CASE STUDY SERIES

EXTREME WEATHER

Drought | Iceland | October 2013 to March 2014

This case study is part of an extreme weather impact project, in partnership with Swiss RE Corporate Solutions and Marsh & McLennan Companies, which aims to identify and share best practice within the energy sector to enable a more agile and adaptive response to extreme weather and natural hazard impacts on energy systems and supplies. The below case study has been executed by the World Energy Council FEL Taskforce: Ivar Baldvinsson, Andres Lloret, Pedro Ferreira, Rodrigo Alonso-Suárez.

CASE STUDY AT GLANCE

WEATHER EVENT
Drought, low reservoir inflow

ORGANISATION
Landsvirkjun, National Power Company of Iceland

INDUSTRY SUB-SECTOR
Utility Company

RESILIENCE RESPONSE
Documented Action Plan and Improved Communication with Costumers

RESILIENCE COSTS
Loss of revenue (millions of USD)

RESILIENCE BENEFITS
Increased load flexibility to withstand future extreme weather events/Improved warning system to provide notices to customers

In the winter of late 2013 and early 2014, key seasonal storage reservoirs of the Icelandic hydropower system suffered critically low water levels. The reservoir levels at the start of the new water cycle in October 2013 (when reservoirs are at their fullest) were low due to a dry summer, with only 73% of stored capacity in the south-west of Iceland and 87% for the whole country. This was followed by one of the driest winters on record in the South and West Regions. In the 53 years on record, the South West catchment area experienced the lowest 5 percentile of rainfall and in the North West among the lowest 10 percentile. Delay in the construction of a new hydro power plant and overestimation of reservoir capacity worsened the impact of the event. Being an isolated insular system with only minor dispatchable thermal backup power and heavily relying on seasonal hydro storage, the company resorts to flexibility clauses in energy sales contracts to deal with droughts and low reservoir inflows. In the face of this event, Landsvirkjun curtailed energy sales to energy intensive customers of around 300 GWh over 3 months which led to loss of revenue in millions of USD. Industries such as aluminum and alloy smelters were the most affected, whereas domestic and commercial sectors suffered little to no impact. The company had not experienced such an extreme event since the deregulation of the energy market in 2003, thus the curtailment procedures were not readily available resulting in a delay in decision making. The 2013-2014 droughts made the company better prepared to face future events and actions have been taken to reduce the risk of being heavily impacted by them. Actions points included: (i) design of procedure policy against energy scarcity with enhanced communication, (ii) focus on demand side flexibility and (iii) improving the use of energy models with climate-adjusted inflow forecast and multiple scenario generation.

CONTEXT

ORGANISATIONAL PROFILE: Landsvirkjun

- Iceland has an isolated electric power system dominated by hydropower (70%), followed by base-load geothermal power (30%).
- State-owned Landsvirkjun is responsible for 75% of the national electricity production and possesses 95% of the national hydro capacity.
- About 80% of electricity generated by Landsvirkjun is sold to energy intensive industries.

Icelandic hydro-reservoir system

Landsvirkjun owns and operates 14 hydropower stations distributed between 5 separate watersheds with 3 of them accounting for 95% of the runoff energy. The largest share of runoff energy is in South West Iceland (47%) followed by 41% in the East Iceland and 7% in North West. The South West Iceland watershed also holds the largest electric power capacity. Winter inflow in 2013/2014 was close to record low, resulting in critically low levels of hydro storage reservoirs.

The Icelandic electric generation system is therefore highly sensitive to the water budget in South West Iceland. Roughly half of the hydro reservoirs' inflow comes from glacier and snow melt, making the reservoir system just as prone to temperature anomalies as to droughts.

ENERGY IMPACTS

Winter inflow in 2013/2014 close to record low, resulting in critically low levels of hydro storage reservoirs.

Power supply was reduced mostly to energy intensive industries. District heating and fisheries were also affected.

Approximately 300 GWh were cut from industries resulting in a proportional loss of sales.

RESILIENCE: PREVENTION AND IMMEDIATE RESPONSE

In early October 2013, Landsvirkjun was aware that the situation in the seasonal storage reservoirs was considered just about fair and required close observation in the coming weeks and months. The total stored energy in the reservoirs at the beginning of the new water cycle (October) was only 87% of the reservoirs´ total storage capacity. The situation in South West Iceland was especially bad with stored energy only about 73% of its capacity. Despite rather dire initial conditions of hydro reservoirs and considerable uncertainty in future inflows, electricity generation planning of the new water cycle (for the upcoming 12 months) showed a decent outlook for storage levels of the reservoirs, based on a stochastic probability analysis of the system.

Following one of the driest Octobers on record in South and South West Iceland, the outlook for the new water cycle had worsened. The CEO and the executive board were informed of the situation and possible prevention efforts to avoid heading into an energy scarcity scenario were considered. One alternative was to attempt to speed up the commissioning of a new 95 MW hydro power station located in the South of Iceland using the same run-off water in cascade with 2 other stations. The possibility of decreasing energy sales was also considered. In November, customers were informed about the state of the system and potential curtailment in the coming months. Regardless of these efforts, generation did not start until February 2014.

Given the lack of backup energy options, Landsvirkjun has implemented measures to protect itself against low reservoir inflow and low storage level events, by including flexibility clauses in long term contracts with certain customers. This flexibility is constructed to mitigate against worst case inflow scenarios and is explained in detail to customers during contract negotiations.

By mid-December, it was highly likely that Landsvirkjun might not have enough energy stored to uphold all energy sales commitments to their full capacity until summer. Customers with secondary energy contracts were informed mid-January that electricity sales would be curtailed from mid-February of 200-300 GWh in total. This would later be further increased by 100 GWh as it was identified that the storage capacity of one of the reservoirs was overestimated due to newly formed sand dunes in the outlet canal. This applied mainly to heavy industries but also district heating companies and fisheries.

With spring melt and warmer weather, reservoirs began to recover, and by the end of April, active restrictions were reduced to half. Restrictions of energy supply were fully revoked after the first week of May when the situation became stable and the outlook of reservoir levels in early fall were considered sufficient. It took time however for some customers like aluminum smelters to reach full production capacity again.

BARRIERS

- Lack of experience in dealing with drought situations within the company
- Lack of established and documented action plans
- Curtailment procedures not readily available
- Long-term uncertainty in forecasted inflow
- No dispatchable backup power infrastructure

ENABLERS

- Review of curtailment and communication procedures
- Improved optimisation methods for reservoir management strategies
- Improvement in forecast and production planning methods with more comprehensive scenario analysis
- Enhancement of communication strategies with customers and public engagement

> Magnus Sigurdsson, Hydropower Operations Engineer
>
> **Resiliency in the electric industry would be on the load side, with that the resiliency is introduced at a lower cost, a lower cost alternative. You might say you invest less but you invest smarter.**

LESSONS LEARNT FOR DYNAMIC RESILIENCE

As a result of climate change and unsustainable land management, drought has become one of the most impactful disasters and, according to climate change projections, it is expected to progressively cause more damage until the end of the 21st century[1]. Iceland is already 100% renewable in both heat and power, with hydropower being the primary energy source for electricity generation and geothermal energy, being the primary energy source for space heating. This bold achievement implies that the energy supply is very much linked to the climate, particularly in the medium to long-term perspective, and therefore is prone to be highly impacted by extreme weather phenomena. Considering dynamic resilience to extreme weather events under these perspectives, the following lessons have been learnt:

- √ Flexibility of demand is critical in the operation of the Icelandic power system; increasing the load flexibility capacity in low inflow situations could be a good approach to develop a more resilient supply chain.
- √ Increase in backup power capacity, either through diversification in power plant portfolio or interconnective transmission, would provide key support to a predominant hydro power energy system in times of water shortage.
- √ Better locally-adapted and multi-scenario forecasting tools are required to reduce the uncertainty in the energy availability, and therefore the risk cost.
- √ A close observation and long-term strategy are required to boost the system resilience to changes in hydrological trends and weather patterns.

[1]RMetS, *"Will drought events become more frequent and severe in Europe?"*, 2017