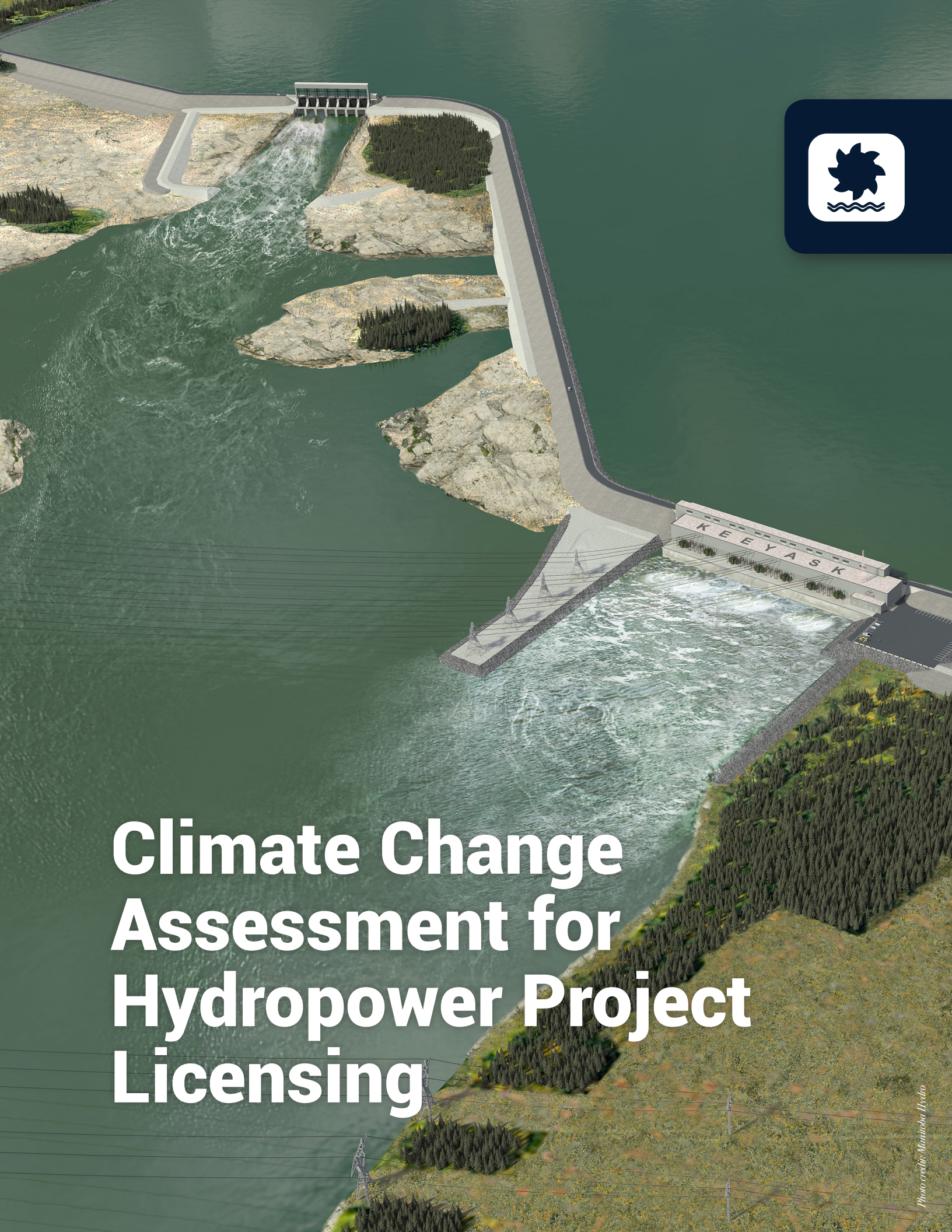

Climate Change Assessment for Hydropower Project Licensing

Photo credit: Manitoba Hydro

Manitoba Hydro is currently building the Keeyask Generating Station in northern Manitoba on the lower Nelson River. During the licensing process, regulators recognized the necessity to ensure that the new facility would operate effectively and efficiently, including in an era when changing climate may affect water resources. The licencing procedures and public hearings addressed this issue in unprecedented detail. Having initiated the study of climate change impacts on its operations more than a decade ago, Manitoba Hydro was well positioned to incorporate climate change impacts into the environmental assessment and into an economic assessment as a sensitivity analysis to evaluate climate change against other risks for the project.

"We learned that climate change is very important to our stakeholders and they want to know that Manitoba Hydro is prepared for it."

Kristina Koenig, Head of Hydrologic and Hydroclimatic Studies, Manitoba Hydro [1]

CONTEXT

Traditionally, large investments in hydropower are based on observations and measurements of the natural environment. Climate and hydrological characteristics are of particular interest in the conceptualization and sizing of equipment built to harness the forces of nature.

To date, most facilities have endured very long periods of relatively consistent climate and hydrological conditions. Research shows that these conditions have started to change in recent years. These changes can increasingly affect the future operation, performance and safety of existing hydropower assets. In addition, the changes indicate that the planning of new installations can no longer rely solely on historical records, as they may no longer be good predictors of future patterns.

In Manitoba, Canada, an average of 98% of all electricity is generated from hydropower. Manitoba Hydro, a Crown corporation based in Winnipeg, manages and maintains hydropower facilities that serve approximately 500,000 electric customers. A large portion of the corporation's generating capacity is located near the outlet of the Nelson-Churchill river system, one of North America's largest watersheds. From the eastern slopes of the Rocky Mountains in southern Alberta, water flows eastward more than 2,000 kilometres to the mouth of the Nelson River on Hudson Bay (see Figure CS4.1).

The watershed dips slightly into the United States and extends into the northern limits of the boreal forest, spanning several climatic zones that influence water availability in the system. Manitoba Hydro has extensive knowledge of the hydrological characteristics of the sub-watersheds that contribute to its network of hydropower generating stations and has a long-term streamflow database (LTFD) that extends back to 1912.

Well aware of its dependency on climate and streamflows, Manitoba Hydro incorporates the assessment of future climate into its business strategy and resource planning. During the last decade, the study of climate change has become an integral part of several environmental and economic assessments.

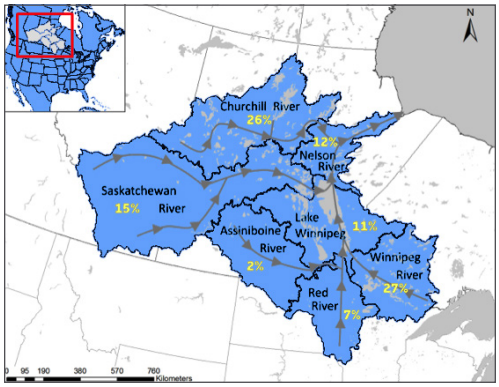

Figure CS4.1 Map of the basins of the Nelson-Churchill watershed (Approximate % flow contributions to total average water supply)

KEEYASK GENERATING STATION PROJECT LICENSING

Like every major public-infrastructure project, the 695 megawatt (MW) Keeyask Generating Station (the Project) on the lower Nelson River[2], went through regulatory approvals and environmental licensing

processes. Unlike similarly large projects from the past, this time the procedure considered a new factor that could affect the environment and economic viability - climate change.

Manitoba Hydro's climate change team—part of its Water Resources Engineering Department—was up to the challenge. The team on behalf of the The Keeyask Hydropower Limited Partnership (KHLP) took an anticipatory approach by addressing climate change in the project's Environmental Impact Statement (EIS) and Needs for and Alternatives to (NFAT) business case[3].

The EIS considered three aspects of climate change: (1) the effect of the environment, including climate, on the Project, (2) the effect of the Project on the environment, including greenhouse gas (GHG) emissions and (3) the sensitivity of the assessment to climate change.

While the first two were requirements of the federal EIS Guidelines, the latter was done by the Partnership as a precautionary approach to assess whether the environmental assessment conclusions would hold for future climate conditions.

This information was presented to the Clean Environment Commission (CEC), which is an arms-length agency of the Government of Manitoba and provides the Minister of Conservation and Water Stewardship with licensing recommendations (see Figure CS4.2).

For the NFAT business case, Manitoba Hydro assessed the needs for its Preferred Development Plan, which included the Keeyask Generating Station, to determine whether or not the Plan is in the best long-term interest of the Province. As part of the business case review, the Province of Manitoba assigned a panel of the Public Utilities Board (PUB) of Manitoba to conduct the review and issue a recommendation to the Minister. Climate change and its possible impacts were discussed as one of the uncertainties in several alternative development plans presented.

To assess the potential impacts of climate change, the company's team of climate-savvy engineers selected five out of 109 Global Climate Model (GCM) simulations to represent future changes in average system inflows through the 2050s—the equivalent of a 35-year planning horizon. The selected projections cover 90% of all the climate simulations' uncertainty and range from a 9.6% reduction in overall inflows to a 28% increase. To integrate this hydrological assessment into an economic-feasibility analysis, the change signals from the five simulations

Figure CS4.2 Keeyask Clean Environment Commission Hearing at the Fort Gary Hotel in Winnipeg, Manitoba (October 21, 2013).

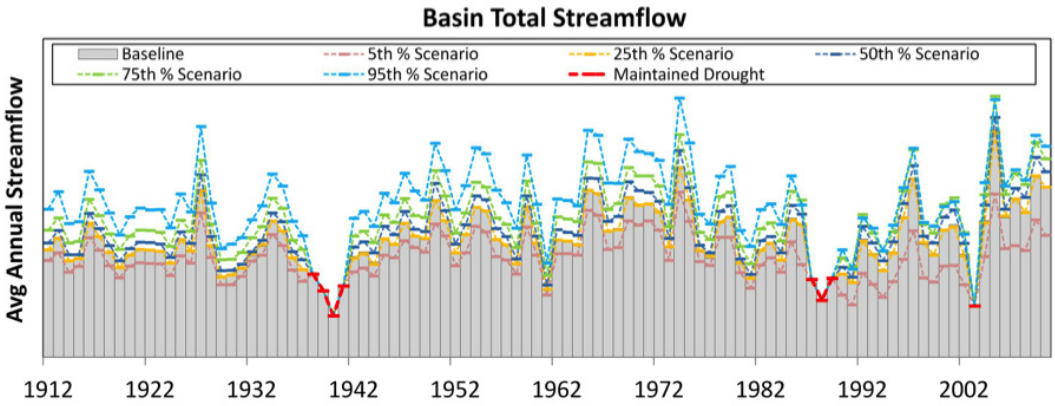

Figure CS4.3 Observed long-term flow data and their perturbations using five climate change scenarios. These scenarios were used to drive the Simulation Program for Long-Term Analysis of System Hydraulics to assess revenues as a function of climate change impacts.

were added to the observed long-term stream-flow database record (see Figure CS4.3).

The resulting five future stream flow scenarios were then fed into the Simulation Program for Long-term Analysis of System Hydraulics (SPLASH) to estimate average annual revenues. As Manitoba Hydro's existing system consists of predominantly hydro-based generation, the assessed development plans showed sensitivity to changes in inflows. The preferred plan - which included Keeyask - showed the highest potential for increases in both incremental average revenues and incremental net present value. With 70% of the initial 109 climate model projections showing increased inflows, the analysis attributed a higher likelihood of increased revenues to the plan which included Keeyask.

To address the complex question of the future risk of drought, the worst drought periods were held constant in the historic record, while mean annual inflows were modified using the climate model simulations. This addressed the fact that current research remains undecided concerning confident statements about the future evolution of drought risk. During the review process, Manitoba Hydro indicated that it was able to deal with the largest drought of record and would further increase its resilience for any future potential droughts by developing generation and transmission capacity for energy imports so that a drought more severe than the ones on record could be withstood.

During PUB hearings, external expert reviewers scrutinized the company's analysis. Concerns included that the resolution of the climate models used was inadequate and that the company's analysis focused exclusively on mean annual runoff and did not address changes to the seasonal cycle and in the severity of drought. However, the rebuttal of the criticism presented little difficulty as it addressed issues that Manitoba Hydro's climate change team had considered extensively in their studies, for example, the fact that the runoff variable they used integrates changes in precipitation, evapotranspiration, radiation and wind.

Manitoba Hydro also took advantage of its membership in the Ouranos consortium which supported the utility's case with written and oral evidence from scientists dedicated to regional climate change and adaptation to climate change.

"Our affiliated membership with Ouranos enhanced our ability to address regulator concerns and added credibility,"[1] said Michael Vieira, professional engineer, Manitoba Hydro's Water Resources Engineering Department.

BECOMING AWARE OF CLIMATE CHANGE EARLY

According to Kristina Koenig, head of Manitoba Hydro's Hydrologic and Hydroclimatic Studies, Manitoba Hydro's interest in climate change started more than two decades ago in the planning process for the proposed future Conawapa Generating Station on the lower Nelson River, when engineers first started to notice small changes in the watershed and questioned what the future climate and streamflows would look like in Northern Manitoba.

Work on the Conawapa project of the 1990s later ceased, but interest in quantifying climate change impacts and vulnerabilities resurfaced in the mid-2000s, when Manitoba Hydro began to plan and construct the Wuskwatim Generating Station on the Burntwood River in Northern Manitoba.

Future drought risk was one of the drivers behind that interest but public and stakeholder expectations were also growing. "Manitoba Hydro realized that if we wanted to carry out future developments, we would need to become more involved in climate change studies and be able to demonstrate that the infrastructure would be resilient into the future under a changing climate," said Koenig. "Shortly after the regulatory hearings for the licensing of the Wuskwatim Generating Station, the company established the Hydrologic and Hydroclimatic Studies Section that we have today."[1]

Embedded in the Water Resource Department, the section is responsible for providing specialized engineering and expertise across the corporation in the areas of climate change impact studies, hydrology, watershed modelling and inflow forecasting with a focus on environmental studies, resource planning, regulatory review, operations, licensing and technical support during planning, design and construction.

BUILDING A TEAM TO STUDY CLIMATE

Manitoba Hydro chose to develop and strengthen climate-related capacity in-house, eventually assembling a team with the appropriate knowledge and aptitude (see Figure CS4.4). The team started to study the latest science on climate change and what it indicates for its facilities in the Nelson-Churchill watershed. Manitoba Hydro became an affiliated member of Ouranos in 2007 to benefit from a large climate database, participate in joint projects and to tap into the experience of other climate experts.

The company conducted several studies that established important knowledge about historic climate normals and trends, and developed

future climate scenarios for numerous project sites, as well as for the individual sub-basins of the Nelson-Churchill watershed. The studies informed long-term planning and operations, and enabled the company to start to plan for future adaption for infrastructure and business practices as required[4].

Many of Manitoba Hydro's major capital projects involve regulatory review processes. Although these processes may not explicitly require assessments of climate change impacts, a precautionary approach suggests that they should be completed. As a result, the team prepared reports on the past and projected climate conditions at the sites of new or modified infrastructure. These reports supported the company's case for climate resilience during environmental review and licensing process for projects such as the Pointe du Bois spillway replacement, the Bipole III transmission line, Lake Winnipeg Regulation and the planned Manitoba-Minnesota Transmission Project (MMTP).

Figure CS4.4 The Hydrologic and Hydroclimatic Studies Section at Manitoba Hydro (left to right): Phil Slota, Mark Gervais, Kristina Koenig, Michael Vieira, Shane Wruth

Preparations for hearings into Keeyask represented the team's biggest challenge to date and required an increasingly sophisticated understanding of climate change compared to past studies.

LESSONS LEARNED

The company's understanding of its climate dependency has increased substantially over time and eventually this knowledge was required to be incorporated into regulatory processes. There was really no textbook recipe for how to exhaustively incorporate climate change into the environmental assessment, so they had to develop a method that would follow the original approach as close as possible but allow them to add the climate change layer to it.

Close contact with scientists at Ouranos helped the team evolve in a consistent and professional manner, yielding positive effects on the company's business practices. For example, tools that had been developed for climate change studies like physically based watershed models were adapted to also be used in short-term forecasting.

Whenever climate-related questions arise in the company, the in-house team responds, and it

Figure CS4.5 Keeyask Construction Site Photo (June 21, 2015)

drives the company to look further into adaptation to climate change. Consequently, Manitoba Hydro's latest integrated resource plan, a high-level strategic document that outlines the various resource combinations being considered to meet Manitoba's future electricity needs, will explore additional steps to better factor climate change impacts into long-term planning. These include exploring future changes to seasonal water-supply variations, droughts, energy demand and peak demand forecasting.

After considering recommendations from both the CEC and PUB, in 2014 the Province of Manitoba issued a licence to the Keeyask Hydropower Limited Partnership and the project is currently under construction (see figure CS4.5). During the economic assessment, uncertainties due to climate change impacts on streamflow were found to have less impact on the assessment when compared to other uncertainties such as future electricity prices.

The Manitoba Hydro team sees increasing stakeholder interest in climate change topics. "We believe hydroelectric companies looking into new generation may be faced with a lot of the same climate issues and the scrutiny of regulators, stakeholders and interveners in regulatory processes," states Mr. Vieira. Ms. Koenig concludes "We learned very quickly that we have to stay on top of the continually advancing climate sciences and be current in our studies."[1]

Author : Marco Braun, Ouranos | **Collaborators :** Élyse Fournier, Kristina Koenig, Michael Vieira
Copy Editing : Peter McKinnon | **Translation to French :** Lise Malo, La Plume Déliée | **Layout Design :** André Hughes, Pro-Actif
Suggested citation : Ouranos, 2016. Climate Change Assessment for Hydropower Project Licensing. Case Study Presented to Climate Change Impacts and Adaptation Division, Natural Resources Canada, 9p.

[1] Koenig, K. & Vieira, M. Personal Communication (2015)
[2] Keeyask Hydropower Limited Partnership, http://keeyask.com/
[3] NFAT Business Case; http://www.pub.gov.mb.ca/nfat_mbhydro_application.html
[4] Manitoba Hydro Climate Change Report Fiscal Year 2014-2015; https://www.hydro.mb.ca/environment/pdf/climate_change_report_2014_15.pdf

AT A GLANCE

KEYTAKEAWAYS

1. **Public and stakeholder interest in climate resilience is strong and increasing.**

2. **Developing in-house expertise while partnering with climate experts and other businesses is a good practice for highly climate-dependent energy businesses.**

3. **Developing and fully understanding climate change impact studies is a long process.**

ORGANIZATION(S)
Manitoba Hydro (Canada)

POWER SUB-SECTOR(S)
Hydropower generation

ADAPTATION TYPE(S)
- Informational – Climate services
- Management – Regulatory exemptions and contracts
- Management – Re-organization and governance

CLIMATE CHANGE IMPACT(S)
- Long-term changes in basin hydrology

ADAPTATION COSTS
- The cost of developing in-house climate expertise is medium.

ADAPTATION BENEFIT(S)
- Climate-related risks were evaluated to obtain the regulatory approval for a new hydropower generating station.
- Studying climate change improved overall system understanding and fostered the implementation of new tools to analyze climate change and hydrological assessment.
- Climate resilience of the production system increased.

CONTACT DETAILS
Kristina Koenig
kkoenig@hydro.mb.ca

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

OURANOS

Ressources naturelles Canada | Natural Resources Canada
Canada