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POLICYBRIEF

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ENERGY IN ICELAND: ADAPTATION TO CLIMATE CHANGE

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HIGHLIGHTS

Even in the era of climate change, Iceland is a pioneer in the use of natural resources for the production of renewable energy. Iceland is already 100% renewable in both heat and power with geothermal energy being the primary energy source for space heating and hydropower being the primary energy source for electricity generation. Primary energy use in Iceland of 85% is from domestic renewable sources, with the remaining 15% mainly due to the transport sector and shipping fleet. Iceland indeed has done and is applying modifications for present and future hydropower assets to cope with and take advantage of climate change.

Iceland demonstrates that a 100% renewable electricity system is possible and not only for small isolated systems or for a minimal level of access to electricity. Renewables can and do supply sufficient electricity for industry and economic growth of a country.

THE CHALLENGE

In Iceland, the biggest hydroelectric power stations are fed by glacial rivers. Over the last decades, increased flows and changes in the seasonal distribution of river flows have been observed. Further increases in flows are expected from melting glaciers due to global warming.

A peculiarity of the Icelandic power system is the non-interconnections to other grids. In this regard, if the climate continues warming with corresponding increases in glacial runoff volumes, then not accounting for climate change may lead to wrong investment decisions regarding the operation and expansion of the power system.

On the other hand, if adaptation measures are to be taken, multiple questions should be first addressed:

- What temperature increases should you anticipate?
- For operational rules for your power system how should you adjust your existing historical inflow series?
- For prospective investments how far should you look into the future to make sure that your investment is climate resilient with respect to climate?
- What is the risk if you overestimate or underestimate future flows?

ADAPTATION OF ENERGY PRODUCTION TO WARMING CLIMATE

Climate change is a reality that the world has to face. The historical global temperature trend over the period 1880–2012 has been at 0.85 ˚C and is estimated to increase by between 0.3–4.8 ˚C at the end of the century (IPCC, 2014). The change in climate due to anthropogenic impacts affects distributional properties of climate processes and calls for sophisticated risk analyses to evaluate climate change in both the near and far future (IPCC, 2012). The rise of global temperature is also accelerating the melting of glaciers around the world, implying that the operational regime for hydroelectric stations fed by glacial water should be under continuous review. In watersheds fed by large glaciers, the impact of climate change is expected to accelerate the process of ice melting and increase flow rates of many rivers. On the other hand, in watersheds fed by glaciers that have already lost the majority of their mass, the flow rates may decrease. Additionally, the decreased glacial pressure causes the elevation of the surrounding land, potentially altering coast lines and having serious effects on sea erosion.

In future scenarios, the projected changes in precipitation and temperatures will have diverse implications for hydroelectric generation since some regions will get wetter while others drier. Along with water availability, the regional demand for electricity is also likely to vary due to climate change, with potentially lower heating demand during winter but higher cooling demand during summer.

In some cases, careful management strategies make existing hydro-resources climate resilient. In other cases, even with thoughtful management, it will not be enough to cope with the climate changes. In these cases, assets modifications are needed.

A common asset modification need is increasing storage capacity of the reservoir and/or increasing installed turbine capacity to handle larger volumes of water.

ICELAND AS A CASE STUDY

Landsvirkjun, the National Power Company of Iceland, is one of the few companies around the world that have justified modifications to management strategies and design specifications for present and future hydropower assets. To achieve that, Landsvirkjun together with other companies, institutions and scientists from the Nordic region has in the last 15 years been studying climate change effects on river flows. Landsvirkjun has focussed the efforts on the evaluation of the impact of climate change on renewable hydropower generation (Sveinsson et al., 2008 and 2012; Ouranos, 2016). Climate change projections for temperature precipitation and its impacts on glacial melt were generated and the study has shown that since 1950 both the volume and seasonal distribution of flows changed mainly because of glacial melt (Fenger, 2007; Johannesson et al., 2007; Thorsteinsson and Bjornsson, 2012).

Convincing the Landsvirkjun executives to take the first steps towards adaptation to climate change impacts was a step-by-step process; surely being a part of a larger Nordic study did help to eventually get to where we are today. In 2006 Landsvirkjun started using only the latest 20 years of historical records instead of the time series records dating back to 1950. The argument for the change was that climate change impacts were already being perceived in Iceland and that the cold period of the years 1965–1971 was unlikely to repeat.

In 2010 Landsvirkjun took the full step of using climate adjusted historical records to reflect current and future climate conditions. Combining the estimates of historical temperature and precipitation trends with the projected future climate trends and future shape of Icelandic glaciers, Landsvirkjun created different sets of flow scenarios for 2010 and for the future periods 2015, 2025, 2035 and 2050.

In detail, the flow scenarios were created using calibrated rainfall-runoff models for historical records, both observed and from regional models. The historical temperature and precipitation records were corrected using seasonal climate trends to create climate representative of each of the period to be analysed. The generated record length of each period has the same length as the historical record, where the observed natural variability has been corrected using current climate or future climate. Every five years these flow scenarios are updated using latest hydrological models and climate scenarios.

MODEL SCENARIOS OUTPUT

Looking at the 2010 scenarios created back in 2010 for operational use. This flow scenario incorporated climate changes that were considered to have already occurred and used the current size of Iceland glaciers. Not only did the flow rate of certain glacial rivers increase, but also the seasonal distribution was significantly altered with spring floods arriving earlier and the glacial melting season being extended later into the fall and more frequent winter melting events. The current power system was able to utilise 85% of the increased flow, increasing the annual generating capacity by 8% through the modification of reservoir management strategies.

Looking at the future scenarios by 2050, the volume of inflow will increase by an additional 15% with respect to 2010. The existing power system can only utilise 30% of that increase and the rest is expected to be spilled over the spillways. This is because the existing power system is already seeing higher utilisation than expected by design after adopting the 2010 scenario. To increase the utilisation of increased flows the installed capacity of the existing systems will need to be increased and reservoir storage will also need to be increased to accommodate higher flow rates.

Looking at the future scenarios by 2080, the glaciers in Iceland will have reduced so much in size that the flows will start decreasing. By 2200 we expect that the glaciers have disappeared. With the glaciers gone the annual volume of flows is likely to be similar to what it was around 1990 when the glaciers were in equilibrium, since the expected increase in precipitation with the future climate is expected to be largely offset by a similar increase in evaporation. On the other hand the seasonal distribution of flows will be markedly different, characterised by precipitation induced flow events throughout the year instead of summer dominated glacial melting season. This altered seasonal flow cycle should make better use of storage facilities with reduced spill volumes.

LESSONS LEARNED

The issue of climate change is today a matter of great importance to Landsvirkjun and research on climate change is now an intrinsic part of Landsvirkjun's operations. However, to get to where Landsvirkjun is today, it took time. A step-by-step approach was necessary to get a full buy-in at Landsvirkjun and reach the level of awareness that we have today. The results have been used to give valuable information for decisions makers on future investments in Iceland. Moreover, adaptation measures have been currently undertaken at Landsvirkjun, namely:

- Present and future flow scenarios have to be created by correcting historical climate series with expected future climate trends.
- For current day operation the optimisation of reservoir management strategies make use of time series applicable to today's climate.
- The design of future power projects, including refurbishments and capacity increases, accommodates the expected increased flow rates 15–20 years into the future. In addition the design takes into account that capacity may have to be increased further in the future to increase climate resilience of the power projects.
- Landsvirkjun has adopted an action plan to reduce emissions from its operation and to become a carbon neutral company.

Today in Iceland, 77% of all generated electricity goes to power intensive industries. This makes Iceland the largest generator of electricity in the world per capita, even though more than 90% of space heating in Iceland makes use of geothermal resources directly.

Since the electricity in Iceland is 100% renewable, it can be argued that Iceland is mitigating greenhouse gas emissions for the same number of industries generating electricity with thermal sources placed elsewhere outside Iceland.

Feasibility of interconnections with Great Britain is currently being explored. This would aim at further increasing the efficiency of the Icelandic power system and also towards shared storage capabilities and supply security with Great Britain, thus mitigating some greenhouse gas emissions from thermal sources in Great Britain.

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POLICY RECOMMENDATIONS

- Climate change is already happening and the past climate is not necessarily a good measure of future climate. Climate dependent Infrastructure needs to use updated corrected climate information to reduce its vulnerability to climate change.
- Climate change mitigation and adaptation have to go hand in hand. Through combined effort, where dependence on fossil fuel is reduced, some of the expected climate change impact may be mitigated. Adaptation should be aimed at making infrastructure resilient to climate change and increased natural variability.
- Hydropower is the largest renewable electricity source today, in addition to being extremely flexible for balancing of complex power systems. Hydropower with reservoir storage can act as a battery storing energy, while at the same time providing flood control and water storage for municipal and irrigation use.

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