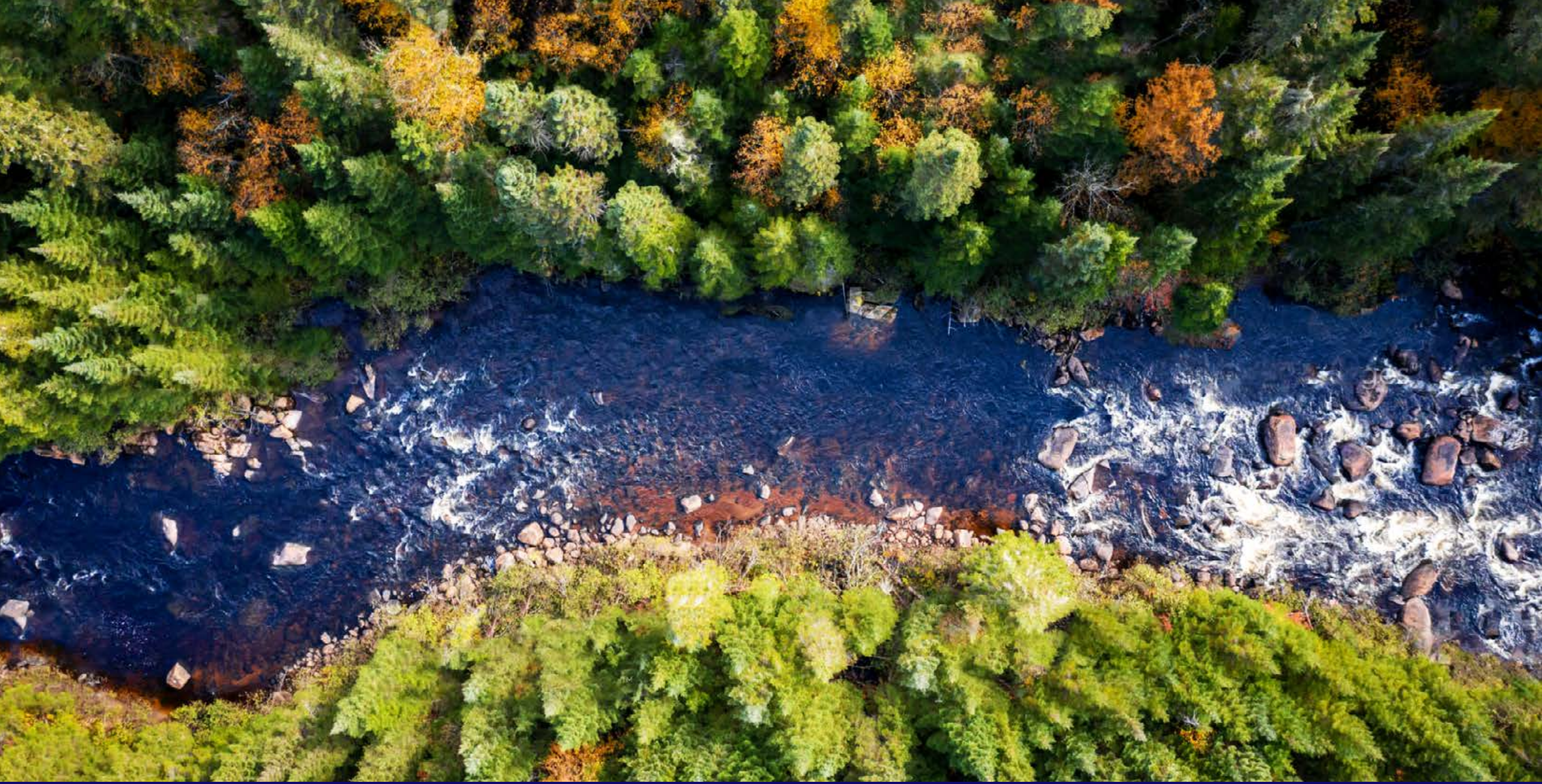

Climate Change Adaptation Plan

2022–2024

Message from the President and Chief Executive Officer

There is no longer any doubt about the reality of climate change. The consensus among the scientific community, including the Intergovernmental Panel on Climate Change (IPCC), is that the impacts of climate change will continue to accelerate. More frequent and intense extreme weather events indicate an urgent need for action, not only to reduce our greenhouse gas (GHG) emissions and limit global warming but also to adapt and build resilience in the face of such change.

Hydro-Québec is working on both these fronts. Integral to our outlook for many years and reiterated in our *Strategic Plan 2022–2026*, Hydro-Québec's corporate objectives—to drive the efficient decarbonization of Québec while achieving carbon neutrality in our own operations by 2030—make this clear. Meeting our target to reduce GHG emissions will also mean adapting our practices. For example, the way we design and manage our systems is evolving to take into account the impact of climate change on their operation.

Taking action to curb global warming while analyzing, anticipating and preparing for the associated risks. That is our strategy to preserve the integrity of our system, to guarantee a reliable supply of electricity for Quebecers and to take a leadership role in stakeholder mobilization.

Hydro-Québec's approach to adapting to climate change is nothing new. It began over 20 years ago with the co-founding of the Ouranos consortium, an innovation cluster for regional climatology and adaptation to climate change that has built an international reputation. Today, this is made concrete with the release of our first *Climate Change Adaptation Plan*. With this plan, we demonstrate our commitment to better understanding the future climate and its potential impacts and to making climate change a key consideration in everything we do.

The plan sets out an approach, a framework and a series of actions to help us move forward. I would like to thank everyone who has contributed to its development. It is a living document that will be updated regularly as the situation and our knowledge evolve.

The challenge is immense! Our *Climate Change Adaptation Plan* is the tool we need to meet it. I am confident that everyone at Hydro-Québec will get behind the plan to make sure it is implemented throughout the organization so we can continue to fulfill our mission for the benefit of the people of Québec.

Sophie Brochu

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Glossary

The following definitions were taken or adapted from those in the IPCC glossary.

Climate change adaptation: A process by which a community seeks to protect itself against the effects of anthropogenic climate change and to respond positively to its consequences through a combination of skills and resources.

Climate change: Observable change in global climate variables that is attributable, directly or indirectly, to human activity, through the emission of greenhouse gases.

Decarbonization: The implementation, in an industry or sector, of measures and techniques with a view to limiting the emission of carbon dioxide and other greenhouse gases. Decarbonization is achieved through a variety of means, including substituting clean energy sources for hydrocarbons, improving the energy efficiency of facilities and processes, or using carbon capture and storage.

Greenhouse gas (GHG): A naturally occurring or man-made gas present in the atmosphere that absorbs infrared radiation and radiates it back to the Earth's surface. Water vapor, carbon dioxide, nitrous oxide, methane and ozone are the main greenhouse gases that contribute to global warming through their increased concentration in the atmosphere.

Climate model: A numerical representation of the climate system that is based on the physical, chemical and biological properties of its components and their interactions and feedback processes.

Climate projection: A projection of the response of the climate system to emissions or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, generally based on climate models. Climate projections differ from climate predictions in that they depend on emission, concentration or radiative forcing scenarios used, which are based on assumptions about factors such as socioeconomic changes and future technological developments. As these assumptions may or may not be borne out, they represent a high degree of uncertainty.

Resilience: The ability of a system, community or society to withstand or adapt to hazardous events to maintain structures and operations at an acceptable level. Resilience refers primarily to the capacity to withstand and recover effectively from hazardous events with minimal damage. In a sense, it is the opposite of vulnerability.

Greenhouse gas (GHG) emissions scenario: A plausible representation of the future development of emissions of potentially radiatively active substances (e.g., greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (such as technological advances and demographic and socioeconomic change) and their main interactions.

Climate simulation: The result of a climate model run for a certain period of time. The duration of a simulation can range from a few years to thousands of years. Simulations may be executed for both the past and the future.

Energy transition: The phasing out of fossil energy sources in favor of various forms of renewable energy. It also refers to behavioral changes seeking to eliminate the overconsumption and waste of energy, and the emergence of a culture of energy efficiency.

Vulnerability: The extent to which a system is sensitive to—or unable to cope with—the adverse effects of climate change, including climate variability and extreme events. Vulnerability depends on the nature, magnitude and rate of climate variation to which the system is exposed, the sensitivity of the system and its adaptive capacity.

Preface

Despite international efforts to reduce greenhouse gas (GHG) emissions, climate change has already started and is set to escalate over the coming decades. As humanity must learn to live with this new reality, climate action takes place on two fronts: first, by reducing GHG emissions to limit the magnitude of the changes and, second, by adapting to climate change to prepare for its consequences.

Hydro-Québec is taking action on both these fronts. The company actively participates in climate change mitigation because its energy production system has one of the lowest carbon emission rates in the world. Hydro-Québec has made its role as a driving force behind decarbonization the first priority in its *Strategic Plan 2022–2026*, and is committed to helping Québec consume more efficiently, encouraging the growth of electric transportation, facilitating the deployment of alternatives to fossil fuels and achieving carbon neutrality in its own operations by 2030. Hydro-Québec must also adapt to the new reality imposed by climate change to continue to fulfill its primary mission of providing reliable and sustainable power across Québec and to its neighboring markets.

To achieve this, Hydro-Québec has undertaken an extensive analysis of its assets and activities and established measures to ensure their resilience. This initial *Climate Change Adaptation Plan* provides a governance framework and a set of concrete steps enabling Hydro-Québec to take coordinated action across its organization and to manage even more effectively the various climate risks it faces in delivering power to its customers.

The past two years have been marked by numerous extreme and unexpected weather events in Québec and around the world. For example, in 2021, British Columbia experienced a heat wave that reached temperatures above what many climate models have projected for the end of this century. In May of the following year, a derecho storm across much of southern Québec and Ontario caused extensive power outages, making it Hydro-Québec's most costly weather event since the 1998 ice storm.

Unfortunately, given that the climate warming we are currently experiencing is the result of GHG emissions from previous decades, there is every reason to believe that such extreme weather events will increase in frequency and intensity in the future as the climate changes further. That is why, as an organization, Hydro-Québec must give itself the flexibility to update its adaptation plan on a regular basis in order to respond proactively to the climate challenge as it evolves.

Outline

PART 1

Entitled *Approach*, the first part of the plan describes the process Hydro-Québec embarked upon to adapt to climate change. It is divided into four sections:

1. The **background** section presents an overview of Hydro-Québec, climate change adaptation governance and the impacts of climate change on the province and company.
2. The **methodology** explains how Hydro-Québec's key climate change risks and action areas were identified.
3. The **spheres of action** describe how Hydro-Québec plans to make climate change considerations integral to its operations.
4. The **next steps** indicate how the plan will be updated and what may be added to the plan to improve it.

PART 2

The second part, entitled *Strategies*, explains Hydro-Québec's 26 action areas for adapting to climate change. It also presents the actions Hydro-Québec has already taken in this regard. This part will be updated regularly to monitor actions that have been undertaken and to adjust the action areas and adaptation measures as required, according to how science and Hydro-Québec's needs evolve.

Objectives

This initial plan reflects Hydro-Québec's commitment to adapt to climate change and focuses on the following four objectives:

1. **Demonstrate** Hydro-Québec's firm commitment to addressing climate risks while taking opportunities to improve its practices by actively participating in the collective effort to strengthen the resilience of Québec society.

2. **Take** proactive steps to increase the resilience of Hydro-Québec's infrastructure, ensure the safety of both its personnel and the public, and provide reliable and sustainable power by limiting power outages.

3. **Inform and educate** the public, as well as Hydro-Québec's personnel and partners, regarding climate change and how to adapt to it.

4. **Work** with Hydro-Québec stakeholders to address common adaptation issues and identify action areas that can be replicated in other contexts.

Part 1: Approach

Background

Hydro-Québec at a glance

Hydro-Québec is a government corporation with a small carbon footprint, best known for producing clean, renewable energy primarily from hydroelectricity. Hydro-Québec's activities also include transporting and distributing electricity, building infrastructure, developing technological innovations and operating its own telecommunications network. Hydro-Québec's approach to climate change adaptation is made more complex by the wide variety of its activities (see Figure 1) and the vast territory it covers (see Map 1).

Figure 1: Hydro-Québec's core business and assets as at December 2021

TRANSMISSION

34,775 km

Transmission lines

GENERATION

37,248 MW

Installed capacity

INFRASTRUCTURE INVESTMENT

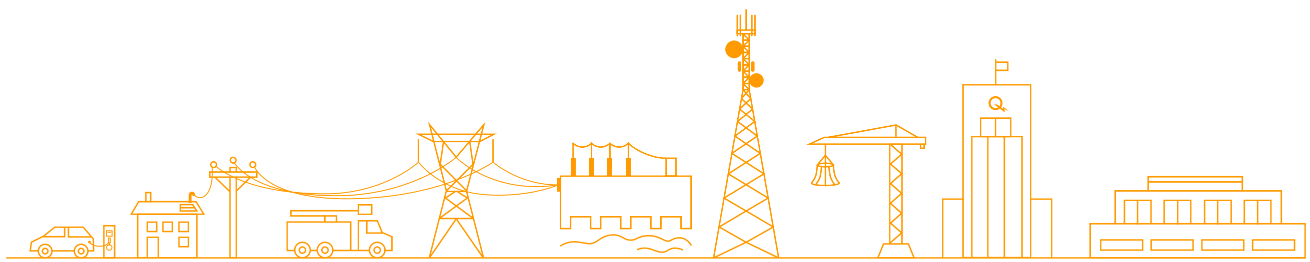
$**3.7** billion

Average investment over five years (2017–2021)

TECHNOLOGICAL INNOVATION

$**173** million

R&D budget allocated to Hydro-Québec's research center in 2021



DISTRIBUTION AND CUSTOMER SERVICES

4,457,800

Customers

INFORMATION AND COMMUNICATIONS TECHNOLOGIES

850,000 km^2

Telecommunications network coverage

CORPORATE AFFAIRS

$**4.9** billion

Contribution to the Québec government's revenue

Map 1: Hydro-Québec facilities across Québec

Off-grid generating stations

- Thermal generating station (diesel)
- Hydroelectric generating station
- Thermal generating station (heavy fuel oil)

Generating stations of 245 MW and over

- Hydroelectric generating station
- Thermal generating station

Other facilities

- 735-kV substation
- 735-kV line
- 735-kV line under construction
- Schematic diagram of neighboring systems
- 450-kV direct current line

HYDRO-QUÉBEC CUSTOMERS

Hydro-Québec's mission is to provide its customers with high-quality service and reliable power by means of energy sources that are both clean and 99% renewable. In 2021, Hydro-Québec supplied a total of 4,457,800 residential and business customers.

POWER DISTRIBUTION

The majority of the distribution system consists of overhead lines supported by wooden poles that crisscross the streets of every town and city in Québec, delivering power to homes, public and commercial buildings, industrial sites and more. Of the 119,345 km of medium-voltage distribution lines, a small proportion are located underground, mostly in urban areas.

POWER TRANSMISSION

High-voltage transmission lines (up to 735 kV) are supported by a network of towers and H-frames that extends across Québec, as the core of production is located far away from major consumption centers. Hydro-Québec operates the largest transmission system in North America, with close to 35,000 km of lines.

POWER GENERATION

Hydro-Québec is one of the largest producers of hydroelectricity in the world, with an installed capacity of over 37,000 MW. It operates some 100 hydroelectric facilities, including 62 generating stations, plus 28 reservoirs and 680 dikes and dams. Since 2021, it has also operated two solar generating stations. Less than 0.4% of Hydro-Québec's output comes from thermal generation, which powers off-grid systems that are too remote to be connected to the main system. Hydro-Québec is currently working on converting several off-grid systems to renewable energy sources.

TELECOMMUNICATIONS NETWORK

Hydro-Québec has its own telecommunications network, which it uses to manage and monitor all its facilities. This network of microwave links, fiber optic cables and telecommunications towers covers 850,000 km^2, or nearly half the area of Québec, and is supported by applications, software, servers, switches, routers and telephone consoles. It also serves the mobile radio communications needs of more than 8,000 people.

INFRASTRUCTURE INVESTMENT

Hydro-Québec's operations require a massive infrastructure portfolio. The company is responsible for designing, building and maintaining multiple assets. While infrastructure investment has averaged $3.7 billion over the past five years, according to Hydro-Québec's *Strategic Plan 2022–2026*, this amount is projected to rise to $5.0 billion over the next five years.

INNOVATION

Hydro-Québec operates its own research center and works on developing a variety of technological innovations such as safe battery materials, energy storage systems, electrical powertrain systems and line maintenance robots. It also has a research team specialized in climate science that works closely with Ouranos, a consortium and innovation hub for regional climatology and adaptation to climate change.

Climate change adaptation governance

Hydro-Québec's interest in climate change adaptation is nothing new. It was sparked by a series of extreme weather events that shocked the province, namely the 1996 Saguenay flood and the 1998 ice storm. These extraordinary natural disasters highlighted Hydro-Québec's vulnerability to climate hazards and prompted it to think more about the impacts of climate change on the frequency and magnitude of such extreme events. To better understand the vulnerability of its assets and activities to these changes, Hydro-Québec co-founded Ouranos with the government of Québec in 2001. Since then, it has been involved in numerous research projects and deepened its knowledge in a range of topics.

More recently, in 2019, Hydro-Québec established a governance structure to guide and prioritize its actions. This framework is designed to ensure that the needs of the different areas of activity in its value chain are fully taken into account, to enable the efficient flow of information across all levels of management and to optimize decision-making.

The members of this governance structure represent different functions within Hydro-Québec (e.g., design, operations, integrated risk management, environment, sustainable development, insurance) throughout its value chain. This has enabled the company to produce its first comprehensive analysis of climate change physical risks and identify the actions needed to mitigate them. The ongoing commitment of all those involved in this vast undertaking is key to the smooth implementation and sustainability of the adaptation process. They will be required to participate in adjusting the action areas as needed, implement the necessary actions and monitor the results. The buy-in and involvement of all members at every stage is crucial.

STAKEHOLDER RELATIONSHIPS

Successful adaptation is impossible without the cooperation of all stakeholders, both internal and external. For this initial adaptation plan, Hydro-Québec has focused on its own assets and activities while continuing to sit on various interministerial committees and fulfilling its role as electricity lead in the Québec government's emergency response plan (restoring power and deploying generators).

Hydro-Québec is already in contact with several municipalities that have also initiated an adaptation process. It seeks to act as a catalyst to help these municipalities, and others in government and civil society, implement their initiatives. Hydro-Québec has already met with a number of stakeholders to present its plan and gather their feedback with a view to making improvements. It intends to continue to do this and to work more closely with its partners, including municipalities, public safety bodies, Indigenous communities and other organizations.

Hydro-Québec also wants to continue working with other major energy companies in Canada. Identifying industry best practices, communicating issues and sharing solutions are key to maintaining a robust adaptation process.

Impacts of climate change on Hydro-Québec

The climate has been significantly changing throughout Québec for some time, with temperatures rising between 1°C and 3°C during the period from 1950 to 2011 (Ouranos, 2015). Changes in weather conditions such as rain, wind and snow have also been observed.

Over the coming decades, the consequences of climate change on major trends in averages and extremes will be variable, and the intensity will vary seasonally. Although all regions will be affected, different areas will experience these impacts in different ways—with the greatest changes felt in northern Québec. This is an important fact to keep in mind as Hydro-Québec's assets and activities are spread across the province, ranging from off-grid systems in the north to major cities in the south, where the majority of its customers are located. Adaptation plan updates will have to take the regional variability in climate hazards into account.

CLIMATE MODELING

Hydro-Québec's adaptation plan includes climate projection maps along with a brief explanation of how they were developed and how to interpret them. For more detailed information, please consult these documents: *A Guidebook on Climate Scenarios* (Ouranos, 2016a) and *Toward adaptation: Synthesis on climate change knowledge in Québec* (Ouranos, 2015; in French only).

Climate models are complex digital tools that project climate change over a certain period of time. Every major climate modeling center in the world has its own model. Using climate simulations based on a range of models is recommended to get results that are as representative as possible. For this reason, it is customary to see a range of results on climate projection maps (10th percentile, median, 90th percentile) representing the range of outcomes simulated by different climate models. It is impossible to choose the "best" climate model or simulation, as each simulation is a plausible representation of the future.

Climate modeling is based on various GHG emission scenarios. These are developed by the Intergovernmental Panel on Climate Change (IPCC) and are the same for all climate models in the world. These scenarios predict the different possible levels of GHG emissions, aerosols and other gases in the atmosphere, taking into account socioeconomic factors such as population change as well as policy decisions related to GHG reduction targets.

Representative Concentration Pathways (RCPs) were used as emission scenarios to develop this climate change adaptation plan. Hydro-Québec's approach is based on best practices in climate science and therefore on the following two scenarios:

- The high emission scenario (RCP 8.5), according to which GHG emissions would continue to increase rapidly over the century
- The moderate emission scenario (RCP 4.5), according to which GHG emissions would decrease to meet certain reduction targets and stabilize by the end of the century

In other words, the climate simulations resulting from the high emission scenario project greater temperature changes than those in the moderate emission scenario. As it is difficult to know exactly how emissions will evolve, it is strongly recommended that two GHG emission scenarios be used for all types of studies.

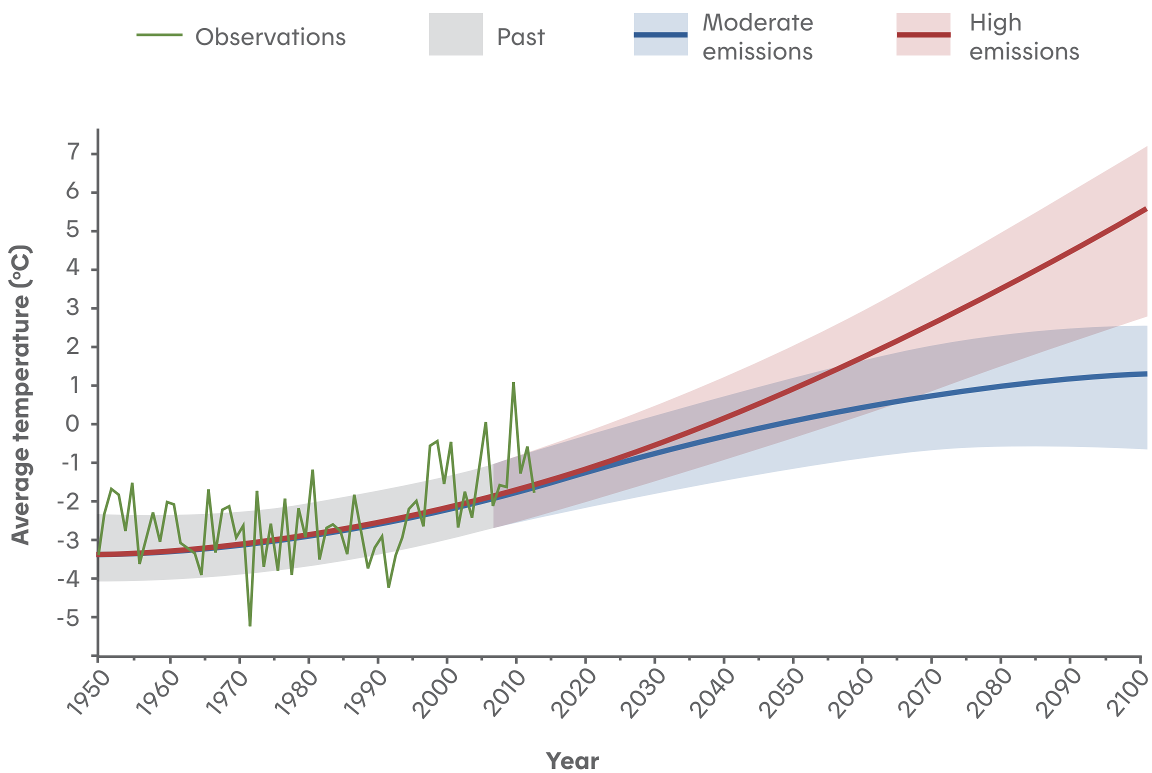
Emission scenarios are updated when new data or methods become available. For example, RCPs will eventually be replaced by SSPs, or Shared Socioeconomic Pathways. In a future update of this plan, the most recent climate simulations dictated by SSPs will be used.

Graph 1 presents the change in annual average temperatures in the province of Québec. As the broken green line illustrates, warmer years have been followed by cooler years. This fluctuation is commonly referred to as *natural climate variability*. As the years go by, however, there is an upward trend in temperatures.

Until approximately 2050, the blue band largely overlaps the red band, indicating little difference between the moderate and high emission scenarios. It is important to understand that the climate change impacts that we are experiencing today are the consequence of GHG emissions generated a few decades ago. **We will therefore have to wait until 2050 to see the impact of our current efforts to reduce GHG emissions. In other words, the actions we take today are what will stabilize the climate toward the end of the century (blue band).**

This graph shows that the need to adapt to climate change is inevitable even with the introduction of significant GHG reduction measures in the near future. It also demonstrates how crucial it is to maintain our efforts to slow the climate crisis.

Graph 1: Annual average temperature in Québec from 1950 to 2100 based on a set of global climate models*



Source: Ouranos (2021a).

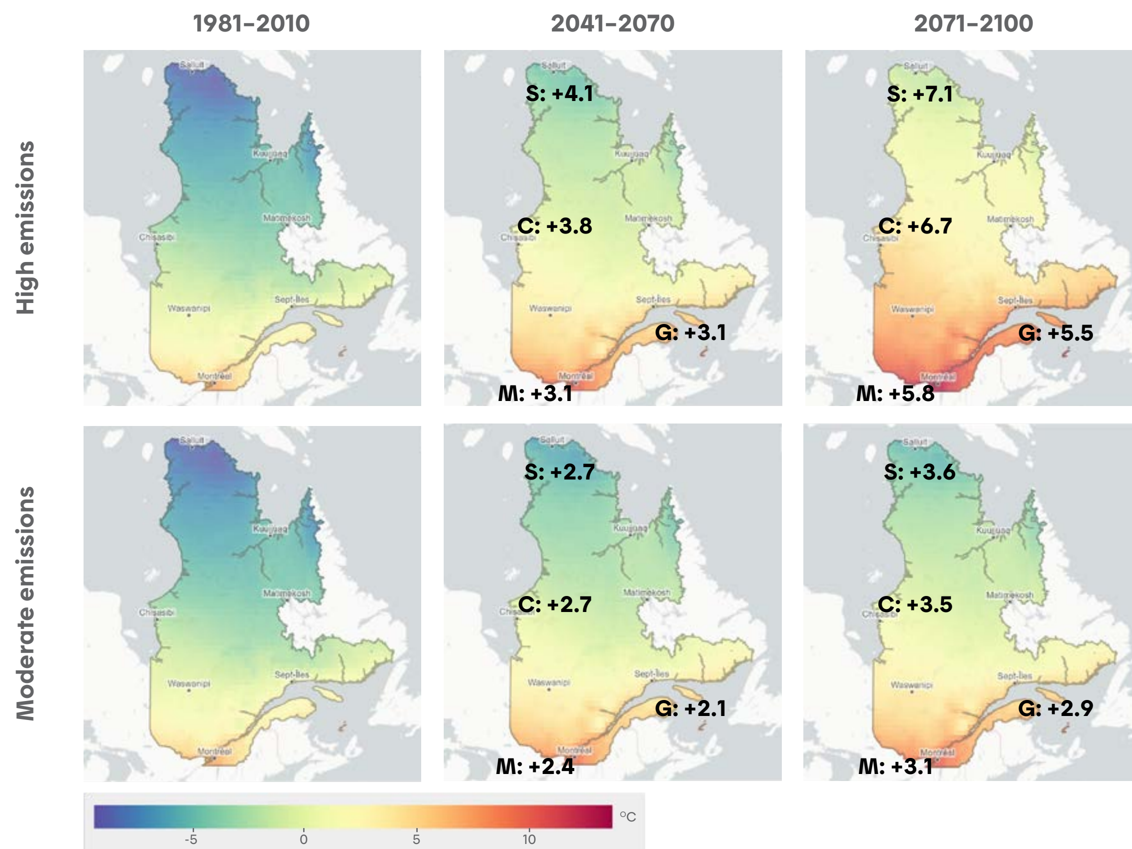
* The bands represent values between the 10th and 90th percentiles of simulations used for past (1951–2005) and future (2006–2100) periods, while the curves represent the medians.

CHANGES IN TEMPERATURE AND PRECIPITATION IN QUÉBEC

Québec's climate is characterized by significant north-south variation in terms of annual average temperature. In other words, the weather is much warmer in the south than in the north. The intensity of climate change is also expected to vary geographically. For example, according to a high GHG emission scenario, the median temperature change by the end of the century would be +7.1°C in the north, in Salluit, but +5.8°C in the south, in Montréal (see Figure 2). These variations are also likely to differ from season to season, with winter temperatures subject to the greatest change: for example, +12.1°C in Salluit versus +6.5°C in Montréal.

Significant changes in temperature extremes, such as heat waves, are also predicted. For example, in the area around Baie James (James Bay), during the baseline period from 1981 to 2010, the temperature very rarely exceeded 30°C—generally just one day per year. According to the high GHG emission scenario, such hot days would become more frequent, with an estimated 15 hot days per year by the end of the century. This would undoubtedly have a significant impact on communities in this region and their infrastructure.

Figure 2: Annual average temperature in Québec (color scale) and increase in temperature (°C) for Montréal (M), Gaspé (G), Chisasibi (C) and Salluit (S), by GHG emission scenario and time horizon*



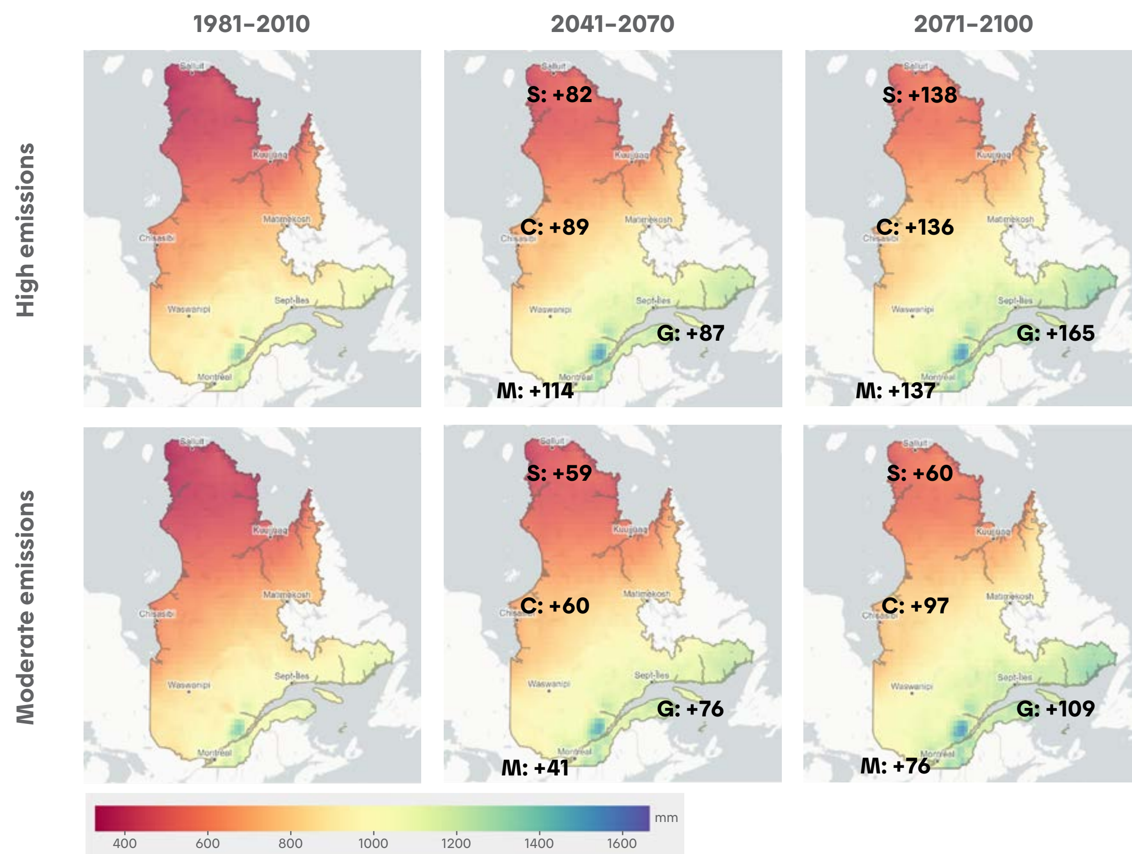
Source: Ouranos (2021a).

* Data representing the median of the model simulations. The temperature increases on the map correspond to the difference between the annual average temperature for the baseline period (1981–2010) and for future periods.

In terms of precipitation, the highest levels tend to be recorded in the St. Lawrence River Valley (see Figure 3). The northern part of the province may receive up to half as much annual precipitation as the south. By the end of the century, the entire province will see an increase in average precipitation.

Climate change will also affect the type of precipitation. Generally speaking, snowfall will decrease in the southern regions of Québec, while the opposite will be true in the north. Certain extreme events, such as maximum five-day precipitation, will tend to increase across the province. Extreme rainfall management could therefore become an issue for several Hydro-Québec facilities.

Figure 3: Annual average precipitation in Québec (color scale) and increase in precipitation (mm) for Montréal (M), Gaspé (G), Chisasibi (C) and Salluit (S), by GHG emission scenario and time horizon*



Source: Ouranos (2021a).

* Data representing the median of the model simulations. The precipitation increases on the map correspond to the difference between the annual average precipitation for the baseline period (1981–2010) and for future periods.

EXAMPLES OF IMPACTS BY REGION

As shown in Figure 4, the climate change impacts likely to affect Hydro-Québec will vary from region to region, even for the same type of asset. For example, an electrical pole could be affected by permafrost degradation in arctic regions, forest fires in central Québec or erosion in coastal areas (see Table 1 on page 31 for more examples of impacts).

Figure 4: Examples of current or future issues faced by Hydro-Québec

ARCTIC QUÉBEC

Rising temperatures and permafrost degradation

- Damage to roads and infrastructure
- Northward migration of the treeline
- Impact on off-grid systems (e.g., subsidence caused by thawing permafrost could force the shutdown of a thermal plant that supplies power to the system)

CENTRAL QUÉBEC

Increase in wildfires and precipitation

- Changes in water management practices due to changes in peak flow regimes
- Damage to infrastructure
- Reduced transmission capacity

COASTAL QUÉBEC

Increase in storms, storm surges and erosion

- Highly vulnerable infrastructure (roads, power lines, buildings)
- Change in wind power potential due to change in average prevailing wind direction

URBAN AND RURAL QUÉBEC

Rising temperatures and extreme precipitation

- Heat stroke among workers
- Increase in floods
- Increased summertime energy demand

Methodology

A two-phase approach

To be able to take action at the right time and in the right place, Hydro-Québec initiated a major analysis to identify the main physical risks it faces in relation to climate change. Hydro-Québec used an analytical method tailored to its specific needs and in compliance with various standards (ISO 14091:2021; ISO 14090:2019; ISO 31000:2018) as well as national and international climate change guidelines (Canadian Electricity Association, 2017; Canadian Council of Professional Engineers, 2008; IPCC, 2014; Infrastructure Canada, 2018; International Hydropower Association, 2019; Saucier and Ministère de la Santé et des Services sociaux, 2017).

The exercise was carried out in two phases (see Figure 5):

- The first phase consisted of compiling a list of climate change risks that could affect Hydro-Québec's assets and activities (Steps 1–3).
- The second phase focused on establishing Hydro-Québec's action areas, identifying potential adaptation measures and determining what actions to take to mitigate these risks (Steps 4–5).

Figure 5: Hydro-Québec adaptation plan development process

Step 1: Assess the vulnerability of assets and activities

SELECTING ASSETS AND ACTIVITIES

Assets and activities were selected for vulnerability assessment based on exposure to climate hazards. In a series of workshops with specialists from each Hydro-Québec area of expertise, more than 700 at-risk elements (groups of components or activities) were targeted for analysis. These elements were grouped together either due to their comparable design or because they were likely to be affected by changing climate conditions in a similar way.

ASSESSING THE VULNERABILITY OF ASSETS AND ACTIVITIES

The level of vulnerability of the assets and activities was then determined by specialists. This exercise made it possible to ensure a common understanding of the method and provide instructions on filling out the analysis grids.

The climate change vulnerability assessment of assets and activities was based on the following three impact criteria:

- **Physical condition of the asset**: Impacts on the structural integrity of the asset that could lead to accelerated degradation or premature failure.
- **Asset functionality or service reliability**: Impacts on the normal operation of the asset or the quality of service, leading to levels of service below expectations.
- **Resources or operational constraints**: Impacts on the ability to do maintenance on the asset and access facilities, on the deployment of resources to carry out activities or on the productivity of personnel affected by a particular climate hazard.

Based on their expert judgment, the internal and external specialists involved in the risk assessment then assigned a vulnerability rating ranging from low (1) to very high (4) for the 700 or so at-risk elements.

Step 2: Identify the main climate change impacts

SELECTING PRIORITY CLIMATE HAZARDS

Based on weather events that have impacted Hydro-Québec assets and operations in the past, several climate parameters and various intensity thresholds were selected. In some cases, a combination of two or more hazards was also assessed (e.g., freezing rain and high winds). Table 1 presents the climate hazards selected for analysis, their evolution (trends) in Québec and examples of potential impacts for Hydro-Québec.

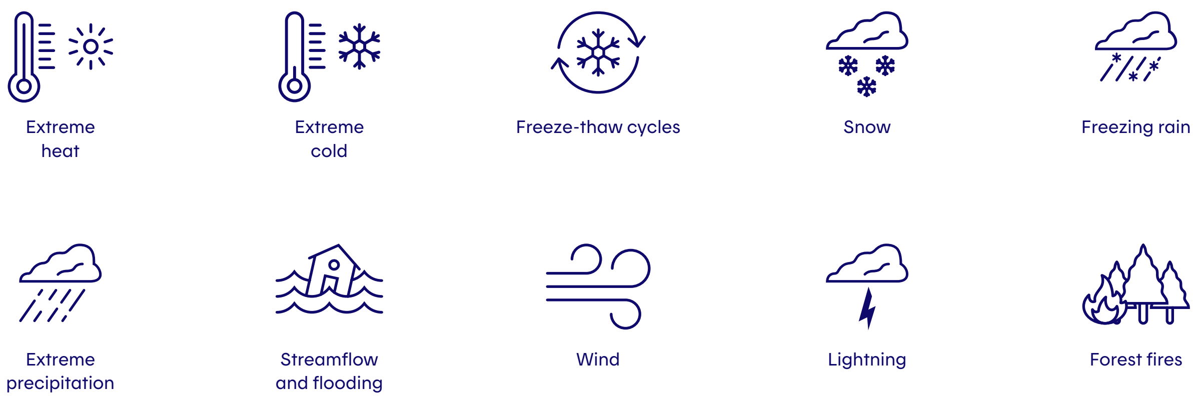


Table 1: Overview of climate hazards most likely to affect Hydro-Québec

Climate hazards		Trends in Québec	Examples of impacts on Hydro-Québec
Temperature	Extreme heat (heat waves)	↗ Extreme heat episodes tend to increase in frequency, duration and intensity.	• Impacts on worker health and safety (e.g., heat stroke) • Increased cooling load for buildings • Reduced transmission line capacity as temperatures increase
	Extreme cold (cold snaps)	↘ Extreme cold episodes tend to decrease in frequency.	• Less disruption to electrical and electronic equipment due to less frequent extreme cold events • Less harsh working conditions in winter
	Freeze-thaw cycles	= The frequency of freeze-thaw cycles tends to remain stable. However, seasonality will change: there will be a few more cycles in winter, but a few less in shoulder seasons.	• Cracks and water ingress in building foundations • Additional maintenance needs in case of deterioration of infrastructure (e.g., buildings and roads)

Climate hazards		Trends in Québec	Examples of impacts on Hydro-Québec
Precipitation	Extreme precipitation (short- and long-term events, high intensity)	↗ Extreme precipitation tends to increase in frequency, duration and intensity.	• Challenges in managing streamflow in rivers and reservoirs in the event of more intense, more frequent or less predictable flooding • Backflows in drainage infrastructure • Access issues affecting emergency response (e.g., flooding or fallen trees blocking roads) • Flooding of buildings and equipment
	Streamflow and flooding	↗ ↘ Streamflow tends to increase in the north and decrease in the south.	• Variation in average streamflow depending on the region
	Snow (heavy snowfall, wet snow, blizzards)	↘ ↗ The frequency of heavy snowfall and accumulation tends to decrease in the south and increase in the north.	• Clearing snow from building roofs, access roads and camps • Health and safety risks to personnel when traveling • Changes in intensity and onset of spring peak flows
	Freezing rain	↗ ↘ Some areas tend to have more freezing rain, while others have less.	• Increased risk of power outages • De-icing of certain assets • Inability to access certain assets

Climate hazards		Trends in Québec	Examples of impacts on Hydro-Québec
Wind	Sustained winds and gusts	↗ High wind events tend to increase in frequency and intensity.	• Damage to transmission line structures, telecommunications towers and electrical poles • Increased risk of power outages • Disruption to aviation activities (e.g., helicopter transportation, drone-based inspections)
Other	Lightning	↗ Lightning tends to increase in frequency.	• Damage to overhead lines and associated assets • Risks to health and safety of workers
	Vegetation growth	↗ The growing season tends to be longer.	• Adaptation of vegetation control activities to account for faster growth (e.g., operational constraints and resource requirements)
	Forest fires	↗ Forest fires tend to increase in frequency.	• Loss or destruction of assets • Power outages due to direct exposure of equipment to smoke or ambient temperatures that are too high • Reduced visibility and higher risk of cardiorespiratory problems among workers

DETERMINING HAZARD LIKELIHOOD

Hydro-Québec used all available information to predict how the climate hazards identified are likely to play out. Where possible, the hazards were assessed based on data from climate simulations available on ClimateData.ca (Environment and Climate Change Canada *et al.*, 2021). This data portal provides climate indicators for which climate change modeling is at an advanced stage, producing results that are quantifiable and with high confidence. In other cases, where the state of the science did not allow for sufficiently robust results, qualitative ratings were based on a literature review and the judgment of climatology subject matter experts.

A probability score ranging from very rare to certain was assigned to each hazard (see Table 2) for each climate zone, time horizon and GHG emission scenario examined (see Figure 6). The probability scale used aims to represent the majority of Hydro-Québec's assets and activities. However, for extremely rare events, such as an exceptional flood with a probability of occurrence of 1 in 10,000—known as a *10,000-year flood*—the available scores were inadequate. The risks associated with very infrequent events were therefore assessed based solely on the vulnerability of the assets.

Table 2: Climate hazard likelihood scale based on probability of occurrence

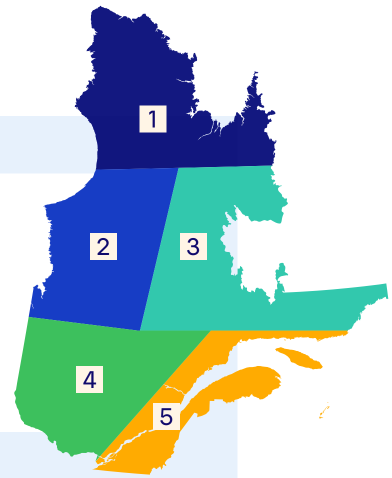
Score	Description	Probability	Return period
Qualitative*	Very rare	P ≤ 1%	< 1/100 years
1	Rare	1% < P ≤ 2%	1/100 years – 1/50 years
2	Somewhat possible	2% < P ≤ 4%	1/50 years – 1/25 years
3	Possible	4% < P ≤ 10%	1/25 years – 1/10 years
4	Fairly probable	10% < P ≤ 50%	1/10 years – 1/2 years
5	Probable	50% < P ≤ 100%	1/2 years – 1/year
6	Certain	100% < P ≤ 500%	1/year – 5/year
7	Frequent	P ≤ 500%	≤ 5/year

* Certain climate hazards for which it is difficult to determine a probability score with confidence were treated qualitatively based on a description of their trends and their impacts on the asset.

Figure 6: Framework for calculating the probability of occurrence of climate hazards

Climate Zones of Québec

Zone 1: North
Zone 2: West – Hudson's Bay to Baie James
Zone 3: East
Zone 4: Southwest
Zone 5: Southeast – St. Lawrence River Valley



Time Horizons

Baseline period
1981–2010

Future periods
Short term: 2021–2050
Medium term: 2041–2070
Long term: 2071–2100

GHG Emission Scenarios

Moderate emissions
RCP 4.5

High emissions
RCP 8.5

CLIMATE ZONES

Hydro-Québec's assets and activities cover a vast area and will be exposed differently to climate hazards depending on their geographic location. For example, the level of risk associated with increased heat waves may be higher for a substation located in southern Québec, in Zone 5, than for a similar substation located in the north, in Zone 1.

For the purpose of this analysis, the territory was split into five climatic zones; a single zone would have resulted in information that was too broad, while using more zones would have bogged down the exercise with too much detail. The results for these zones provide an overview of the evolving risks facing Hydro-Québec across the province. However, finer-scale data will be used to implement the adaptation measures.

TIME HORIZONS

The useful service life of Hydro-Québec's assets varies greatly. For example, wooden poles in the distribution system have a useful service life of 50 to 60 years, compared to about 120 years for an embankment dam. To assess the risk over an appropriate period of time for each asset category, three time horizons were selected. This approach allows us to consider the asset's useful service life and evaluate whether the risk level changes over time.

GREENHOUSE GAS EMISSION SCENARIOS

Two GHG emission scenarios were used: one moderate (RCP 4.5) and one high (RCP 8.5) (see Climate modeling, p. 20).

Step 3: Evaluate the risks

A typical risk evaluation considers the results of the vulnerability assessment (Step 1) and the probability of occurrence of each climate hazard (Step 2). The risk level can be determined by combining these two components (see Figure 7).

This approach, replicated for each time horizon, made it possible to gauge the evolution of risk levels over the coming decades. The criticality of each risk and its amplification over time were two factors used to identify the main risks facing Hydro-Québec.

Figure 7: Determining risk levels

Step 4: Establish action areas

Based on the detailed risk assessment conducted in the previous step and their expert judgment, those involved in the process established 26 action areas for Hydro-Québec (see Table 3), evaluating the severity of potential impacts on various aspects (e.g., public health and safety, continuity of service, the environment, and Hydro-Québec's finances). Each action area is considered of equal importance to Hydro-Québec. Some action areas may relate to events that involve more severe impacts but that are much less likely to occur than others, or vice versa. For example, heat island effect is a prominent issue affecting a large portion of the population, including Hydro-Québec personnel, now and in the future. While the impact of heat island effect may not be catastrophic in the short term, adaptation measures designed to prevent them will receive just as much attention as any other issue.

In this step, the 26 action areas were divided into four categories:

1. **Design**: Assets whose current design may no longer be suited to the new climate conditions.
2. **Operations**: Inability to conduct activities according to current methods or requirements.
3. **Power outages and impacts on assets**: Incidents caused by high-intensity weather events.
4. **Worker health and safety**: Deterioration of the work environment due to climate change.

Table 3: Hydro-Québec's action areas for adapting to climate change*

Category	Action area
Design	1. Adjust design standards and activities
	2. Maintain appropriate discharge capacity
	3. Increase the resilience of control structures
	4. Increase the resilience of retaining structures
	5. Plan the maintenance and replacement of wooden poles to optimize their useful service life in extreme weather conditions
	6. Limit the heat island effect caused by Hydro-Québec facilities
	7. Adapt the management and design of heating, ventilation and air-conditioning systems to extreme heat conditions
	8. Adapt rainwater drainage systems to high-intensity precipitation events
	9. Collaborate with external telecommunications partners to increase the resilience of shared services and infrastructure
	10. Increase the resilience of external penstocks and surge tanks

* Note that the action areas are grouped by category rather than order of priority.

Category	Action area
Operations	11. Adapt snow removal procedures and roof design practices to heavy snow accumulation
	12. Adapt vegetation control to the increased growth of certain species
	13. Maintain good communication with all residential and business customers in a context of growing demand
	14. Plan regular activities in light of increased pressure on human resources due to climate change
	15. Adapt construction practices to the new climate situation
	16. Improve facility access during extreme weather events as much as possible
	17. Plan line maintenance work based on new heat stress conditions
Power outages and impacts on assets	18. Limit the impact of extreme weather events on the reliability of the overhead system
	19. Increase the resilience of off-grid systems
	20. Prevent flooding upstream and downstream of generating stations
	21. Increase the resilience of critical buildings
	22. Protect the safety of assets and activities in areas exposed to forest fire risk

Category	Action area
Worker health and safety	23. Protect personnel from heat stroke and related conditions
	24. Protect personnel from illnesses associated with working outdoors
	25. Adjust health and safety activities to prevent slips and falls on ice
	26. Emphasize the importance of safe behaviors on roads and waterways in the context of climate change

Step 5: Identify potential adaptation measures and implement those best suited to Hydro-Québec

The Hydro-Québec personnel involved in developing the *Climate Change Adaptation Plan* considered multiple potential adaptation measures for each of the 26 action areas. They drew on their own knowledge and took inspiration from measures implemented by other organizations.

For each action area, various adaptation measures were described in a fact sheet as a way to bring as much useful information together as possible. The experts on the technical and scientific working committee were offered numerous information sessions to help them draw up the sheets and brainstorm ideas on different types of adaptation measures (Ministère de l'Environnement et de la Lutte contre les changements climatiques, 2021):

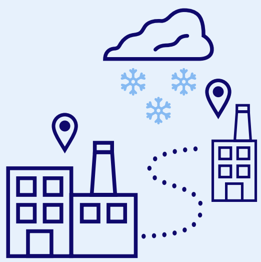
1 **Location**: To reduce exposure to risk, avoid building infrastructure in vulnerable areas. This type of adaptation measure applies primarily to new assets. For example, avoiding construction in floodplains, avoiding areas with high coastal erosion rates.

2 **Design**: When building or renovating structures, opt for a more resilient design or select materials better adapted to the new climate reality. For example, raising power lines, integrating eco-friendly parking, favoring green infrastructure.

3 **Operation and maintenance**: Changing the frequency of maintenance or modifying work schedules can effectively mitigate certain risks. For example, clearing snow from building roofs more often, adapting vegetation control activities, altering water management practices.

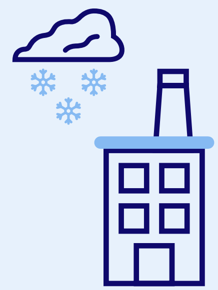
Having a range of options makes it easier for Hydro-Québec to choose those that best suit its needs and to implement climate change adaptation. As illustrated by the example in Figure 8, each risk can be mitigated in different ways. Adaptation measures are chosen based on the specificities of the activity or asset in question, as there is no single one-size-fits-all solution.

Figure 8: Example of different types of adaptation measures to mitigate the risk of increased snow loads on roofs



Location

Choose an area with less snow accumulation



Design

Strengthen the roof to support a heavier snow load

Operation and maintenance

Increase the frequency of snow removal from the roof

Spheres of Action

Having identified its 26 action areas, Hydro-Québec is now ready to implement changes.

Part 2, *Strategies*, describes the initial actions that will be implemented, which will be updated and enhanced on a regular basis. Over the coming years, Hydro-Québec will work on four spheres of action to speed up the company's adaptation to climate change (see Figure 9):

1. Implementing actions related to the 26 action areas
2. Educating, training and collaborating with stakeholders
3. Implementing a research and expertise development program
4. Formalizing Hydro-Québec's long-term commitment to climate action in its policies and guidelines

Figure 9: Spheres of action in Hydro-Québec's adaptation process

Implementing actions related to the 26 action areas

For each action area, the various groups at Hydro-Québec identified actions aimed at mitigating the associated risks. It is important to note that the specialists were already aware of the majority of the impacts of climate change on Hydro-Québec's activities. For this reason, Hydro-Québec has already initiated a number of actions detailed in the *Strategies* section.

Since each action is the responsibility of a specific group within Hydro-Québec, the role of the *Climate Change Adaptation Plan* coordinating committee is to monitor their implementation and track their progress. To this end, progress indicators or targets have been established. The group responsible for each action will be required to regularly assess whether any emerging knowledge, changes in context or new climate events warrant reviewing or improving that action.

Educating, training and collaborating with stakeholders

It is essential that all personnel share a common understanding of climate change issues. The first awareness and training activities took place in 2020:

1. **Awareness capsule for all personnel**: to educate all personnel about climate change and inform them of the ongoing adaptation process.
2. **Manager training**: to educate management personnel about the potential impacts of climate change on their teams' activities, including the cost of adaptation versus the cost of inaction.
3. **Technical expert training**: to explain climate modeling and GHG emission scenarios to specialists, with a focus on the fundamental and technical aspects of using such climate scenarios.

Future activities will seek to develop Hydro-Québec's internal expertise and to train a group of specialists who have a clear understanding of the issues and can act as agents of change within their teams. This phase of the training program will explain how to use climate simulation data and standardize practices across Hydro-Québec. The training will focus on the use of Hydro-Québec's Climate Atlas (see inset on p. 52).

During the development of this adaptation plan, Hydro-Québec presented it to several stakeholders to get their feedback. Hydro-Québec is keen to work even more closely with these stakeholders in the coming years to encourage sharing of experiences and best practices and establish partnerships that catalyze climate change adaptation.

Implementing a research and expertise development program

For over two decades, Hydro-Québec's research center (CRHQ) has been working to expand its climate science expertise and apply it to a range of projects. Some of these projects have been joint endeavors with Ouranos, scientific partners and Hydro-Québec's technical experts. While the first few years were devoted to developing the science and introducing new methods, more recent collaborations have enabled the research center to further enhance its leading-edge expertise and apply it in a real-world context. These projects have led to tangible results for Hydro-Québec's activities. Here are some examples:

- Study of projected hydrological changes for the province of Québec (Guay, Minville and Braun, 2015)
- Calculations of 10,000-year floods (Ouranos, 2021b) and probable maximum floods (Clavet-Gaumont *et al.*, 2017; Ouranos, 2015) in the context of climate change
- Valuation of assets in the context of climate change (Ouranos, 2020)
- Estimation of wind power potential for retrofitting wind farms (Ouranos and Nergica, 2018)

These projects have enabled Hydro-Québec to work effectively to begin implementing its own adaptation plan. Climate change implies a paradigm shift: observation data can no longer be relied upon for assumptions regarding the future of energy production. Climate projections should now play a key role in the management of all Hydro-Québec activities. The use of new data and methodologies requires expert scientific support and know-how. At Hydro-Québec, it is imperative to have this expertise internally to support the company's adaptation process.

Climate change must be taken into account in all Hydro-Québec's activities, and to this end, Hydro-Québec is committed to supporting innovation projects in a variety of ways. Hydro-Québec's research center will support personnel by providing efficient access to centralized, authenticated climate projection data (see inset entitled "Hydro-Québec's Climate Atlas," p. 52), designing decision-making tools and integrating these new methods into Hydro-Québec practices. As climate science is constantly evolving, staying at the forefront of scientific knowledge will also be key to Hydro-Québec's activities and risk assessment process.

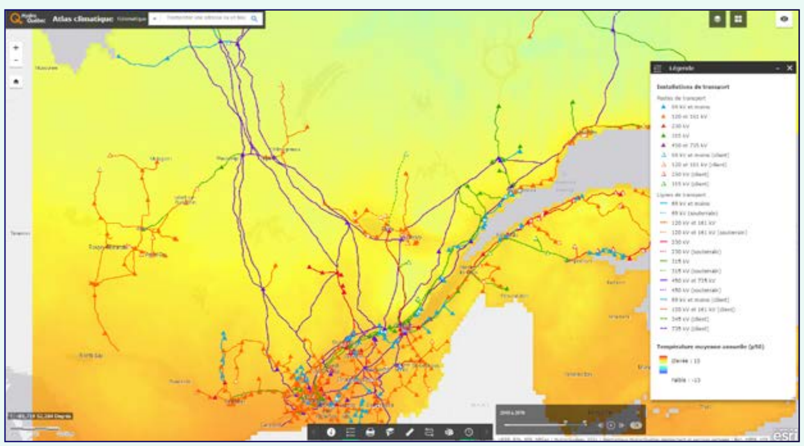
The research strategy for the coming years will focus on making climate information more robust, notably through better management of uncertainty related to climate hazards and better modeling of complex climate events. Particular attention will be focused on quantifying the climate risks associated with extreme events such as heat waves, intense precipitation and high winds. Hydro-Québec has undertaken several projects in this regard, in collaboration with academics and Ouranos.

HYDRO-QUÉBEC’S CLIMATE ATLAS

To help its specialists use the results of climate projections effectively, Hydro-Québec is developing an atlas of climate variables and indicators. The purpose of the atlas is to provide climate data in a centralized, efficient way using a geo-referenced tool tailored to Hydro-Québec’s needs. The information will be updated regularly as required and as new climate projections become available.

The tool will make it possible to present climate data and Hydro-Quebec’s spatial data together on a single map. For example, a user could display both the projected average temperatures for 2041–2070 and the location of Hydro-Québec’s transmission system facilities on the same map of Québec (see Figure 10).

Figure 10: Example of map from Hydro-Québec’s Climate Atlas, currently in development



Formalizing Hydro-Québec's long-term commitment to climate action in its policies and guidelines

Hydro-Québec is keen to go further with its commitment to address the negative impacts of climate change by ensuring they are taken into account in all its activities and decision-making processes. In other words, in addition to the action areas it has identified, Hydro-Québec aims to apply climate change considerations across its practices by adopting clear guidelines.

Its three main objectives are to:

1. Demonstrate Hydro-Québec's firm commitment to addressing climate risks while taking opportunities to improve its practices by actively participating in the collective effort to strengthen the resilience of Québec society
2. Clearly set out expectations and rules to be followed across Hydro-Québec with respect to taking climate scenarios into account
3. Be at the forefront of compliance with potential government requirements in relation to climate change resilience

Strengthening Hydro-Québec's commitment through its environmental policy will make it easier for all personnel to do their part in the fight against climate change. In some cases, Hydro-Québec will seize opportunities created by its projects to implement adaptation measures (see inset entitled "Example of adaptation: Transmission lines," p. 54). In other cases, Hydro-Québec will adapt its practices and reduce its environmental footprint through partnerships (see inset entitled "Example of community partnership: Eco-friendly parking lot in Saint-Léonard," p. 55).

EXAMPLE OF ADAPTATION: TRANSMISSION LINES

Heat causes power lines to expand and sag. Safety standards dictate the minimum distance that must be maintained between power lines and the ground. There are three main sources of heat that cause this warming and expansion: the ambient temperature, the energy absorbed from the sun and the current flowing through the line.

Hydro-Québec's transmission system was designed first and foremost to deal with peak loads in wintertime. For this reason, design practices have historically been calibrated to ensure transmission service in very cold conditions. Today, the system is increasingly in demand during the summer, in part due to the additional cooling load associated with climate change.

In response to this new situation, several years ago Hydro-Québec changed the design practices for its new transmission lines to limit the load on its system in high heat conditions.

Increasing a power line's thermal range is a conventional way to boost its transmission capacity when needed. With climate change, this solution may be applied more often to offset the decrease in transmission capacity caused by an increase in ambient temperature.

As it would be impractical to replace or modify all its towers purely on the basis of projected rises in air temperature, a Hydro-Québec task force is currently studying various aspects regarding the thermal capacity of transmission lines, including climate change considerations.

A project to add, modify or replace sections of lines, to increase transmission capacity or for other reasons, represents a great opportunity to adapt to climate change at the same time and at lower cost. This ensures that long-term needs are met while taking the equipment's future operating conditions into account.

EXAMPLE OF COMMUNITY PARTNERSHIP: ECO-FRIENDLY PARKING LOT IN SAINT-LÉONARD

The Montréal borough of Saint-Léonard asked Hydro-Québec to help create an eco-friendly parking lot under a high-voltage line. This is because any development below these lines must meet strict standards to ensure safe use. Hydro-Québec worked with municipal authorities and electrical safety specialists to ensure the project's feasibility.

With the expansion of community gardens and a dog park nearby, there was a need to increase the number of parking spaces to meet growing demand. The borough of Saint-Léonard is one of the areas most exposed to heat in Montréal and is already affected by the urban heat island effect—an issue that will be amplified by climate change. The borough therefore decided in favor of an eco-friendly parking lot certified by the Conseil régional de l'environnement de Montréal.

A solar reflective coating was applied to the paved surface to help control the heat island effect. The project also includes planting vegetation to create a bioretention system to help manage extreme rainfall. The parking lot is designed to encourage sustainable mobility, with bike racks and spaces reserved for carpooling and car sharing.

Hydro-Québec is eager to play a key role in similar initiatives in collaboration with municipalities while ensuring its facilities are safely and optimally integrated into the landscape.

Eco-friendly parking lot at the corner of Jean-Rivard and Arthur-Péloquin streets in Montréal. At the time of this photo, work was still in progress and not all the vegetation had been planted. Source: Ville de Montréal

Next Steps

Many people worked together to craft this initial climate change adaptation plan. In it, Hydro-Québec is proud to present a summary of its approach, its initial intentions and how it will take action effectively. The plan is designed to be both long-term and flexible, providing a solid foundation that can evolve as technical innovations, Hydro-Québec's concerns and best practices in the field evolve.

The adaptation plan focuses on the physical risks affecting Hydro-Québec's assets and activities. Improvements for the next version are already being explored:

- **Further operational risk analysis**: Until now, the analysis of the operational risks has focused on those with a direct impact on the assets themselves. For the next adaptation plan, Hydro-Québec would like to broaden its analysis to include all its activities while refining the criteria used to prioritize these risks.
- **Update of climate data and projections used**: Climate science is constantly evolving and GHG emission scenarios are periodically redefined. New data sets also become available as knowledge in the field expands. It will therefore be essential to use the most recent and relevant data when updating the plan in the future.
- **Inclusion of risks associated with new areas of activity**: Since the analysis was initiated, Hydro-Québec has added a number of areas of activity, including two solar generating stations, storage batteries and the conversion of off-grid systems. It will be important to incorporate the risks associated with new business lines on a continual basis.
- **Better integration of environmental concerns**: The approach used to date has focused primarily on Hydro-Québec infrastructure and engineering. However, in the future, it will be essential to include an analysis of the cumulative impacts of climate change and Hydro-Québec's activities on the environment.

- **Strengthening the synergy between this process and other key initiatives by Hydro-Québec, government and civil society**: Important issues such as decarbonization and biodiversity have a direct link to climate change adaptation. Hydro-Québec is eager to better align its efforts across these issues to optimize results.
- **Incorporation of climate risk costs**: In line with its adaptation process, Hydro-Québec will publish a financial report on climate risk management.

The plan's progress will be monitored on an ongoing basis using a number of indicators (described in Part 2, entitled *Strategies*) and corporate accountability mechanisms (master plans, sustainable development report). Measuring climate change adaptation progress is a complex process that is still very much in its infancy. For example, during the drafting of this report, the World Bank published a methodology for assessing climate resilience (World Bank Group, 2021). Hydro-Québec will keep abreast of developments in this field and make efforts to accurately measure its progress and level of resilience to climate change.

The intensity of climate change entails a degree of uncertainty due to factors such as social and economic policies to be adopted. However, this uncertainty will not prevent Hydro-Québec from acting and adapting, because the acceleration of climate change is already a certainty. Climate risks must now form an integral part of the corporate decision-making process—something that Hydro-Québec is fully committed to.

Part 2: Strategies

Fact Sheets

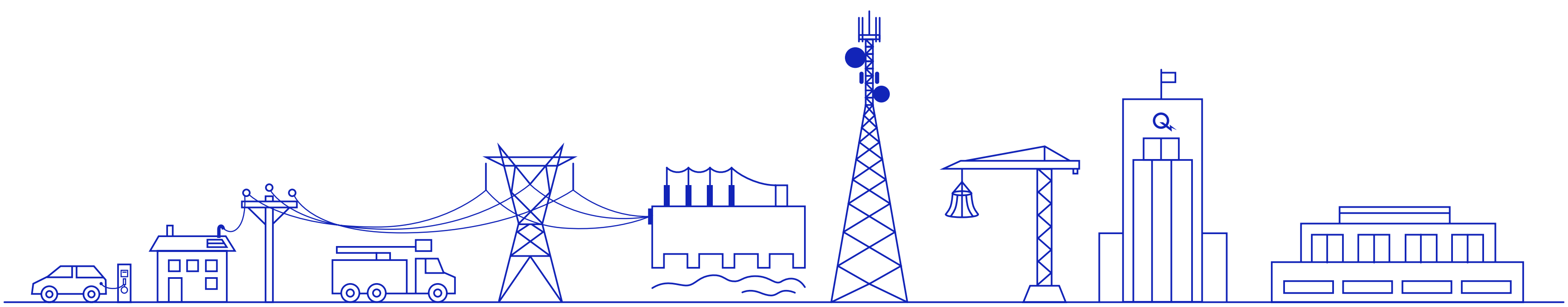
The second part of the plan contains 26 fact sheets—one for each of Hydro-Québec's action areas. Note that these are divided into four categories:

1 Design

2 Operations

3 Power outages and impacts on assets

4 Worker health and safety

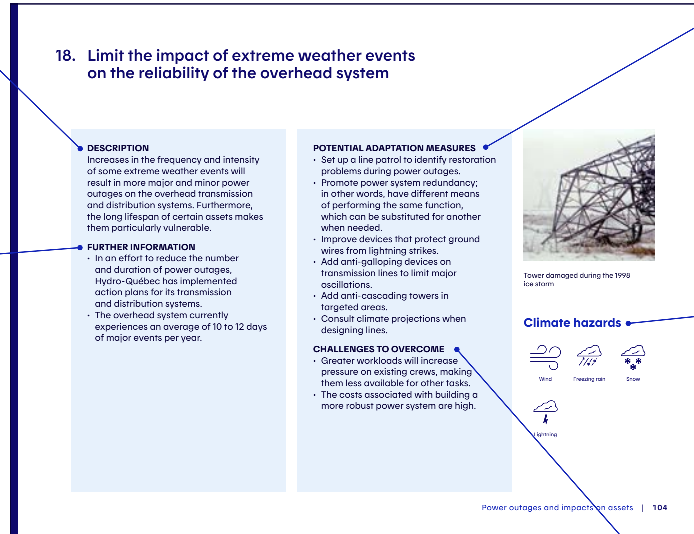


Each fact sheet provides an overview of the action area and the actions associated with it.

Description
Explanation of the impacts of climate hazards on Hydro-Québec's activities and assets and their consequences.

Further information
Additional information to better understand the issues related to the action area.

Actions
The actions listed in this table demonstrate Hydro-Québec's intent to address climate change in more concrete terms. Numerous actions have already been undertaken since many of the impacts of climate change were known at the start of the process and will increase as climate change continues. Hydro-Québec will monitor its actions on an ongoing basis and may adapt them as knowledge and climatic conditions change.



18. Limit the impact of extreme weather events on the reliability of the overhead system

DESCRIPTION
Increases in the frequency and intensity of some extreme weather events will result in more major and minor power outages on the overhead transmission and distribution systems. Furthermore, the long lifespan of certain assets makes them particularly vulnerable.

FURTHER INFORMATION
- In an effort to reduce the number and duration of power outages, Hydro-Québec has implemented action plans for its transmission and distribution systems.
- The overhead system currently experiences an average of 10 to 12 days of major events per year.

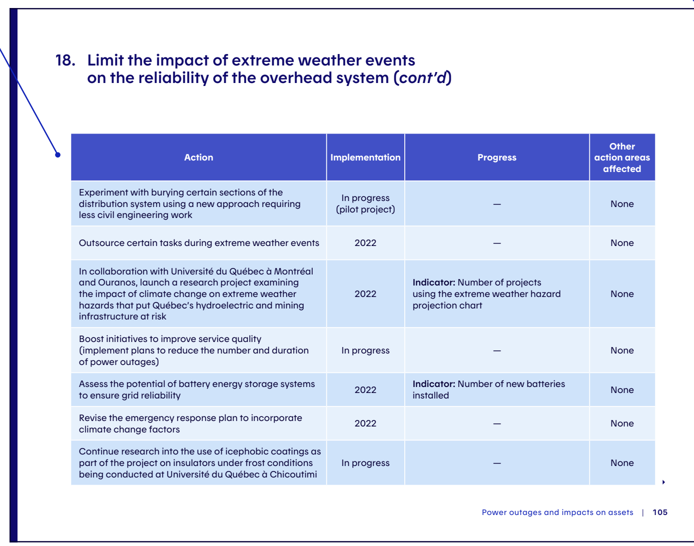
POTENTIAL ADAPTATION MEASURES
- Set up a line patrol to identify restoration problems during power outages.
- Promote power system redundancy; in other words, have different means of performing the same function, which can be substituted for another when needed.
- Improve devices that protect ground wires from lightning strikes.
- Add anti-galloping devices on transmission lines to limit major oscillations.
- Add anti-cascading towers in targeted areas.
- Consult climate projections when designing lines.

CHALLENGES TO OVERCOME
- Greater workloads will increase pressure on existing crews, making them less available for other tasks.
- The costs associated with building a more robust power system are high.

Tower damaged during the 1998 ice storm

Climate hazards

Power outages and impacts on assets | 104



18. Limit the impact of extreme weather events on the reliability of the overhead system *(cont'd)*

Action	Implementation	Progress	Other action areas affected
Experiment with burying certain sections of the distribution system using a new approach requiring less civil engineering work	In progress (pilot project)	–	None
Outsource certain tasks during extreme weather events	2022	–	None
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	**Indicator:** Number of projects using the extreme weather hazard projection chart	None
Boost initiatives to improve service quality (implement plans to reduce the number and duration of power outages)	In progress	–	None
Assess the potential of battery energy storage systems to ensure grid reliability	2022	**Indicator:** Number of new batteries installed	None
Revise the emergency response plan to incorporate climate change factors	2022	–	None
Continue research into the use of icephobic coatings as part of the project on insulators under frost conditions being conducted at Université du Québec à Chicoutimi	In progress	–	None

Power outages and impacts on assets | 105

Potential adaptation measures
A list of adaptation measures identified during the analysis process. Hydro-Québec presents these as examples to share its knowledge in relation to climate adaptation.

Climate hazards
Pictograms representing climate hazards associated with the action area. Climate change is altering the frequency, intensity and duration of extreme weather events. The magnitude of these changes varies depending on the region, time horizon and greenhouse gas emission scenario.

Challenges to overcome
Constraints and barriers to implementing adaptation measures.

Design

1. Adjust design standards and activities

DESCRIPTION
Many of the current design criteria for Hydro-Québec infrastructure are based on historical climate data. For example, the National Building Code of Canada 2015—the version in effect when the plan was drafted—does not take climate change into consideration. Design criteria for infrastructure must be adjusted to reflect climate change; otherwise, there is a risk of failure or improper sizing.

FURTHER INFORMATION
- Currently, power lines are designed based on an ambient temperature of 30°C.
- In Montréal, from 1981 to 2010, the temperature exceeded 30°C an average of 10 days per year. Under a high greenhouse gas emission scenario, this figure would be closer to 40 days per year during the period 2041–2070.
- Existing structures are already designed to withstand extreme weather events, for which a significant margin of safety has been provided.

POTENTIAL ADAPTATION MEASURES
- Adapt calculation methods by using climate projections.
- Rely more on climate projections rather than historical data for design purposes.
- Build a database using both historical data and data from climate scenarios.
- Develop analytical tools and new approaches for selecting design criteria.
- Encourage consultants to develop expertise in climate change.

CHALLENGES TO OVERCOME
- Incorporating climate change into design criteria adds an element of uncertainty, which complicates decision-making. Updating tools adapted to climate change, including a database, requires significant human and financial resources.
- Integrating climate resilience into design may increase project costs.
- Some climate hazards are more difficult to model and cannot yet be included in the design criteria; research will need to be carried out beforehand.

Electrical towers

Climate hazards

1. Adjust design standards and activities (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Initiate migration from a deterministic hydrological model to a stochastic hydrological model, to obtain a range of probable values for analysis, design and operation	2022	—	None
Establish a reference framework for defining hydroclimatic criteria (e.g., streamflow, precipitation, temperature) for facilities in light of climate change	In progress	**Target**: Establish a reference framework for extreme rainfall and flooding criteria by 2023	2, 3, 4
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	**Indicator**: Number of projects using the extreme weather hazard projection map	2, 4, 5, 14, 18
Monitor the weather on worksites to better plan the work and carry out maintenance before an extreme weather event occurs	2022	—	None

1. Adjust design standards and activities (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Use the Climate Atlas in infrastructure design by 2024 – Use hydrological projections in project planning by 2024	2, 3, 4, 20, 21
Participate in workshops to review CAN/CSA-S37-94, *Antennas, Towers, and Antenna-Supporting Structures*, in order to incorporate the concept of climate change	In progress	**Indicator**: Publication of standard by CSA Group	None

2. Maintain appropriate discharge capacity

DESCRIPTION
Control and discharge structures help ensure the safe operation of hydroelectric facilities. Climate change will affect river flow rates, which may make the operation of control and discharge structures more difficult. Consequences for Hydro-Québec include additional operating constraints and emergency work.

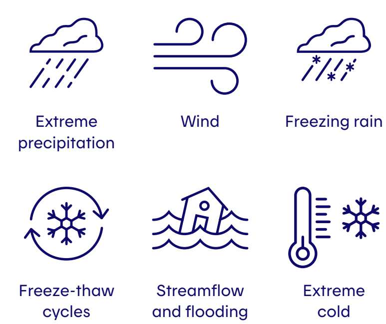
FURTHER INFORMATION
- Hydro-Québec is subject to the *Dam Safety Act*. As such, it is required to ensure the safety of people and property while operating its facilities.
- Control and discharge structures have a useful service life of 70 to 120 years. It makes sense to adapt the design, construction and operation of these structures according to the projected climate for the duration of their useful service life.
- Existing structures are already designed to withstand extreme weather events, for which a significant margin of safety has been provided.

POTENTIAL ADAPTATION MEASURES
- Create guidelines to include climate change in the design criteria.
- Improve knowledge of extreme precipitation events in the context of climate change.

CHALLENGES TO OVERCOME
- Engineers must establish clear guidelines to ensure that climate change is appropriately incorporated into infrastructure design.
- Adaptation measures requiring the retrofitting of existing structures represent significant costs.

Aerial view of Bryson generating station

Climate hazards



2. *Maintain appropriate discharge capacity (cont'd)*

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator**: Number of facilities assessed for resilience	3, 4, 10, 16, 20, 21
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Incorporate the use of the Climate Atlas in infrastructure design by 2024 – Incorporate the use of hydrological projections in project planning by 2024	1, 3, 4, 20, 21
Establish a reference framework for defining hydroclimatic criteria (e.g., streamflow, precipitation, temperature) for facilities in light of climate change	In progress	**Target**: Establish a reference framework for extreme rainfall and flooding criteria by 2023	1, 3, 4
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	—	1, 4, 5, 14, 18

3. Increase the resilience of control structures

DESCRIPTION
Anticipated changes in energy demand and river flow rates will affect the operation of Hydro-Québec's facilities. Increasingly frequent severe wind and ice events may affect the metal structures used to raise spillway gates.

Operating conditions for control and discharge structures in the context of climate change could accelerate the degradation of certain components. Consequently, Hydro-Québec may need to carry out more maintenance, fast track certain refurbishment work or conduct more frequent inspections.

FURTHER INFORMATION
- Hydro-Québec is subject to the *Dam Safety Act*. As such, it is required to ensure the safety of people and property while operating its facilities.
- Control and discharge structures have a useful service life of 70 to 120 years.
- As rising temperatures may alter annual energy demand, Hydro-Québec is likely to face additional constraints and be required to manage water differently.
- Existing structures are already designed to withstand extreme weather events, for which a significant margin of safety has been provided.

POTENTIAL ADAPTATION MEASURES
- Use hydrological and climate projections based on best practices.
- Establish operational adaptation measures.

CHALLENGES TO OVERCOME
- Hydro-Québec must adapt maintenance on its structures according to their age and condition.
- Maintenance management must be optimized to reduce spillway gate downtime.
- Engineers must establish clear guidelines to ensure that climate change is properly incorporated into infrastructure design.

Aerial view of Robert-Bourassa generating station

Climate hazards

3. Increase the resilience of control structures (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 4, 10, 16, 20, 21
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Incorporate the use of the Climate Atlas in infrastructure design by 2024 – Incorporate the use of hydrological projections in project planning by 2024	1, 2, 4, 20, 21
Establish a reference framework for defining hydroclimatic criteria (e.g., streamflow, precipitation, temperature) for facilities in light of climate change	In progress	**Target**: Establish a reference framework for extreme rainfall and flooding criteria by 2023	1, 2, 4

4. Increase the resilience of retaining structures

DESCRIPTION

Retaining structures are essential components of Hydro-Québec's hydroelectric facilities throughout Québec. Climate change may affect wind patterns, streamflow, wave formation conditions, ice cover and water levels.

Such conditions could speed up the deterioration of certain embankment dams and alter the loads on concrete retaining structures. For Hydro-Québec, this would mean more frequent maintenance and more extensive refurbishment work.

FURTHER INFORMATION

- Hydro-Québec is subject to the *Dam Safety Act*. As such, it is required to ensure the safety of people and property while operating its facilities.
- Each dam is designed based on a variety of factors, including known data regarding weather conditions and inflows from the watershed where it is built. Their expected lifespan is at least 70 years.
- Maintenance and repair work can extend the life of these structures.
- Existing structures are already designed to withstand extreme weather events, for which a significant margin of safety has been provided.

POTENTIAL ADAPTATION MEASURES

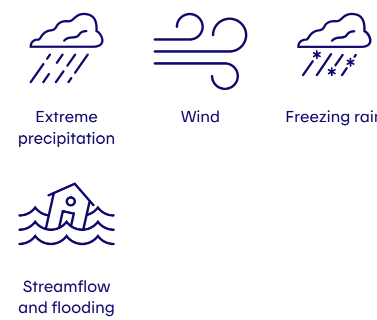
- Map structures' vulnerability to climate hazards.
- Continue to apply temporary corrective measures until permanent solutions are implemented.
- Adapt current calculation methods and design criteria to take climate change into account.
- Establish procedures to limit the risk of ice jams during ice cover formation.

CHALLENGES TO OVERCOME

- Engineers must establish clear guidelines to ensure that climate change is properly incorporated into infrastructure design.
- To take climate change into account, the portfolio of investment projects over a 20-year, or even 50-year, horizon may have to be revised.

Aerial view of the Bersimis-2 dam

Climate hazards



4. Increase the resilience of retaining structures (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 3, 10, 16, 20, 21
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Incorporate the use of the Climate Atlas in infrastructure design by 2024 – Incorporate the use of hydrological projections in project planning by 2024	1, 2, 3, 20, 21
Establish a reference framework for defining hydroclimatic criteria (e.g., streamflow, precipitation, temperature) for facilities in light of climate change	In progress	**Target**: Establish a reference framework for extreme rainfall and flooding criteria by 2023	1, 2, 3
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	—	1, 2, 5, 14, 18

5. Plan the maintenance and replacement of wooden poles to optimize their useful service life in light of extreme weather conditions

DESCRIPTION

When a wooden pole is added to the distribution system, it has an expected useful service life of 60 years. However, certain complications—such as rot, woodpeckers making holes in search of food or shelter, and infestations of carpenter ants—can lead to premature replacement. Rising temperatures lengthen the period when conditions are favorable for rot, even in areas that were not previously affected. The territories and populations of woodpeckers and ants are also expanding. Finally, more frequent and more intense extreme weather events may exceed design standards, causing more poles to break.

FURTHER INFORMATION

- Fungus and rot thrive in environments with temperatures between 10°C and 35°C and humidity above 25%.
- Posts damaged by carpenter ants are replaced on average after 41 years.
- There are some 1.93 million wooden poles in the distribution system.
- Poles are inspected and their condition recorded every 10 years.
- Having initially been treated for rot, poles can be treated again after 20 years if inspection shows that this is necessary.
- In 2021, the cost of replacing a pole was approximately $5,500.
- From 1989 to 2014, the pileated woodpecker population increased by 23% in Québec.

Pole damaged by woodpeckers

Climate hazards

5. Plan the maintenance and replacement of wooden poles to optimize their useful service life in light of extreme weather conditions (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Replace wooden poles with composite or steel poles in targeted areas.
- Revise the expected useful service life of poles downward to reflect climate change.
- Install a protective cap at the top of poles to extend their lifespan.
- Use a product to destroy any ant nests found in the pole during inspections.
- Revise the grade (length and diameter) of the poles to make the distribution system more robust and simplify strategic procurement.
- Add guy wires.

CHALLENGES TO OVERCOME

- Greater workloads will increase pressure on existing crews, making them less available for other tasks.
- Increased material costs and more frequent pole replacements are to be expected.
- Given the size of the system, at-risk areas will have to be targeted based on climate hazards.
- Not all poles belong to Hydro-Québec. Consequently, the design, replacement frequency and pole quality management must be negotiated with other pole owners.

5. Plan the maintenance and replacement of wooden poles to optimize their useful service life in light of extreme weather conditions (*cont'd*)

Action	Implementation	Progress	Other action areas affected
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	**Indicator:** Number of projects using the extreme weather hazard projection chart	1, 2, 4, 14, 18
In collaboration with Université du Québec à Montréal, develop a risk map for the changing territories of woodpeckers and ants due to climate change as part of a research project	In progress	**Indicator:** Number of projects using the risk map for the changing territories of woodpeckers and ants	18
Install composite poles in targeted areas according to a decision-making process based on various criteria (e.g., presence of river crossings, repeated woodpecker damage, strategic equipment)	Ongoing	**Indicator:** Number of composite poles installed per year	None
Assess the feasibility and cost of burying certain overhead distribution lines	In progress (pilot project)	—	12, 17, 18
Optimize the use of different grades and lengths of poles to increase system robustness	In progress	—	1
Conduct research and analysis on certain repellents (e.g., Airepel) to replace chromated copper arsenate (CCA)	Ongoing	—	None

6. Limit the heat island effect caused by Hydro-Québec facilities

DESCRIPTION
More days of extremely high temperatures mean more heat islands produced by Hydro-Québec facilities, including parking lots, storage sites and roads. Because these areas absorb and trap heat, they can cause heat stroke in members of the public and Hydro-Québec personnel. These facilities can therefore harm the health of users and, consequently, Hydro-Québec's reputation, which must be exemplary with respect to the environment and sustainable development.

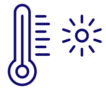
FURTHER INFORMATION
- The temperature difference between an urban heat island and other parts of the city can be as much as 12°C.
- Heat islands also increase cooling requirements for buildings.
- Hydro-Québec's shared services center manages approximately 195 parking lots of varying sizes.

POTENTIAL ADAPTATION MEASURES
- Reduce the size of parking lots by reviewing parking ratios based on a building's floor area.
- Increase the area occupied by vegetation using differentiated management—that is, by reducing vegetation control actions in certain places to promote biodiversity.
- Plant deciduous trees in and around parking lots to create shade.
- Increase sustainable mobility by adding public transit service points to reduce the number of vehicles used and therefore the amount of parking needed.
- Replace existing surfaces with high-albedo (reflective) materials to make eco-friendly parking lots.

CHALLENGES TO OVERCOME
- Each parking lot requires a site-specific adaptation.
- Parking management and design requirements vary from one municipality to another.

Electric vehicles and charging stations

Climate hazard



Extreme heat

6. Limit the heat island effect caused by Hydro-Québec facilities (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Introduce a policy to renovate parking lots to make them more eco-friendly (e.g., by using light-colored materials, adding vegetation, and applying best practices)	In progress	**Target**: Establish eco-friendly parking lot design and renovation criteria	7, 8, 23
Use differentiated vegetation management	Since March 2021 (pilot project)	**Target**: Apply differentiated management in four locations by 2024	7, 8, 23

7. Adapt the management and design of heating, ventilation and air-conditioning systems to extreme heat conditions

DESCRIPTION

More heat waves mean increased use of ventilation and air-conditioning systems in buildings. Offices are generally air-conditioned; some have systems operating at full capacity. Industrial buildings are not all equipped with air-conditioning.

Heat affects people's health and safety, and especially their comfort. Hydro-Québec complies with the *Regulation respecting occupational health and safety* to ensure the health and safety of its employees. If it is too hot inside a building, Hydro-Québec may decide to close it or allow personnel to take more breaks.

FURTHER INFORMATION

- Approximately half, or about 350,000 m^2, of the administrative space managed by the shared services center is air-conditioned.
- Hydro-Québec standards require that a comfortable office temperature be maintained, i.e., between 21°C and 23°C in the winter and between 23°C and 25°C in the summer.
- The average age of Hydro-Québec's administrative buildings is about 25 years.

Rooftop air-conditioning unit

Climate hazard

Extreme heat

7. Adapt the management and design of heating, ventilation and air-conditioning systems to extreme heat conditions (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Increase air-conditioning capacity by upgrading heating, ventilation and air-conditioning (HVAC) systems or by investing in more efficient technologies such as geothermal, ice storage or indirect evaporative cooling.
- Allow higher temperatures in air-conditioned offices.
- Reduce heat gain from solar radiation (e.g., through buildings' orientation and envelope, closing blinds or planting vegetation outside).
- Increase the rate of airflow in industrial spaces, including by installing rotating fans.
- Design buildings to allow for the addition of more efficient HVAC systems as required over their useful service life.
- Take all necessary steps to reduce air-conditioning requirements (see Fact Sheet 6).

CHALLENGES TO OVERCOME

- Efforts must be made to raise awareness among personnel and promote desired behaviors, such as keeping blinds closed in offices during heat waves.
- As each building must be considered on an individual basis, it will necessarily take time to analyze each situation and complete the upgrade work.

7. Adapt the management and design of heating, ventilation and air-conditioning systems to extreme heat conditions (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Increase the maximum allowable setpoint temperature in offices	Since 2019	**Target**: Conduct pilot project in five buildings by 2022	None
Add a poster to the distribution schedule to raise awareness of the importance of closing blinds during a heat wave	2022	**Indicator:** Number of buildings where the awareness poster has been put up	14, 23
Increase the flow of fresh air through ventilation systems at night, when the conditions are suitable, to cool administrative and industrial buildings	2022	**Target**: Implement this practice in five buildings in 2022	14, 23
Install fans or air diffusers, increase airflow rates in industrial buildings and add these aspects to design criteria	2022	**Indicator:** Number of buildings where fans or air diffusers have been installed	14, 23

8. Adapt rainwater drainage systems to high-intensity precipitation events

DESCRIPTION
Increased high-intensity precipitation can potentially overwhelm the rainwater drainage capacity of Hydro-Québec's parking lots, roofs, yards and roads. These types of infrastructure are often made from impermeable materials that cannot absorb a large amount of water in a short period of time. The maximum capacity of rainwater drainage systems has generally been determined based on historical data that do not reflect the intensity of precipitation in a changing climate. Backflows can cause flooding, infrastructure degradation and wastewater management problems. The capacity of municipal drainage systems also affects the capacity of Hydro-Québec's systems. Furthermore, as existing roofs were not designed to handle such intense precipitation, they could be subject to long-term structural problems.

FURTHER INFORMATION
- Rainfall intensity is considered high if 50 mm or more of rain falls within 24 hours.
- During heavy rains, sewer inlets may be blocked by debris (e.g., litter, gravel).
- The majority of Hydro-Québec's drainage systems date back to the 1970s. Because systems and infrastructure were designed to the standards of the time, they may not necessarily be capable of handling current physical and meteorological conditions.

Flooding along roadsides

Climate hazard

Extreme precipitation

8. Adapt rainwater drainage systems to high-intensity precipitation events (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Integrate eco-friendly graywater management using bioretention (rain gardens).
- Increase rainwater infiltration.
- Create vegetated drainage ditches and maximize permeable surfaces.
- Install equipment to reduce the risk of flooding (check valves, copings and foundation drains).
- Increase the frequency of infrastructure inspections.
- Develop a flood emergency response plan and communicate it clearly to those concerned.
- Keep surfaces clean and tidy to prevent litter or other debris (e.g., sand, gravel) from blocking sewer inlets.

CHALLENGES TO OVERCOME

- Regulations for rainwater drainage systems vary by municipality.
- Upgrading aging infrastructure to comply with regulations can be more difficult and costly.

Action	Implementation	Progress	Other action areas affected
Conduct a strategic review of parking lot maintenance and incorporate best practices for eco-friendly parking lots	Since April 2021	**Target**: Implement three Conseil régional de l'environnement de Montréal and LEED certification eco-friendly parking design guidelines	6

9. Collaborate with external telecommunications partners to increase the resilience of shared services and infrastructure

DESCRIPTION
Hydro-Québec's telecommunications network relies on a number of external partners. To deliver its telecommunications services, Hydro-Québec uses cellular and satellite service providers and their infrastructure. Some of these service providers' assets, such as towers, antennas and poles, may be damaged during extreme weather events, potentially affecting the continuity of Hydro-Québec services.

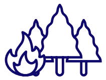
FURTHER INFORMATION
- The loss of cellular service for Hydro-Québec's communications would make managing operations more difficult in a crisis situation.
- If cellular and satellite services are not available from external providers, this may affect remote communications with Hydro-Québec equipment (e.g., smart meters, obstacle lighting).
- Using satellite telephone service may be difficult in emergency situations due to its high sensitivity to a number of climate hazards such as heavy rain, forest fire smoke and snow.

POTENTIAL ADAPTATION MEASURES
- Find out about climate change adaptation measures undertaken by external suppliers.
- Prioritize suppliers and partners that are aware of the risks associated with climate change.
- Communicate Hydro-Québec's adaptation techniques and measures to external suppliers.
- Develop mitigation plans to help manage issues arising from a disruption in telecommunication services.

CHALLENGES TO OVERCOME
- Some external suppliers may be reluctant to engage in climate change adaptation.
- Which technologies are best adapted to climate change is not well known, as this is an emerging risk.

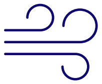
Telecommunications tower

Climate hazards



Forest fires

Freezing rain



Wind

Extreme precipitation

9. Collaborate with external telecommunications partners to increase the resilience of shared services and infrastructure (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Develop an action plan to support bidders' engagement in climate change adaptation	2022–2023	**Indicator:** Development of an action plan	None
Appraise each supplier's level of adaptation to climate change, including design standards and impacts on Hydro-Québec telecommunications services	2022–2023	**Indicator:** Number of suppliers appraised	None
Explore the potential of Hydro-Québec's future 5G network	2022	—	None

10. Increase the resilience of external penstocks and surge tanks

DESCRIPTION
External penstocks transfer water from the reservoir to the turbines. Their foundations may become degraded due to a rise in the number of freeze-thaw cycles, increased vegetation growth and heavy rainfalls. A surge tank is a vertical cylinder used to regulate the pressure in the penstock and reduce the water hammer effect, which can cause significant damage to the penstock. In winter, intense cold can freeze the water in the surge tank and create an ice plug that prevents the tank from performing its function. When the generating station is in operation, there is always water in the surge tank because the penstock is under pressure.

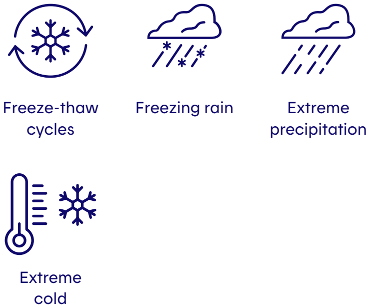
FURTHER INFORMATION
- A broken penstock can result in the complete and prolonged shutdown of the plant.
- External penstocks are only found in the oldest facilities.

POTENTIAL ADAPTATION MEASURES
- Make sure the heating system serving the surge tank and penstock performs well in severe cold.
- Increase the number of inspections based on cold weather forecasts.
- Ensure that existing guidelines cover the impacts of climate change on the foundations of external penstocks (e.g., drainage, vegetation management, checks on soil movement and penstock supports).

CHALLENGES TO OVERCOME
- A total or partial shutdown of production for the repair or reconstruction of a penstock will have repercussions on Hydro-Québec's services.
- Engineers must establish clear guidelines to ensure that climate change is properly incorporated into infrastructure design.
- It may become necessary to conduct inspections of above-ground surge tanks under difficult conditions that may have a negative impact on worker health and safety (e.g., when bad weather makes access dangerous).

Surge tank at Outardes-2 generating station

Climate hazards



10. Increase the resilience of external penstocks and surge tanks (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 3, 4, 16, 20, 21

Operations

11. Adapt snow removal procedures and roof design practices to heavy snow accumulation

DESCRIPTION

Precipitation is projected to increase across Québec. Although it will generally be in the form of rain, there will be greater snow buildup in northern regions. This precipitation is likely to affect the structural integrity of roofs, which will have to bear heavier snow loads, as well as snow removal requirements. Roofs, roads, yards and parking lots will need to be cleared more frequently.

FURTHER INFORMATION

- The area in question contains approximately 450 Hydro-Québec buildings.
- Snow removal is currently carried out at a variable frequency depending on annual precipitation and geographic region.

POTENTIAL ADAPTATION MEASURES

- Determine the load-bearing capacity of each roof.
- Make a building-specific snow removal plan.
- Check roofs for snow accumulation more frequently.
- Establish a snow removal management plan by region.
- Develop the ability to gauge the weight of snow according to its type (e.g., powdery, sticky, wet).

CHALLENGES TO OVERCOME

- Allocating human resources, which will often be needed at the same time.
- Snow removal is carried out under difficult conditions in terms of workers' health and safety, and not all employees have the necessary training.

Snow on the roof of a house with icicles hanging over the edge

Climate hazard

Snow

11. Adapt snow removal procedures and roof design practices to heavy snow accumulation (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Optimize snow removal frequency	Since winter 2019	—	None
Commission an engineering firm to assess the load-bearing capacity of roofs and ensure it is suitable for new snow loads caused by climate change	Since winter 2019	—	18
Develop specific snow removal plans for certain buildings based on their technical characteristics (e.g., age, condition, geographical area)	Since winter 2019	—	None
Take an adaptive approach to snow removal planning on an annual basis by assigning a snow removal management lead for each region (this would involve, for example, planning required resources, checking weather forecasts and gauging snow accumulation on roofs)	Since winter 2019	—	None
Have the ability to quickly gauge the weight of snow according to its type (e.g., powdery, sticky, wet)	Since winter 2019	—	None

12. Adapt vegetation control to the increased growth of certain species

DESCRIPTION

The effects of climate change on vegetation are manifested in different ways. On the one hand, the number of growing degree days increases as temperatures rise. On the other hand, the greater frequency and intensity of extreme weather events increases the occurrence of fallen branches and uprooted trees.

Vegetation can have a variety of impacts on Hydro-Québec operations. Trees and branches can fall on distribution lines and cause power outages if they are not kept far enough away from the lines. Forest pests can also weaken trees, amplifying the problem.

On transmission line rights-of-way, denser vegetation can make access to towers difficult. Roots and uprooted trees can compromise the structural integrity of embankment dams.

FURTHER INFORMATION

Distribution system

- More than 270,000 vegetation control actions (pruning, clearing and logging) and 20,000 customer visits are carried out each year.
- Distribution lines are currently cleared on average every six years.
- From 2016 to 2020, vegetation caused an average of 8,612 power outages (>5 min) per year in the medium- and low-voltage systems.

Transmission system

- Vegetation control work is done on nearly 20,000 ha each year.
- The frequency of work on rights-of-way varies from 3 to 13 years and depends on the type of vegetation and its distance from the lines.
- The further north a transmission line is located, the longer the time between interventions, as vegetation growth is slower.

Tree pruning in a residential neighborhood

Climate hazards

Extreme heat

Freezing rain

Wind

Extreme precipitation

12. Adapt vegetation control to the increased growth of certain species (*cont'd*)

Power generation

- Hydro-Québec owns more than 500 embankment dams.
- The roots of trees growing on an embankment dam may allow water to infiltrate and weaken the structure, requiring remedial work.

POTENTIAL ADAPTATION MEASURES

- Increase the frequency of vegetation inspections and control work.
- Adapt vegetation control cycles based on changing weather patterns and the impact of forest pests on vegetation.
- Revise clearance standards based on hardiness zones and plant growth rates.
- Promote landscaping and recreational activities in rights-of-way.
- Plant and maintain species that grow slowly and are more resistant to pests and diseases.
- Use artificial intelligence to predict plant growth and workload.
- Develop an algorithm to predict the occurrence of fallen trees and branches based on the nature of climate events and the condition of vegetation.
- Assess the impact of Hydro-Québec's approach to vegetation control on the geographic distribution of pests.
- Identify and map pests and diseases that affect vegetation near Hydro-Québec systems.

CHALLENGES TO OVERCOME

- Workload and costs will increase significantly.
- Compensating for a shortage of labor will require greater mechanization of the work.
- Keeping the power system clear of vegetation is becoming increasingly difficult due to faster growth.

12. Adapt vegetation control to the increased growth of certain species (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Increase budgets and resources to carry out the integrated vegetation control program	In progress	—	None
Scale up the felling program for at-risk trees	Ongoing	**Targets**: – Reduce the number of power outages on the distribution system by 25% by 2025 – Improve the rate of power outages associated with vegetation	5
Participate in and support projects led by the NSERC/ Hydro-Québec research chair at Université du Québec à Montréal in relation to the control of tree growth	In progress	**Indicator:** Project advancement and knowledge transfer	None
Resolve Hydro-Québec's safety and service continuity issues in relation to the bigger tree canopy in Montréal	In progress	—	None
Pursue and encourage landscaping and recreational projects in rights-of-way by third parties (e.g., municipalities, farmers)	Ongoing	—	None
Continue to diversify approaches to vegetation control	Ongoing	—	None

13. Maintain good communication with all residential and business customers in a context of growing demand

DESCRIPTION

Climate change leads to more contact with customers due to power outages and equipment failure caused by bad weather. It also increases the amount of on-site work and requests for visits from energy efficiency and power quality specialists. Hydro-Québec also expects increased contact with business customers seeking to take steps to decarbonize their operations and reach carbon neutrality.

FURTHER INFORMATION

- Extreme weather events generate a large number of calls from customers:
  - From 2017 to 2020, Hydro-Québec received an average of 306,062 calls about power outages per year.
  - The numbers of calls about spring flooding in 2017 and 2019 were 10,530 and 9,562, respectively.
  - In 2018, Hydro-Québec received 117 calls following a tornado.
- Sales engineers make 1,500 energy efficiency visits a year.
- Prior to the pandemic, Hydro-Québec made about 500 visits annually to assess power quality.
- Between 2020 and 2025, Hydro-Québec anticipates more requests for technical support from its large-power customers regarding expansion, modernization, decarbonization or energy efficiency projects.

Personnel at Anjou customer relations center

Climate hazards

13. Maintain good communication with all residential and business customers in a context of growing demand (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Adjust procedures, including decision-making and communication diagrams, to be used in crisis situations.
- Ensure online customer tools are updated in a timely manner during extreme weather events.
- Promote Hydro-Québec's outage tracker and other online tools to make customers more aware of the information available.
- Regularly remind customers of the tools to use during extreme weather events to ensure an optimal response.

CHALLENGES TO OVERCOME

- Providing real-time updates to customer information related to climate events requires significant coordination efforts.
- An increase in the volume of cases (e.g., visits, inspections) requiring comprehensive analysis may result in a higher number of field service activities.

13. Maintain good communication with all residential and business customers in a context of growing demand (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Adapt procedures to be used in crisis situations to account for the increase in minor and major weather events and develop tailored plans for business customers whose activities may be affected	Ongoing	**Indicators:** – Customer satisfaction rating – Number of customer contacts related to climate events – Number of on-site service interventions	None
Continue to implement the work schedule management action plan and ensure the proactive and optimal deployment of customer contact and field service teams during weather events	In progress	—	None
Improve communications by promoting online tools (e.g., outage tracker, corporate website) and ensuring that the skills of resources taking calls about power outages or emergencies are kept up to date	2022	**Indicators:** – Customer satisfaction rating – Number of customer contacts related to climate events	None

14. Plan regular activities in light of increased pressure on human resources due to climate change

DESCRIPTION
Increases in the intensity and frequency of extreme weather events mean more power outages, which in turn keep staff busy, making them less available for other tasks such as projects, maintenance and inspections. Extreme events also cause delays in operations, for example when workers are unable to climb structures due to ice or have to wait for a rain shower to end in order to conduct a thermographic analysis. Furthermore, the number of available work hours decreases during extreme heat events.

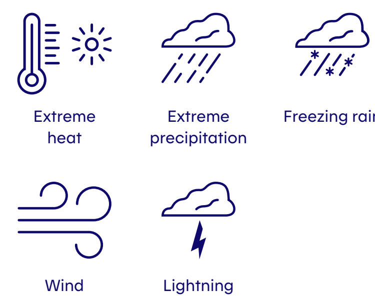
FURTHER INFORMATION
- In 2020, Hydro-Québec had 1,295 employees working on distribution lines.
- During this same year, they spent an average of 30% to 35% of their time repairing breakages and resolving power outages.

POTENTIAL ADAPTATION MEASURES
- Make facilities easier to access through the use of, for example, icephobic coatings and cameras capable of measuring frost levels (see Fact Sheet 16).
- Take weather forecasts into account when scheduling work and assess the potential impact of these forecasts on the workforce.
- Reduce the adverse effects of heat on the workforce. This may be achieved by creating “cool islands,” ensuring personnel are well prepared for working under hot conditions, increasing the number of breaks or scheduling activities in the early morning or late evening (see Fact Sheet 23).
- Assess labor requirements in the case of major events caused by extreme weather conditions.

CHALLENGES TO OVERCOME
- Staff workload is increasing.
- Tasks become more difficult and require more time under extreme weather conditions.

Tornado damage in Mascouche

Climate hazards



14. Plan regular activities in light of increased pressure on human resources due to climate change (*cont'd*)

Action	Implementation	Progress	Other action areas affected
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	**Indicator:** Number of projects using the extreme weather hazard projection map	None
Outsource certain tasks during extreme weather events	2022	—	None
Establish mitigation measures for issues related to employee availability	2022	—	None
Educate managers on the importance of monitoring weather conditions as part of their daily planning activities	Since 2021 (winter conditions) 2022 (summer conditions)	**Indicator:** Number of managers who subscribe to Environment Canada heat alerts (seasonal indicator) or check the weather on a daily basis	None

15. Adapt construction practices to the new climate situation

DESCRIPTION

Certain climate hazards have an impact on the usual ways of working—that is, on the equipment, techniques, processes, procedures and sequences of work normally used. For example, tasks near waterways are more risky and difficult to plan due to the greater variability of water inflows associated with rain, storm cells and melting snow cover. In addition, activities that tend to take place during certain times of year, such as the use of ice bridges, may no longer be possible due to changing conditions (e.g., increased precipitation and mild winter days).

FURTHER INFORMATION

- Increases in the intensity and frequency of precipitation during summer and fall necessitate a change in work sequences.
- Work methods are not adapted to greater variability in the winter climate.

POTENTIAL ADAPTATION MEASURES

- Use remote sensing or other technologies to gauge ice bridge conditions more accurately.
- Take climate projections for snow cover into account in road construction.
- Recalibrate hydrological forecasting models using climate scenarios.
- Take an innovative approach to managing peak flows during refurbishment work.
- Develop new work methods by setting up expert committees and drawing on the approaches of other countries.

CHALLENGES TO OVERCOME

- Developing new practices may:
  - Require more time on worksites
  - Affect work planning if issues are not anticipated
  - Require additional inspections during the work
- Increased construction costs

Construction work
at the Romaine-4 site

Climate hazards

15. Adapt construction practices to the new climate situation (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Recalibrate hydrological forecasting models to take climate projections into account	2022	**Indicator:** Number of projects in which new simulations are used	None
Add measuring stations to the power system to ensure safe monitoring of worksites	Ongoing	—	None

16. Improve facility access during extreme weather events as much as possible

DESCRIPTION
Extreme weather events can make access to various facilities more difficult. Flooding (heavy rain and floods), landslides and forest fires can cause significant damage to road and air infrastructure (roads, bridges, culverts, heliports and airstrips). It may also be impossible to work at heights when there are strong winds or when there is ice on the structures concerned. Maintaining and repairing road and emergency transport (helicopter) infrastructure can incur significant costs.

FURTHER INFORMATION
- Detecting and correcting infrastructure failures in remote areas can take a long time.
- The telecommunications network includes more than 800 sites, the majority of which are difficult to access.
- Many access roads to Hydro-Québec facilities do not belong to Hydro-Québec. It therefore has little influence on their maintenance.

POTENTIAL ADAPTATION MEASURES
- Install remote control systems where possible.
- Install cameras and sensors at telecommunications sites to measure the quantity of freezing rain and observe the structures and their surroundings in real time.
- Ensure that there are at least two ways to access each facility.
- Design and build roads that are more resistant to precipitation and safer to use in the event of severe weather (e.g., create vegetated drainage ditches, use more robust materials, upgrade roads, install protective structures).
- Design and build infrastructure that is more resistant to forest fires (e.g., use more robust materials, control vegetation, install concrete culverts).
- Take a complete inventory of Hydro-Québec's access roads, inspect them more often, and adjust the associated criteria accordingly.

Telecommunications tower completely covered in ice

Climate hazards

16. Improve facility access during extreme weather events as much as possible (*cont'd*)

CHALLENGES TO OVERCOME

- Inspecting the entire road network and associated infrastructure (e.g., ditches, culverts) is a colossal undertaking.
- Extreme weather conditions require the use of unusual means of transportation to ensure the continuity of normal operations, incurring significant additional costs for Hydro-Québec.
- Hydro-Québec may have to maintain access roads that it does not own.

Action	Implementation	Progress	Other action areas affected
Install cameras and sensors at certain telecommunications facilities to measure the quantity of freezing rain and to observe the structures and their surroundings in real time	In progress (pilot project)	**Target**: Produce a report on the pilot project and formulate findings	None
Produce and update records that describe terrain conditions and access issues	2022–2023	**Target**: Update existing fact sheets and create new fact sheets to fill gaps	None
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 3, 4, 10, 20, 21

17. Plan line maintenance work based on new heat stress conditions

DESCRIPTION

Hydro-Québec performs the majority of its line maintenance during the summer. This is the best time, as demand for energy is lower than during the winter, when heating needs are high due to the severe cold. This makes it easier to shut a line down for servicing. However due to climate change, three factors can make shutting down lines during the summer more complicated:

- Increased energy demand due to a greater need for air-conditioning during heat waves
- Higher temperatures, which reduce line capacity
- More extreme weather events causing more power outages

For these reasons, it may become increasingly difficult to schedule line shutdowns during the summer period.

FURTHER INFORMATION

- Power lines are generally designed for an ambient temperature of no more than 30°C. Above this temperature, the current flowing through the lines must be lowered to avoid overheating or excessive stretching. The length of the cable varies depending on its temperature. An overheated line may therefore hang too low and no longer meet the safety criteria with respect to its distance from the ground.
- Hydro-Québec's transmission capacity is already limited in the area south of the Fleuve Saint-Laurent (St. Lawrence River) due to heat stress conditions.
- In Montréal, from 1981 to 2010, the temperature exceeded 30°C an average of 10 days a year. Under a high greenhouse gas emission scenario, this figure would be closer to 40 days a year during the period 2041–2070.

Work on the transmission system

Climate hazards

17. Plan line maintenance work based on new heat stress conditions *(cont'd)*

POTENTIAL ADAPTATION MEASURES

- Install lines with higher operating limits or lower thermal expansion.
- Install more effective cooling mechanisms in substations.
- Educate customers about the importance of reducing energy consumption during peak periods and energy efficiency in general (e.g., Hilo challenges).
- Revise line shutdown schedules to include mild winter days.
- Increase system redundancy.

CHALLENGES TO OVERCOME

- Given the vast scale of the transmission system, any adaptation measure requires a massive effort.
- The longevity of transmission lines (towers, accessories and conductors) means that they are more likely to be affected by climate change during their useful life.

Action	Implementation	Progress	Other action areas affected
Propose optimization strategies as part of an action plan produced by a working group on the thermal capacity of transmission lines	In progress	—	None
Develop tools and protocols to accurately measure and simulate a conductor's temperature to optimize transmission capacity	In progress	—	None

Power Outages and Impacts on Assets

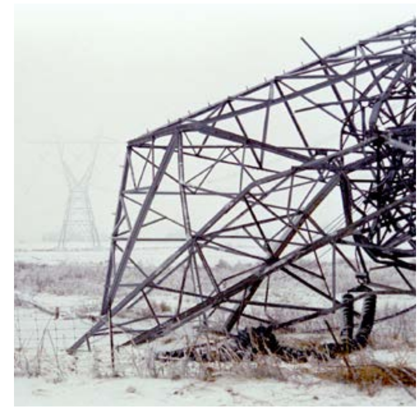
18. Limit the impact of extreme weather events on the reliability of the overhead system

DESCRIPTION
Increases in the frequency and intensity of some extreme weather events will result in more major and minor power outages on the overhead transmission and distribution systems. Furthermore, the long lifespan of certain assets makes them particularly vulnerable.

FURTHER INFORMATION
- In an effort to reduce the number and duration of power outages, Hydro-Québec has implemented action plans for its transmission and distribution systems.
- The overhead system currently experiences an average of 10 to 12 days of major events per year.

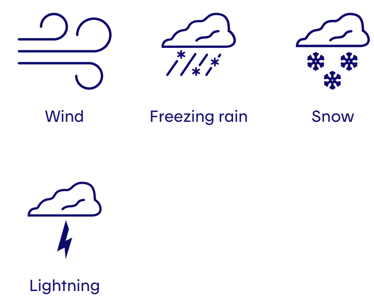
POTENTIAL ADAPTATION MEASURES
- Set up a line patrol to identify restoration problems during power outages.
- Promote power system redundancy; in other words, have different means of performing the same function, which can be substituted for another when needed.
- Improve devices that protect ground wires from lightning strikes.
- Add anti-galloping devices on transmission lines to limit major oscillations.
- Add anti-cascading towers in targeted areas.
- Consult climate projections when designing lines.

CHALLENGES TO OVERCOME
- Greater workloads will increase pressure on existing crews, making them less available for other tasks.
- The costs associated with building a more robust power system are high.



Tower damaged during the 1998 ice storm

Climate hazards



18. Limit the impact of extreme weather events on the reliability of the overhead system (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Experiment with burying certain sections of the distribution system using a new approach requiring less civil engineering work	In progress (pilot project)	—	None
Outsource certain tasks during extreme weather events	2022	—	None
In collaboration with Université du Québec à Montréal and Ouranos, launch a research project examining the impact of climate change on extreme weather hazards that put Québec's hydroelectric and mining infrastructure at risk	2022	**Indicator:** Number of projects using the extreme weather hazard projection chart	None
Boost initiatives to improve service quality (implement plans to reduce the number and duration of power outages)	In progress	—	None
Assess the potential of battery energy storage systems to ensure grid reliability	2022	**Indicator:** Number of new batteries installed	None
Revise the emergency response plan to incorporate climate change factors	2022	—	None
Continue research into the use of icephobic coatings as part of the project on insulators under frost conditions being conducted at Université du Québec à Chicoutimi	In progress	—	None

18. Limit the impact of extreme weather events on the reliability of the overhead system (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Focus efforts on strengthening certain lines using anti-cascading towers in priority areas such as Baie-James, Montréal, the city of Québec and Côte-Nord	In progress	—	None
Revise the emergency stockpile supply strategy to reflect changing extreme weather events in order to repair lines quickly and allow for timely return to service	In progress	—	None

19. Increase the resilience of off-grid systems

DESCRIPTION
Off-grid systems are power generation and distribution systems that are not connected to Hydro-Québec's main power system. These systems are generally located in remote areas where they tend to be more vulnerable to climate hazards such as rising sea levels, coastal erosion, more frequent freeze-thaw cycles, thawing permafrost, high tide flooding, and more frequent high winds accompanying storms and precipitation. All these phenomena represent risks to the infrastructure of each off-grid system.

FURTHER INFORMATION
- Hydro-Québec has 24 off-grid systems across four administrative regions: Nord-du-Québec, Côte-Nord, Mauricie and Gaspésie–Îles-de-la-Madeleine.
- Off-grid generating stations are typically powered by diesel or heavy fuel oil, although two are hydroelectric.
- Hydro-Québec is currently in the process of converting its fossil-based systems to renewable energy sources (hydropower, solar and wind).
- Wet snow, freezing fog and freezing rain can decrease wind energy generation by up to 20%.

Off-grid system located in a northern Québec community

Climate hazards

19. Increase the resilience of off-grid systems (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Institute flood prevention measures such as building protective structures, naturalizing shorelines, practising beach nourishment, relocating generating stations to higher ground, adding valves and drains, laying permeable roadways and creating rain gardens.
- Adjust emergency plans relating to extreme weather events to take climate change into account.
- Increase the frequency of inspections and adjust design criteria to take climate change into account.
- Install wind turbines that are suitable for northern climate conditions (e.g., equipped with a de-icing system).
- Schedule more frequent upgrades to buildings affected by thawing permafrost.
- Design buildings that are better able to withstand freeze-thaw cycles (e.g., in terms of drainage, roof membrane protection and effective moisture control).

CHALLENGES TO OVERCOME

- Finding suitable land—that is on higher ground, near a community and unoccupied—to build generating stations on can be difficult.
- Few wind turbine manufacturers offer de-icing systems that are reliable and effective.

19. Increase the resilience of off-grid systems (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Analyze the risks for each generating station in Nunavik based on maps of natural hazards (e.g., avalanches, erosion and submersion) produced by the Centre d'études nordiques for the Ministère de Sécurité publique du Québec	2022	**Indicator:** Number of off-grid systems analyzed	None
Assess the climate change resilience of new facilities planned as part of large-scale projects	In progress	**Indicator:** Number of climate change resilience analyses carried out	None
Assess losses associated with ice buildup for future wind farms and consider installing wind turbines equipped with de-icing systems	Ongoing	**Indicator:** Number of wind farms analyzed	None

20. Prevent flooding upstream and downstream of generating stations

DESCRIPTION
Climate change has the potential to increase the frequency and magnitude of flooding in certain areas. Whether upstream or downstream of a generating station, flooding can have an impact on worker health and safety as well as the environment. If water levels reach the turbines, this can cause severe damage to the equipment, forcing the generating station to shut down for an extended period. The financial losses associated with suspending production and repairing equipment can be significant.

FURTHER INFORMATION
- The risk of flooding is generally higher for generating stations that are above ground than those that are underground.

POTENTIAL ADAPTATION MEASURES
- Increase the reliability of flood detection systems by ensuring that they include the automatic closure of intake gates as well as signage to ensure that personnel can quickly evacuate the generating station.
- Ensure that the electrical circuit to close the intake gates in the event of a flooding emergency has a reliable power source.

CHALLENGES TO OVERCOME
- Assessing flooding impacts on generating stations due to climate change is a major undertaking that must be done on a case-by-case basis.
- Engineers must establish clear guidelines to ensure that climate change is properly incorporated into infrastructure design.

Structures at Chute-Bell, Grenville-sur-la-Rouge

Climate hazard

Streamflow and flooding

20. Prevent flooding upstream and downstream of generating stations (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 3, 4, 10, 16, 21
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Use the Climate Atlas in infrastructure design by 2024 – Incorporate the use of hydrological projections in project planning by 2024	1, 2, 3, 4, 21

21. Increase the resilience of critical buildings

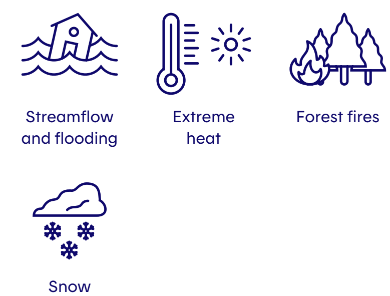
DESCRIPTION
Climate hazards such as floods, forest fires and landslides can cause significant damage to buildings, whether they are used for power generation or for living quarters. Since dams are often located in remote areas, Hydro-Québec must house its personnel near their workplace, ensuring their comfort and safety. Heat waves are another consideration, as they can prevent employees from working effectively if buildings are not air-conditioned.

FURTHER INFORMATION
- In 2020, employees at Péribonka generating station had to vacate Hydro-Québec living quarters to make way for crews that were fighting a fire within one kilometre of the station. Fortunately, the living quarters escaped the flames.
- Most generating stations are located in remote areas without nearby fire services.
- Areas exposed to landslides may be even more at risk due to climate change.

POTENTIAL ADAPTATION MEASURES
- Institute measures to protect against forest fires, such as managing vegetation responsibly, choosing more fire-resistant materials and tree species, maintaining roofs and gutters and installing detection systems (see Fact Sheet 22).
- Create a map showing which buildings are most vulnerable to the effects of climate change.
- Institute measures to eliminate the risk of structural collapse, such as adjusting design parameters, reinforcing existing structures and clearing snow from roofs more often.
- Institute measures to protect against flooding of buildings occupied by personnel, such as reducing impermeable surfaces or installing protective structures, check valves, copings and foundation drains (see Fact Sheet 8).
- Establish a temporary measures plan in the event of the loss of a building (e.g., plan for accommodation at other sites).

Aerial view of building at Bryson generating station

Climate hazards



21. Increase the resilience of critical buildings (*cont'd*)

CHALLENGES TO OVERCOME

- Engineers must establish clear guidelines to ensure that climate change is incorporated into infrastructure design.
- Carrying out additional inspections of such a large number of buildings, including various related infrastructure (e.g., parking lots, sewers, rainwater drainage) represents an enormous amount of work.

Action	Implementation	Progress	Other action areas affected
Conduct climate change resilience assessments of targeted facilities (generally during refurbishment work)	In progress	**Indicator:** Number of facilities assessed for resilience	2, 3, 4, 10, 16, 20
Facilitate and standardize the use of hydrological and climate projections using a data portal	In progress	**Targets**: – Incorporate the use of the Climate Atlas in infrastructure design by 2024 – Incorporate the use of hydrological projections in project planning by 2024	1, 2, 3, 4, 20

22. Protect the safety of assets and activities in areas exposed to forest fire risk

DESCRIPTION

Over the coming years, the number of forest fires will increase significantly in some areas due to climate change. Several factors contribute to a longer active fire season, such as forest maturation, more frequent periods of heat and drought, reduced snow cover, higher lightning strike rates and the earlier arrival of spring. This risk affects all Hydro-Québec's activities, from the generation, transmission and distribution of power to telecommunications services. A forest fire threatening or directly impacting company assets can have devastating effects on service reliability, worker health and safety, the environment and Hydro-Québec's finances. Furthermore, much of the infrastructure that is critical to Hydro-Québec activities is located in remote areas, far from organized fire departments.

FURTHER INFORMATION

- In 2017, a research project was initiated by Université du Québec à Rimouski, in partnership with Hydro-Québec's research center and Ouranos, with the aim of modeling forest fire probabilities over the coming years.
- It is difficult to establish how many fires take place on an annual basis. However, data for a well-defined area in northwestern Québec over the past 30 years suggest that an average of 2.5% of the area burns each year. Therefore, the equivalent of 100% of the area is likely to be affected by forest fire over a 40-year period.
- Hydro-Québec has established a monitoring and response agreement with the Société de protection des forêts contre le feu (SOPFEU), covering 155 critical pieces of infrastructure located in northern Québec.

Daytime darkness caused by a forest fire near the Sarcelle camp

Climate hazards

22. Protect the safety of assets and activities in areas exposed to forest fire risk (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Consider using more fire-resistant materials.
- Develop and implement responsible vegetation management practices, including creating fire breaks and using more fire-resistant tree species.
- Review forest fire protocols on a regular basis.
- Create a list of all possible means of extinguishing fires and of protecting people and assets in anticipation of fire risk situations.
- Develop a forest fire risk management model identifying the most vulnerable areas.
- Maintain roofs, gutters and areas around buildings, removing easily combustible materials (e.g., leaf litter).
- Incorporate local Indigenous knowledge into the activities of multidisciplinary forest management committees.
- Prior to the start of the fire season, communicate fire risks to forest users and educate them on the importance of applying best practices to prevent forest fires.

CHALLENGES TO OVERCOME

- Regardless of the adaptation measures implemented, forest fires will remain a risk that is difficult to predict and impossible to avoid completely.
- Planning resources for future seasons will remain a challenge.

22. Protect the safety of assets and activities in areas exposed to forest fire risk (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Continue mapping forest fire probabilities due to climate change in the Baie-James region (research project in progress with Ouranos and Université du Québec à Rimouski)	In progress	**Indicator:** Number of projects in which the map is used	12, 21
Strengthen prevention efforts by implementing adaptation solutions as a priority for critical infrastructure and renewing the SOPFEU agreement	Ongoing	—	12, 21

Worker Health and Safety

23. Protect personnel from heat stroke and related conditions

DESCRIPTION

Heat waves can affect personnel working outdoors, but also those who work inside buildings without air-conditioning or in certain generating stations where the temperature inside can be higher than it is outside. Employees required to wear personal protective equipment are particularly affected.

Climate change can cause longer, more frequent and more severe heat waves that increase employees' risk of heat stroke and related conditions (exhaustion, edema, electrolyte imbalance, kidney dysfunction, exacerbation of certain respiratory and cardiovascular diseases).

FURTHER INFORMATION

- With more days of high heat conditions projected per year, workers' needs in terms of breaks and hydration are expected to increase.
- A range of risk factors can lead to heat stroke:
  - High ambient temperature and humidity
  - Working in the sun
  - Wearing dark or inappropriate clothing
  - Doing physically demanding work without rest periods
  - Inadequate hydration
  - Lack of heat acclimation
- High heat can also cause glasses to fog up and hands to sweat, potentially increasing the risk of accidents and incidents for certain workers.

Distribution line workers

Climate hazard

Extreme heat

23. Protect personnel from heat stroke and related conditions (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Create "cool islands" to allow personnel to take breaks sheltered from the heat.
- Implement measures to limit the heat island effect (see Fact Sheet 6).
- Check weather forecasts on a daily basis and plan work accordingly.
- Before workers are exposed to heat, provide training on the health and safety risks of heat stroke and promote best practices (e.g., taking more breaks, eating and drinking appropriately to stay hydrated, recognizing the signs and symptoms of heat stroke).
- Keep indoor workplaces as cool as possible, such as by increasing air-conditioning and ventilation capacity, keeping blinds closed and increasing airflow rates in industrial spaces.
- Provide workers with the equipment they need to stay comfortable in the heat (water bottles, neck coolers, appropriate clothing).
- Increase the number of breaks, especially during the first heat wave of the season to promote better heat acclimation.

CHALLENGES TO OVERCOME

- It is not always possible to reorganize work.
- Not all adaptation measures can be applied to all outdoor crews, especially when they are away from air-conditioned buildings and vehicles.

23. Protect personnel from heat stroke and related conditions (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Educate managers on the importance of monitoring weather conditions as part of their daily planning activities	In progress (winter conditions), 2022 (summer conditions)	**Indicator:** Number of managers who subscribe to Environment Canada heat alerts (seasonal indicator) or check the weather on a daily basis	14
Promote and deliver training on working in high heat conditions (intranet site)	In progress	**Indicator:** Number of personnel who have received training on working in high heat conditions	None
Propose guidelines to systematize the planning of outdoor work and to ensure the appropriate organization of work in advance of extreme heat events	2022	**Indicator:** Number of postponements of work due to heat	14
Add a poster to the distribution schedule to raise awareness of the importance of closing blinds during a heat wave	2022	**Indicator:** Number of buildings where the awareness poster has been put up	6
Publicize the availability of equipment that Hydro-Québec personnel can use to keep cool (e.g., neck coolers, water bottles)	In progress	**Indicator:** Number of cooling items purchased annually	None

24. Protect personnel from illnesses associated with working outdoors

DESCRIPTION

Climate change increases the risks associated with working outdoors. First, there is an increase in both the number and the geographic range of vectors and plants associated with certain pathologies (e.g., Lyme disease, West Nile virus, phytodermatitis, phytophotodermatitis, insect bites and stings).

Secondly, seasonal flooding can expose personnel to certain waterborne diseases (e.g., sewage worker's syndrome, gastroenteritis and hepatitis A in the case of contact with wastewater), injury (tetanus), hypothermia and drowning.

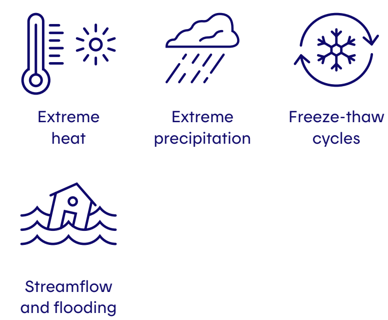
Furthermore, seasonal allergies currently affect between 10% and 20% of the population. With climate change, their prevalence is likely to increase, leading to more allergy symptoms and asthma-like syndromes.

FURTHER INFORMATION

- Lyme disease, West Nile virus and plant-related injuries are risks that Hydro-Québec is aware of and manages.
- Cases of other rare diseases and viruses borne by insects and other animals (e.g., rabies, hantavirus pulmonary syndrome, chikungunya, dengue fever and encephalitis) are projected to appear or increase by 2080.
- As waterways are subject to the consequences of rapid melting of snow cover, increased ice movement from freeze-thaw events and heavy precipitation, seasonal flooding and other water-related issues are expected to become more common.

Invasive plants in a transmission line right-of-way

Climate hazards



24. Protect personnel from illnesses associated with working outdoors (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Provide personnel with the equipment they need to protect themselves (e.g., long clothing, closed shoes, tweezers in first aid kits, mosquito repellent).
- Offer vaccination where possible and appropriate.
- Provide training (e.g., identifying disease vectors, adopting better work habits).
- Share the risk maps for Lyme disease produced by Institut national de santé publique du Québec (INSPQ).
- Create safe work areas (e.g., put down mulch, remove dead leaves and clear brush in wooded areas).
- Establish a procedure in case of infection or contact with toxic plants.
- Ensure workers take basic health and safety precautions in flood conditions.

CHALLENGES TO OVERCOME

- Raising awareness of risks that have a low probability of occurring (e.g., rabies, hantavirus pulmonary syndrome, insect-borne diseases) can be a challenge.
- Compiling a list of all work teams potentially affected by a particular risk requires careful analysis to promote the relevant training for those concerned.

24. Protect personnel from illnesses associated with working outdoors (*cont'd*)

Action	Implementation	Progress	Other action areas affected
Ensure the mass dissemination of information on invasive plant species and how to treat their effects on the skin	Ongoing	**Indicator:** Number of information sessions or intranet site visits	None
Promote the program raising awareness of best practices for avoiding insect bites and stings that may cause allergic reactions	Ongoing	**Indicator:** Number of information sessions or intranet site visits	None
Promote tools for preventing Lyme disease (INSPQ map, post-exposure prophylaxis, best prevention practices, keeping a record of tick bites)	In progress	**Indicator:** Number of presentations or intranet site visits	None
Each spring, issue reminders about how to prevent health issues in the event of flooding	Ongoing	**Indicator:** Number of presentations or intranet site visits	20

25. Adjust health and safety activities to prevent slips and falls on ice

DESCRIPTION

Increased frequency and intensity of certain climate hazards during the winter—such as freezing rain, rain followed by a freeze, and sudden temperature fluctuations—may lead to more slips and falls on icy surfaces.

These weather events tend to increase the risk of hip and wrist fractures in particular, as well as hospital admissions for trauma (Ali and Willett, 2015).

FURTHER INFORMATION

- Climate change is likely to increase the frequency of slips and falls on ice, but not their severity.
- Over the past several years, Hydro-Québec has invested significant effort in adjusting the design and maintenance of its parking lots, which has reduced the risk of falls.

POTENTIAL ADAPTATION MEASURES

- Provide employees with the necessary equipment to ensure their safety, such as appropriate footwear, crampons or spikes, de-icing products, shovels and lights.
- Provide training on fall hazards and appropriate prevention measures.
- Inspect and maintain traffic routes and parking areas around Hydro-Québec buildings and facilities.
- Monitor weather forecasts and issue timely alerts.
- Ensure adequate lighting for traffic routes and parking areas.
- Organize work so as to limit or eliminate exposure to severe weather (e.g., by making telework mandatory or postponing work during storms).
- Improve the design of traffic routes and parking areas (e.g., covering pedestrian areas and building entrances, heating certain vehicle areas, ensuring zones for pedestrians and for vehicles are clearly marked).

Fall prevention in parking lots

Climate hazards

25. Adjust health and safety activities to prevent slips and falls on ice (*cont'd*)

CHALLENGES TO OVERCOME

- The adoption and implementation of measures may vary from one workplace to another.
- Significant effort may be required to ensure compliance with measures recommending postponing work by personnel, including managers.

Action	Implementation	Progress	Other action areas affected
Encourage first-level managers to refer to the seasonal indicator during the winter and to use a tool to help plan prevention measures accordingly	In progress (pilot project)	**Indicators:** – Number of first-level managers using the seasonal indicator on a daily basis during the winter – Number of managers receiving Environment Canada weather alerts	None
Provide corporate guidelines on organizing work to limit or eliminate exposure to severe weather (e.g., by making telework mandatory or postponing work during snowstorms or ice storms)	2022	**Targets**: – Approval of guidelines – Communication of guidelines to personnel concerned	None

26. Emphasize the importance of safe behaviors on roads and waterways in the context of climate change

DESCRIPTION

Increased frequency and intensity of certain climate hazards (e.g., thunderstorms, snowstorms and ice storms) can lead to adverse conditions for traveling on road, off road or on the water. Adverse conditions include:

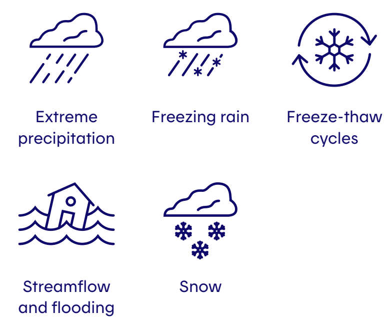
- Reduced visibility
- Longer braking distances
- Reduced alertness due to fatigue
- Reduced traction
- Reduced quality of traffic routes (e.g., snowmobile trails that are obstructed or lacking snow cover)
- High water levels

FURTHER INFORMATION

- Each year, the Ministère des Transports du Québec plants trees to act as windbreaks and improve the safety of road users in exposed areas, as these barriers are effective in reducing blowing snow and snow accumulation.
- Winter conditions make roads more dangerous, with the number of collisions increasing significantly during this period (October to March) compared to snow-free periods (April to September).
- In total, Hydro-Québec personnel travel approximately 100 million kilometres per year.
- Heavy snowfalls are set to increase in northern Québec.
- Vehicles are increasingly equipped with smart driving tools.

Damage following an ice storm

Climate hazards



26. Emphasize the importance of safe behaviors on roads and waterways in the context of climate change (*cont'd*)

POTENTIAL ADAPTATION MEASURES

- Plan trips so as to limit the distance traveled or reduce driving time.
- Check weather conditions before planning a trip and reschedule as needed.
- Educate personnel about unsafe driving behaviors.
- Ensure that every vehicle or boat supplied to personnel is in good condition and is suitable for both the trip and the task to be performed.
- Implement a vehicle inspection and preventive maintenance program, as well as a procedure for reporting defects, and ensure they are applied.
- Train workers who need to travel, whether on or off the road, to help them acquire new skills and adopt best practices.
- Implement a travel risk management policy that sets out roles and responsibilities, preventive measures and expectations.

CHALLENGES TO OVERCOME

- Ensuring compliance with new occupational health and safety practices can be a challenge.
- When personnel are given time off to take part in training activities, they are not available to carry out their usual work.

Action	Implementation	Progress	Other action areas affected
Provide corporate guidelines on organizing work to limit or eliminate exposure to severe weather (e.g., by making telework mandatory or postponing work during snowstorms or ice storms)	2022	**Indicator:** Approval of guidelines	None
Update safety guidelines for working on or near water	2022	**Indicator:** Approval of guidelines	None

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