified asset modifications of this type to take advantage of the opportunities—or to mitigate the risks—associated with climate change.

Iceland is blessed with an abundance of renewable-energy resources; hydro and geothermal generate virtually all of the country's electricity. Power-intensive industries, such as aluminum manufacturing, account for 80% of the total demand for electricity. Hydro and geothermal generation meets this fixed base load, while direct use of geothermal energy meets 90% of the demand related to heating. Increases in the melting rate of Iceland's glaciers represent an opportunity to produce clean energy and attract new power-intensive industries.

Landsvirkjun, The National Power Company of Iceland, produces and distributes electricity to both industries and utilities. The company has long recognized that it must take advantage of increased flows on the island. During the last 15 years, Landsvirkjun has become a pioneer in adapting to climate change by modifying not only the management of its hydroelectric power plants, but also the design of its assets.

FINE-TUNING OBSERVATIONS

"Sometime around 2005, we saw that the flows into the system were different from what the history was suggesting they should be"[1] says Óli Grétar Blöndal Sveinsson, Landsvirkjun's Executive Vice-President of Research and Development. At that time, the company was already engaged with

Norden—a coalition of Scandinavian governments and research agencies—to identify and analyze the impacts of climate change on renewable energy.

In this collaborative research, observed temperature and precipitation data, as well as glacier area-volume-elevation curves, were adjusted according to climate model trends. For example, temperature trends call for increases of 0.75°C per century for the period 1950–1975, 1.55°C per century for 1975–2000 and 2.35°C per century after 2000. These trends were applied to historical data on observed temperatures to project future climate. This information was then fed into a hydrological model to produce corrected flow series.[2] Watersheds with large shares of glacial inflow showed the strongest responses to increased temperature. For the Karahnjukar watershed—75% covered by glacier—the corrected flow series shows an increase of about 10% compared to the last 50 years of records (See figure CS2.1).

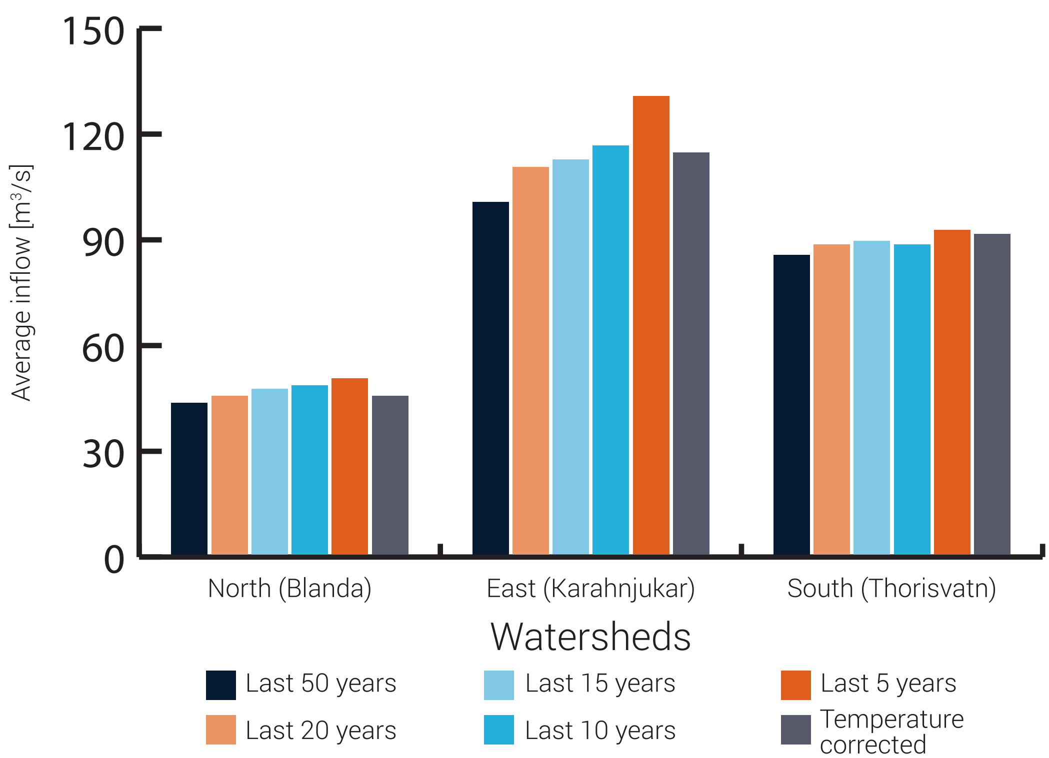

Figure CS2.1 In 2005, when historical flows were being analyzed, an upward trend became clear. The average flow reduced for all watersheds when the averaging window was extended further back. The average flow for temperature-corrected series (grey) was in all cases higher than the historical mean (black), especially for watersheds with considerable glacial-flow contribution.

LANDSVIRKJUN TAKING THE LEAD

Following the collaboration with Norden, Landsvirkjun went beyond analyzing the impacts of climate change based on corrected flows and incorporated the data into its reservoir-management strategies. Managing reservoirs to maximize hydro capacity while balancing environmental and social considerations is a complex undertaking. As a first step, Landsvirkjun decided to use only the 20 most recent years of river flows to manage reservoirs. By doing this, their production capacity jumped from 12.4 to 13.1 TWh/yr, as shown in figure CS2.2. (blue line Meas to blue line Meas20). The second step was to use the 20 most recent years of river flows and join them end to end with selected corrected flow series. The last step—and the approach they use today—is to consider only corrected flow series and to update the series every five years to reflect current climate conditions.

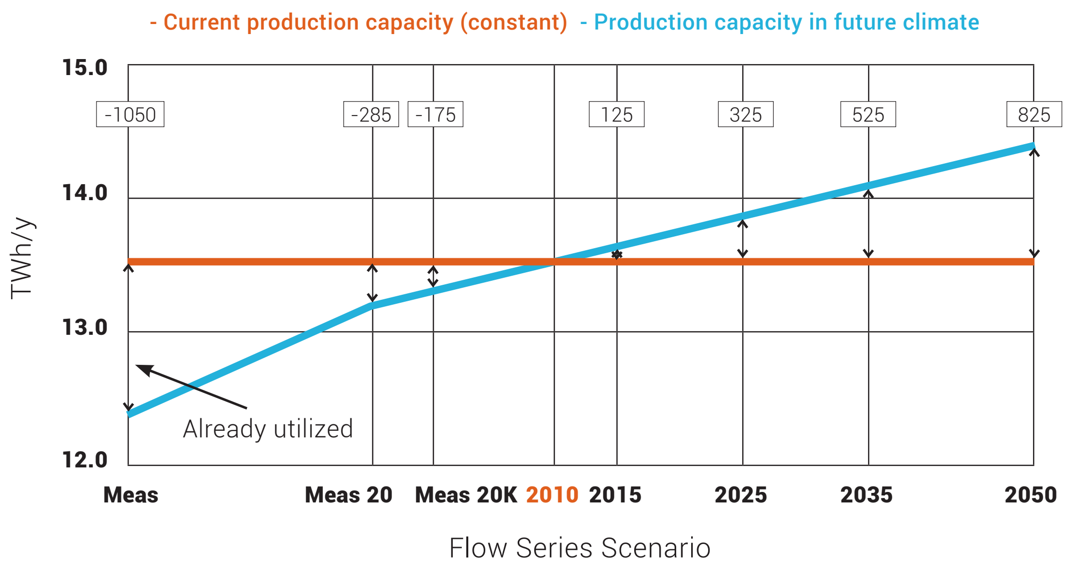

Figure CS2.2 Production capacity of Landsvirkjun for the 2010 series (orange line) and potential production capacity in a warming climate (blue line). Meas considers 50 years worth of data of river flows; Meas20 includes the 20 most recent years of data; Meas20K combines Meas20 with corrected river flows; and 2010, 2015, 2025, etc., represent corrected river flows for specific years. Numbers in boxes show the differences between production capacity of the flow scenario and the 2010 flow scenario (GWh) .

As the inflow increases with warming climate, modification of reservoir-management plans will not be enough to take full advantage of increased river flows and higher proportions of the flows will go over the spillway, because the capacity of assets will be exceeded. The runoff increase between the historical records and the 2050 flow scenario is 3.9 TWh/yr, but at the same time, the system can only cope with a 1.9 TWh/yr increase in production capacity, as shown on figure CS2.2 (1050 GWh+825 GWh). Therefore, Landsvirkjun has also adjusted the designs of planned new assets to take advantage of increased flows. "We use the flows that we expect in the future, 15 years or 20 years from now, to design the capacity of new power plants" [1] explains M. Sveinsson.

"The proposed expansion of Bùrfell power plant is a good example. At first, it didn't seem economically feasible to add 70 MW of capacity. But taking into account the corrected flows for 2025, the project is economically feasible and we increased the capacity of the turbine from 70MW to 100MW" [1] (see figure CS2.3 and CS2.4). At another proposed project, Hvammur, the original plan called for a capacity of 83MW. To accommodate the expected increased flows, the new plan is to increase the capacity to 95MW. Landsvirkjun evaluates that once those projects are complete, the company will be able to increase its sales of electricity by 8%.

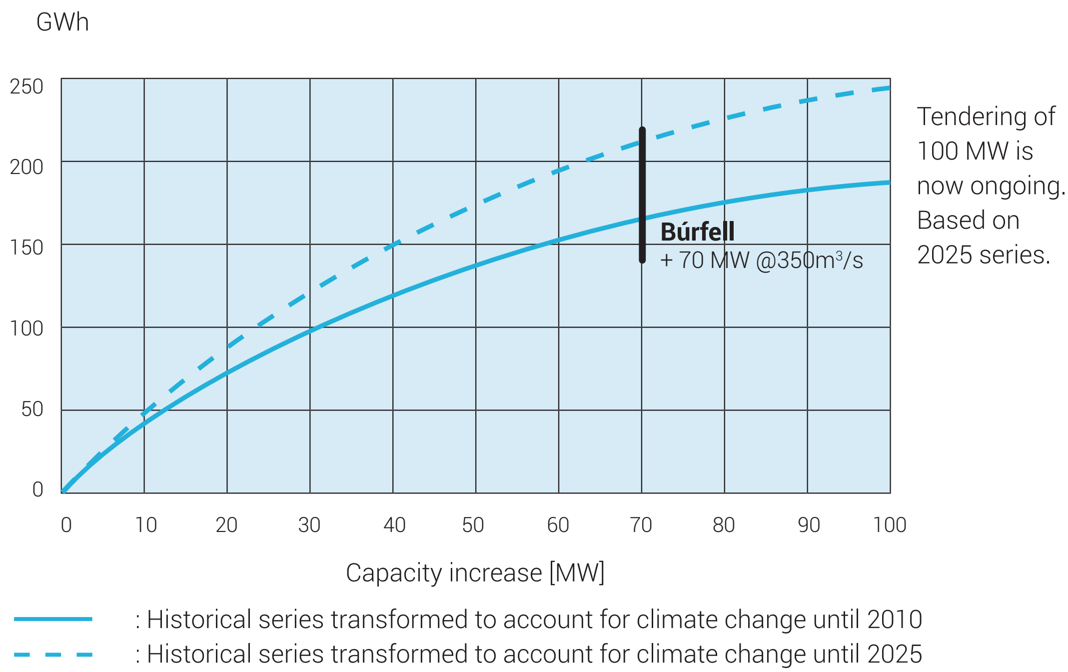

Figure CS2.3 Potential annual generation increase at Búrfell power plant when using corrected flows of 2025 instead of 2010 flows

And what will happen when there are no more glaciers? "We expect the total amount of rain will remain about the same" [1] explains Úlfar Linnet, Landsvirkjun's Director of Resources. "The system is not going to dry out, but the flows into the reservoirs will be more steady throughout the year, instead of coming mostly during from glacial melt during the summer months," [1] adds Óli Sveinsson. "By 2030, we expect the flows to reach a plateau, then not change much between 2030 and 2080. By 2080, the volume of the glaciers will have decreased so much that the flows will start reducing. [1] At that time, the system and the market will both be completely different." [1] This long-term phenomenon has little impact on current project, because investment decisions are based on projections of only 50 years.

Figure CS2.4 Graphic modelling of the projected underground expansion of 100 MW at Búrfell generating station. The left side of the picture shows the old Búrfell generating station and the right side shows a computer drawing of the projected discharge channel of the underground generating station.

LESSONS LEARNED

When they began to work on incorporating data about climate change, glacial melting and hydro generation, Sveinsson and Linnet say they faced a lot of scepticism. As early adopters, they now have much to share to help others in their climate change adaptation journeys.

Úlfar Linnet explains that convincing sceptics can be difficult if they cannot see clear trends in the observed data. "For us it was maybe easier, because we have these measurements that really show different characteristics in flow, as well as glacier measurements that show long-term shrinkage during the past two decades." [1]

Ultimately, though, the scepticism had a positive effect: "it forced us to answer many tricky questions and improved the quality of our work." [1]

According to Óli Grétar Blöndal Sveinsson, following a careful step-by-step approach was key to the project's success. "Back in 2006, a decision was made to omit the oldest years of the historical records and use only the 20 most recent years. As a result, some of the natural variability inherent in the record was lost, but it enabled us to move on to the next step: joining 20 years of historical records end to end with corrected flows series. Finally, we began to use only corrected flow series in the year 2010." [1]

Another key to success was collaborating with other groups. "Working as part of a big Scandinavian group with many power companies, universities and other institutions, gave the project credibility and significance," [1] says Linnet, and Sveinsson adds: "it would have been impossible at the time to sell the idea without participating in the international collaboration. The climate scenarios were selected jointly by all of those institutions, for the region as a whole." [1] Sharing the workload also facilitated the project.

Landsvirkjun bases its estimate of future changes on both IPCC scenarios and specific results for Iceland, revising them every five years.

Analysis has shown that the distribution of inflow for the last 10 years is significantly different from historical flows and follows the corrected flow series. Given the uncertainty in climate forecasts, Landsvirkjun maintains alternate plans that can be implemented should the selected scenario prove to be inaccurate. There has been much less uncertainty about the economic benefits for Landsvirkjun. "This is how you sell the idea," says Óli Sveinsson, "let the people feel it in their pockets." [1]

Today, there is a good consensus within the company that it is on the right track, largely thanks to the commitment of Óli Sveinsson and Úlfar Linnet.

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[1] Sveinsson, O. & Linnet, U. Personal Communication. (2015).
[2] Nordic Co-operation. Climate Change and Energy Systems : Impacts, Risks, adaptation in the Nordic and Baltic countries. (Nordic Council of Ministers, 2012). at < http://norden.diva-portal.org/smash/get/diva2:707411/FULLTEXT01.pdf >

AT A GLANCE

KEY TAKEAWAYS

1. **People are more receptive to a step-by-step approach to climate change adaptation.**

2. **Collaboration with other power companies, universities and other institutions facilitates and boosts the credibility of adaptation efforts.**

3. **Having an alternative plan is a good way to cope with the inherent uncertainty of greenhouse gas emission scenarios.**

ORGANIZATION(S)
Landsvirkjun (Iceland)

POWER SUB-SECTOR(S)
Water endowment and hydroelectricity

ADAPTATION TYPE(S)
- Physical – New generation, carrying and transformation capacity
- Management – Design and operation standards, guidelines, tools and maintenance schedules

CLIMATE CHANGE IMPACT(S)
- Increased rate of glacier melt
- Changing availability of water resources

ADAPTATION COSTS
- The cost of investing in research projects as part of a Scandinavian collaborative is moderate.
- The cost of modifying the reservoir management plans is moderate.
- The cost of modifying the design of planned assets is high.

ADAPTATION BENEFIT(S)
- Increased generating capacity

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FULL REPORT
https://ouranos.ca/en/programs/energy-adaptation-case-studies/

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