CASESTUDY SERIES

EXTREME WEATHER

Ice storm | Canada | January 1998

This case study is part of an extreme weather impact project, in partnership with Swiss RE Corporate Solutions and Marsh & McLennan Companies, which aims to identify and share best practice within the energy sector to enable more agile and adaptive response to extreme weather and natural hazard impacts on energy systems and supplies.

CASE STUDY AT GLANCE

WEATHER EVENT
Ice storm

ORGANISATION
Hydro Quebec (HQ)

INDUSTRY SUB-SECTOR
Generation, Transmission Distribution

RESILIENCE RESPONSE
Physical hardening, R&D, collaborations and partnerships

RESILIENCE COSTS
815-1028 M$ (Hydro-Quebec)

Between January 5 and 10, 1998, Québec experienced exceptionally harsh weather as three successive storms left up to 110 mm of ice over the south of the province. Though robust and well-maintained, the Hydro-Québec (HQ) grid suffered unprecedented damage. Thousands of poles, towers and kilometres of lines fell, often through a domino effect, sometimes increasing by 80% the time it took to restore service to customers. In the days and weeks that followed, thousands of HQ workers, with substantial support from colleagues from Québec companies and neighbouring electrical utilities, worked relentlessly to restore power in the regions hardest hit. Following the event, HQ made a series of major grid investments to better withstand the impacts of such extreme weather events. This includes setting new construction standards to increase the mechanical strength of the grid, vegetation control near T&D lines and changing the configuration of the T&D system to make energy sources more secure and to include redundant sources of supply in case of line failures.

This case study describes the events related to the exceptional ice storm of 1998, which caused widespread damage to the T&D system of HQ. The facts presented here are retrieved from the enterprise's technical documentation, presentations, papers and archives, information available publicly at the HQ's site devoted to this event, as well as from findings and recommendations presented by the Special Governmental Commission (Commission Nicolet) created following the icestorm.

CONTEXT

ORGANISATIONAL PROFILE: HYDRO QUEBEC

- Manages 63 hydroelectric power plants, 38 GW approximately installed generation power, and 353 hydroelectric generators.
- Operates the most extended and complex transmission line network in North-America, with over 34,000 km comprising high voltage (49 kV to 735/765 kV) lines and 533 transmission substations.
- 85% of concentrated load is located in the south within the larger Montréal (Metropolitan) loop.
- 15 strategic inter-connections with neighbour grids for exports/imports (Ontario, New Brunswick, NE USA).

ICE STORM, 1998

Three episodes of freezing rain with average ice accretion between 50 and 70 mm. The regions of Outaouais, Montérégie, Beauce and Montréal were the hardest hit

ENERGY IMPACTS

Storms damaged 24,000 poles, 900 steel towers and 3,000 km of lines and left 1,393,000 customers without power.

The ice storm has had an overall cost to the public finances of $1.656 billion with two-thirds or $ 1.028 billion, was borne by the Québec government, directly or through HQ.

Starting on January 6, the ice storm hit the T&D system in and around Montréal hard. A short-circuit signal tripped switches that put T&D lines out of commission. Ground wires sagged under the weight of the ice and the suspension system of many transmission lines broke and fell, creating short circuits. Fasteners holding power lines and ground wires snapped under the heavy ice and some towers were pulled down by the shift in load. When the transmission lines were no longer working, HQ used other circuits to provide service, however these also collapsed, leading to a breakdown in power supply. Although hydropower stations were still generating electricity, it could not get to the substations and the distribution system that would carry it to customers. In urban areas, fallen branches and trees damaged distribution lines and poles, and in rural areas, transformers caught fire and power lines snapped under the weight of the ice. Violent winds further damaged distribution lines.

THE 1998 ICE STORM ❄

The 1998 ice storm was exceptional because of two unusual situations that occurred hundreds of kilometres away from Québec. First, El Niño caused a large mass of warm air to form over the Gulf of Mexico. Due to prevailing winds, this warm air mass moved to Québec followed by another one. Second, the usual pattern of west-to-east prevailing winds stopped for a few days as a result of a major high-pressure system that stationed over Newfoundland and Labrador. The 1998 ice storm consisted of three successive freezing rainfall events within a very brief span of time, covering a space of about 400 000 km^2, of which 130 000 km^2 were in Québec. According to Environment Canada, during these three episodes of freezing rain, the average ice accretion was between 50 and 70 mm.

RESILIENCE: RESPONSE AND RECOVERY

The whole society was mobilized in recovery activities. Every afternoon at 5, the Quebec's Premier Lucien Bouchard, HQ's President and CEO, André Caillé, and a representative of the Organisation de la sécurité civile (ORSC) held a press briefing to inform the public about the condition of the grid. The aim was to provide accurate information and keep the public informed at every stage of the response. The Québec government became responsible for overseeing the entire emergency response plan and maintaining the line of communication between the public and civil society organizations, HQ and the Canadian Armed Forces.

On January 10, the ORSC set 'Operation Ice Storm' into motion, which comprised several work units, each charged with a priority mission to assist disaster victims. Some 750 volunteers from government departments and agencies took care of administration, food, financial assistance, firewood, generators, accommodation and information. Close to 9,000 soldiers were called in to help pick up branches, dispose of broken parts of transmission and distribution lines, transport new components for rebuilding lines and ensuring safety. Thanks to their invaluable assistance, the ORSC, fire fighters, police and HQ employees could concentrate on their own essential duties. The media played a dual role in the ice storm. Firstly, they provided information on the grid's condition to blackout victims and the public at large. They also reported on events in the field and painted a picture of the situation, complementing those of other players. People in disaster areas especially appreciated radio coverage.

The main underpinning of the emergency response plan was indisputably the mutual support of Quebecers in all regions. Not only did they offer room and board to friends and strangers alike but they generously donated cords of firewood, generators, food and blankets. They ran shelters and comforted victims. Some companies, like Zellers and Walmart, provided blankets to the town of Saint-Jean-sur-Richelieu and L'entrepôt RONA and Canadian Tire stayed open around the clock so that people could buy tools to clean up or rebuild.

From the very outset, HQ set up 30 missions to be deployed in the affected areas. Each mission consisted of some 120 people, including a mission chief, a building supply procurement manager, about 50 soldiers, tree trimmers, line crews and a community relations officer. Disaster victims were reassured when the mission convoys showed up. On top of that, 1,500 tree trimmers and line workers from 29 utilities came from other Canadian provinces and the United States to help HQ's crews. Given the urgency of the situation, HQ decided to put up a temporary transmission system using wooden H-frames. They were later replaced by sturdier steel towers. A transmission line that would usually take four months to build went up in two weeks. Before the T&D lines could be rebuilt, all the components had to be on hand. Those working on building supply procurement did their very best to get the 5,973 km of cable, 30,929 poles, 167,848 insulators, 6,775 transformers, 1,168 disconnect switches and 10,002 cutouts needed to rebuild the grid.

Quebecers really appreciated HQ's candor and reassuring presence throughout the crisis. On top of communications in the field through missions and daily press briefings by the Premier and HQ's President and CEO, disaster victims could count on the media relations team 24/7. The team used every means of communication available to them to rise to the challenge. The HQ's website, which was still in its infancy, actually had more visitors in January 1998 (1,250,000 clicks) than it has had in any month since. A year later, in 1999, HQ received an award for its communications during the crisis.

RESILIENCE: PREVENTION AND MITIGATION

Following the 1998 ice storm, HQ has undertaken a comprehensive programme to reinforce its grid. This includes R&D efforts to better understand icing events and mitigation measures to strengthen facilities and assets. Test lines were built at HQ's research institute, IREQ, in order to replicate icing conditions, and to test and validate specific designs and parameters. New maps were produced for extreme winds, ice accumulation, frosts and their combinations. Results were incorporated into construction standards and methods, while various research

projects helped to make the power system more robust. Innovations include the new generation of insulators to better protect facilities and interphase spacers that curb the effects of galloping and high-amplitude oscillations along overhead conductors. Several projects to secure power supply to customers were implemented such as diversifying generation sources (e.g. interconnections) and supply corridors (e.g. Montreal loop). More than 900 km of lines were rehabilitated to more robust design criteria (greater than the CSA Standard) and with the installation of anti-cascading pylons. New posts and 295 km of new lines were added while existing 552km of lines were also reinforced. A new 1,250 MW interconnection to Ontario (Outaouais substation) was built. Other preventive and mitigation measures include:

- Vegetation control to prevent power failures by maintaining clearance around power lines.
- Sygivre, a real-time ice storm management system that detects ice storms, tracks their development and keeps potential users informed.
- De-Icing means: Remotely Operated De-Icing All Weather Vehicle, Lévis Substation De-Icing, De-Icer actuated by Catridge, On-Load Network De-Icer, and Joule Effect De-Icing.
- Towers in reserve at the Lines' Emergency Bank.
- Emergency measures plan updated.

ANTICIPATION OF FUTURE EVENTS

On top of the improved operational and management practices as well as R&D and innovation at HQ, further recommendations were made to cope with future extreme weather risks and uncertainties as follows:

- Pursue the aim of excellence in general, risk and operation management as well as asset management atall organizational levels through a continuous improvement.
- Continue participating in various pertinent industry working groups to ensure leadership among electrical utilities and define future works.
- Continue participating in relevant standardization bodies in order to influence orientations in the standardization and regulatory framework.
- Continue participating at pertinent conferences and other forums enabling further contacts, feedbacks and balisage among pairs.
- R&D and innovation, collaboration with IREQ, universities, other research institutions.
- Develop and integrate new technologies or improve existing ones which would help increase efficiency of preventive and mitigating measures (e.g. smart grid features).
- Develop new analysis methods and models able to quantify impacts of extreme weather events in a complex operational and business environment and its deep uncertainties. Those new approaches should provide new insights and enable assessing the adequacy of preventive and mitigating measures with regard to the overall performance and resilience of the organization and support a sound decision making at all management levels. These activities may involve i) understanding short- and long-term impacts of extreme weather events on assets and their systems such as required performance, reliability and availability, physical and structural integrity, duration of their useful life; ii) improving ordeveloping new risk analysis and aggregation methods in the context of the complexity and deep uncertainties, including the characterization of systemic and emergent risks as well as those of extreme weather events and iii) enhancing multi-criteria decision-making methods in order to better integrate the impact of overall complexity and interdependences to their outcomes.

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