9.3 HYDRO-QUÉBEC COPING WITH CLIMATE CHANGE ANTICIPATED EFFECTS

René Roy * and Georges Desrochers
Hydro-Québec

Van Thanh Van Nguyen
McGill University

1. INTRODUCTION

HYDRO-QUÉBEC

Created in 1944 by the Québec government, its only shareholder, Hydro-Québec supplies electricity to over 3.5 million Québec customers. The company also does business with dozens of power companies in northeastern North America and participates in energy-related infrastructure projects on several continents.

With assets of nearly $60 billion, annual sales of $11.4 billion and a work force of 20,676, Hydro-Québec ranks among the leaders of the North American energy industry. Approximately 97% of the installed capacity is based on hydropower, which translates into significant economic and environmental benefits. In ecological terms, hydroelectricity has many advantages at a time when considerable efforts must be made to reduce greenhouse gas emissions.

Four divisions in charge of core operations

Québec opened its wholesale electricity market to competition in 1997. To adapt to the new regulatory environment, Hydro-Québec restructured its activities, assigning responsibility for its core operations to four business divisions:

- Hydro-Québec Production
- Hydro-Québec Distribution
- TransÉnergie
- Hydro-Québec Engineering, procurement and Construction

Outstanding environmental performance

Hydro-Québec's excellent environmental performance stems from two main factors, namely the choice of a clean generating option (hydroelectricity) and the adoption, in the early 70s, of measures to improve the environmental management of its activities.

Thanks to hydroelectricity, Hydro-Québec supplies renewable, safe and clean energy to its customers.

In 1999, the company produced 29% of the electricity generated in Canada but only 0.8% of CO_2 emissions, 1.5% of SO_2 emissions and 1.8% of NO_x emissions from power generation.

Its electricity sales outside Québec also help obviate the need for neighbouring systems to use their thermal generating facilities, thereby contributing to an improvement in air quality in Québec and on the entire North American continent.

In 1997, Hydro-Québec began implementing an environmental management system in compliance with ISO standard 14001. This system will be deployed in all business units by 2002.

Technological innovation: The key to profitability and efficiency

In 2000, Hydro-Québec invested slightly over $100 million in technological innovation projects, ranking first in this area among Canadian utilities and fifteenth in Canada as a whole. The company intends to remain at the forefront of technological advances and to capitalize as much as possible on the benefits of R&D.

The efficiency of Québec's power system as a whole from production to consumption is already impressive. In order to continue enhancing this strong performance, Hydro-Québec focuses a significant part of its technological innovation efforts on the generation, transmission and distribution of high-quality power, at the lowest cost and as efficiently as possible.

* *Corresponding author address :* René Roy, Project Manager, Hydro-Québec, 75 René-Lévesque Blvd, 9th Floor, Montreal, Quebec, CANADA, H2Z 1A4;
e-mail : roy.rene@hydro.qc.ca

2. HYDRO-QUÉBEC AND CLIMATE CHANGE

Considering that Hydro-Québec is generating his electricity out of hydro power, the company decided to investigate in further details the potential effects of climate change on the availability of his primary fuel : the water. Besides the effects of climate change on the water availability upstream our reservoirs, we are anticipating significant changes in the electric load pattern and volume that we would like to document. Finally, the evolution of the climate may result in increasing the occurrence of extreme events (floods, droughts, freezing rain, etc.) that may considerably affect our installations (transportation and distribution networks, dams, power houses, etc.).

With the very important anticipated effects of climate change in the above mentioned areas in mind, Hydro-Québec decided to structure his efforts to evaluate the impacts of climate changes on different fields of activities and to adapt to the most probable changes foreseen. The initiatives are threefold :

- Hydro-Québec corporate project on climate change
- Participation in the Ouranos Consortium
- Participation in the E7 Climate Change Working Group

2.1 Hydro-Québec corporate project on Climate Change

The anticipated consequences of Climate Change on electric load, water inflows and extreme events led Hydro-Québec to initiate at the beginning of 2001 a programme to evaluate the impacts of climate change and eventually to develop strategies of adaptation. The Project is subdivided into three major phases :

2.1.1 Investigate the areas of activities that might be affected by climate change

We first identified the most important fields of activities that might be affected by climate change (Figure 1).

Those fields of activities can be arranged in three different groups (first level concerns) according to the anticipated affects related to the modification of ;

✓ the hydrologic regime ⇨ water availability;
✓ the thermal regime ⇨ electricity demand;
✓ the occurrence of extreme events.

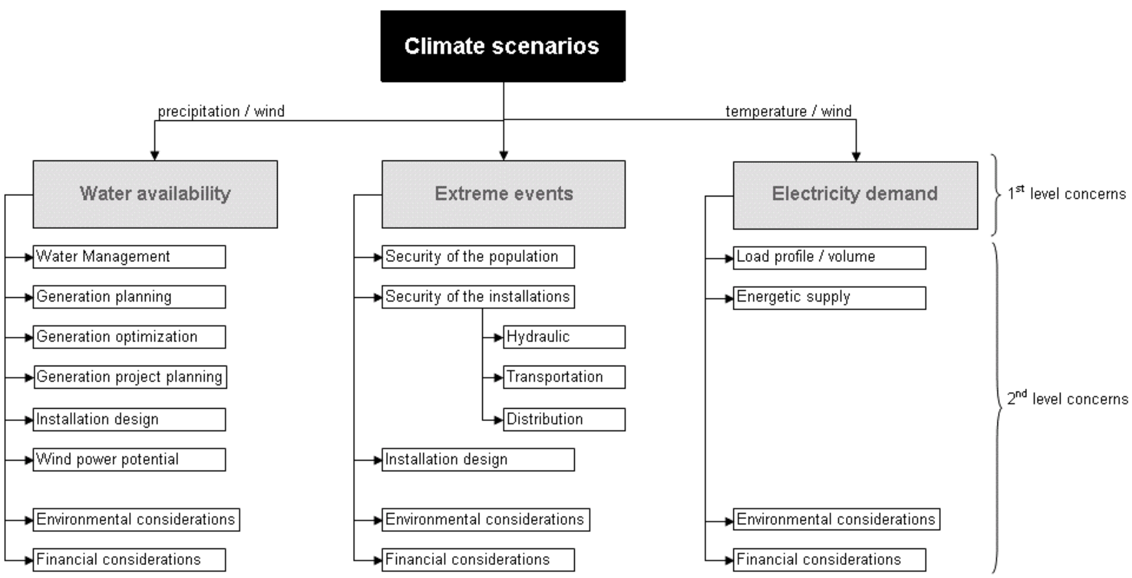

Figure 1 Most important fields of activities that might be affected in the perspective of Climate Change

2.1.2 Evaluate the impacts of climate change related to the targeted activities

We have undertaken studies to evaluate the consequences of climate change scenarios on water availability, electricity demand and extreme events (first level concerns on Figure 1). The electric demand scenarios, the water inflows scenarios and the anticipated extreme events scenarios according to the anticipated climate change shall the be used to address the impacts on second level concerns related to these scenarios.

We realized that the likelihood of impact studies rely on the quality of the selected climate change scenarios. General Circulation Models (GCMs) have been recognized to be able to represent reasonably well the main features of the global atmospheric circulation, but these models so far could not reproduce well details of regional climate conditions (e.g., precipitation) at temporal and spatial scales of relevance for our specific concerns (IPCC, 2001; Xu, 1999). Hence, there is a need to develop tools for downscaling GCM predictions of climate change to regional and local or station scales. In recent years, different downscaling methods have been proposed in a number of studies around the world (Murphy, 1999; Yarnal et al., 2001; Wilby et al., 2002). Of particular importance for the management of water resources systems are those procedures dealing with the linkage of the large-scale climate variability to the historical observations of the surface parameters of interest (e.g., precipitation, temperature, etc.). If this linkage could be established, then the projected change of climate conditions given by a GCM could be used to predict the resulting change of the selected surface parameters for hydrological impact and electric demand studies. The required linkage can be developed using a wide range of downscaling methods.

Two broad categories of these downscaling procedures currently exist: dynamical downscaling (DD) techniques (or regional climate modeling), involving the extraction of local scale information from large-scale GCM data based on the modeling of regional climate dynamical processes, and statistical (or empirical) downscaling (SD) procedures that relied on the empirical relationships between observed (or analyzed) large-scale atmospheric variables and observed (or analyzed) surface environment parameters. Some recent comparisons of DD and SD techniques for climate impact studies (e.g., Mearns, et al., 1999; Gutowski, et al., 2000) have indicated that neither technique was consistently better than the other. In particular, based on the assessment of the climate change impacts on the hydrologic regimes of a number of selected basins in the United States, Gutowski et al. (2000) have found that these two methods could reproduce some general features of the basin climatology, but both displayed systematic biases with respect to observations as well. However, an important finding from this study was that the assessment results were dependent on the specific climatology of the basin under consideration. Hence, it is necessary to test different, but physically plausible, downscaling methods in order to find the most suitable approach for a particular region of interest.

In general, several features distinguish DD and SD methods for regional climate simulation. DD procedures are mainly based on regional climate models (RCMs) that describe the climate physical processes using fundamental conservation laws for mass, energy and momentum. DD methods contain thus more complete physics than SD techniques. However, the more complete physics significantly increases computational cost, which limits the simulation of a climate by RCMs to typically a single realization. On the other hand, SD approaches are relatively fast and less expensive than computationally intensive DD methods. These advantages of the SD allow the users to develop a large number of different climate realizations and thus to be able to quantify the confidence interval of simulated climate variables. In addition, SD methods can directly account for the observed climate and weather data available at the study site. The results are thus consistent with the regional and local climate conditions as described by the observations.

We believe that the climate change impacts analyses will benefit from the considerable efforts spent to improve the quality of downscaled climate scenarios.

The climatic scenarios generated from the most appropriate technique are then used as inputs for the electric demand and inflow forecast deterministic models. Through these tools, the climatic scenarios generated for the next decades will provide us electric demand and inflows scenarios that are going to be used for impact analyses (first and second level concerns on Figure 1).

2.1.3 Develop adaptation strategies

According to the impacts anticipated from the above mentioned analyses, we will have to develop adaptation strategies. At this stage, we can not foresee these strategies but we can list a few questions that should be answered :

Electricity demand

By improving our knowledge regarding the potential changes in the thermal regime, we should have better indications of the electricity load pattern and volume for the next decades. This information could lead us the revisit the planning of new generation equipments or to reconsider the energy market in order to adapt to the potential global warming.

The following questions should be addressed :

- Will the load pattern and volume be modified significantly in Quebec ?
- If the changes are significant will it affect the generation equipment planning ?
- Shall we consider alternative markets to sell the energy that might be saved given the potential global warming ?

Water availability

By improving our knowledge of the hydrologic regime, we should be in a better position to evaluate our capacities to generate energy for the next decades.

The following questions should be addressed :

- If we have to build hydroelectric power stations, are the indications of hydrologic regime changes will allow us to select the most suitable sites (increase of precipitation) ?
- Will the improvement of our knowledge of the hydrologic regime help us in dimensionning hydraulic structures (dams, power houses, bridges, etc.) ?
- Could our long term planning be improved by including the indications of the non stationnarity of the annual energy inflow serie ?

Extreme events

In the framework climate change :

- Will the freezing rain events be more frequent and intense (January 1998) ?
- Will the occurrence and intensity of floods increase (Saguenay, 1996) ?

2.2 Participation in the Ouranos Consortium

Ouranos, is a Consortium in regional climatology and adaptation to climate change. This research initiative of international scope will be the only one of its kind on our continent. What distinguishes Ouranos is the sum of scientific expertise it brings together into a single team. The mission of Ouranos is to develop, structure and produce synergetic team work dedicated to the analysis and the search for solutions to climate change adaptation issues in a North American context. In addition to greenhouse gas emission reductions called for by the Québec government, the creation of Ouranos constitutes an additional means of addressing climate change and a tool for adaptation to new regional situations stemming from global warming.

A partnership that is truly unique and without precedence in Canada, Ouranos will regroup over 250 persons in multidisciplinary research teams hailing from universities and governmental and para-governmental organizations in areas that have been traditionally working apart: climate sciences, statistical analysis, characterization, impact and adaptation studies. The merging of isolated teams of scientists under Ouranos, it is hoped, will pull in relevant scientific data and information needed by decision makers to plan responses to the rapidly evolving climate situation. The creation of Ouranos has been made possible thanks to financial contributions from nine Québec government departments and agencies: Environnement, Affaires municipales et Métropole, Ressources naturelles, Sécurité publique, Recherche, Science et Technologie, Agriculture, Pêcheries et Alimentation, Transports, Hydro-Québec, Valorisation-Recherche Québec, as well as the Canadian Meteorological Centre, Natural Resources Canada and the Canadian Foundation for Climate and Atmospheric Sciences. This effort to unify human, financial, technical and computer science resources is estimated to cost upwards of 9 million dollars a year and is supported by four universities, namely, Université du Québec à Montréal, McGill University, Université Laval and the Institut national de la recherché scientifique (INRS), all Ouranos Consortium members.

The Ouranos Consortium will make coordination and support of fundamental research possible. This research on climate change is an advantage for setting up a true emergency preparedness culture and a sound prevention policy. It is consistent with the Québec government's mission to provide for the safety and protection of the population. We need to better understand the phenomenon to better plan, better prepare ourselves and, consequently, better protect ourselves. The sensitivity of Québec in conjunction with its geoclimate amply justifies the efforts and investments expended in setting up Ouranos.

2.3 Participation in the E7 Climate Change Working Group

The E7, concerned by the threat of global warming, is fully engaged in the global debate to reduce the earth's greenhouse gas emissions. The E7 has participated and presented its position at the UN Conference of the Parties (COP) in Kyoto, Buenos Aires, Bonn, The Hague and Marrakech.

The efficient and greater use of electricity generation substitution can be an effective means for controlling greenhouse gas emissions. Government and industry must ensure that all sectors of society contribute to greenhouse gas emission reductions and that the burden does not fall disproportionately to any industry, sector, or country. Globally, electricity's share of energy use will continue to grow as developing countries industrialise.

All actions that produce real and verifiable reductions in greenhouse gas emissions should receive the appropriate recognition. In response to climate change, the E7 companies are taking appropriate measures in their own generating stations to achieve significant reductions in GHG emissions.

In 1995, the Climate Change Working Group (CCWG) was established in response to the first Conference of Parties (COP1) in Berlin. The CCWG was formed to identify and examine the issues surrounding energy greenhouse gas emissions in order to table recommendations or implement policies for the concrete advancement of the climate change debate. At COP1, a five-year pilot phase for Activities Implemented Jointly (AIJ) was initiated. Emerging as pioneers, the E7 Network of Expertise for the Global Environment reacted with the initiation of their three AIJ projects in Indonesia, Jordan, and Zimbabwe.

In June, 1996, at the E7 Summit in Cologne, the CCWG was mandated to provide assistance to the E7 Network's three AIJ projects. Meanwhile, the Working Group completed the E7 Framework for Joint Implementation paper and started the preparation of its critical climate change position paper, the Greenhouse Gas Management Strategy paper.

The GHG Management Strategy, implemented by each E7 member company, represents a real commitment on the part of the E7 companies and underlines the role that electricity, as a source of energy, has in promoting Sustainable Energy Development and reducing greenhouse gas emissions. Positive results continue to be achieved and further improvements have been made.

In December, 1997, at the Third Conference of Parties in Kyoto (COP3), the E7 hosted an Open Forum with the theme of "The Response of the Electricity Industry to Climate Change". Presentations were given by Mr. Edmund Alphandery, the acting Chairman of the E7 and Chairman of EDF and by Mr. Maurice Strong, the Executive Co-ordinator for UN Reform and Chairman of the Earth Council.

The E7 also organised a closed pre-forum workshop at COP3 with its partner utilities from developing countries and selected representatives from international organisations while maintaining an exhibition booth to publicise the E7 and to disseminate its two position papers (see E7 Observer, N°15 - 1998 - Special Issue).

Resulting from the creation of the E7 Fund in June of 1998, the E7 obtained recognition by the UNFCCC as an NGO whereby granting it the privilege to participate in the global climate change debate during the Conference of Parties. Consequently, at the November 1998 COP4 in Buenos Aires, the E7 hosted an Open Forum where Mr. Chicco Testa, Chairman of Enel, unveiled and presented the E7's position paper on the Design of Flexibility Mechanisms to Manage Greenhouse Gas Emissions: E7 Recommendations. Mr. Isamu Miyazaki, the acting E7 Chairman and the Chairman of the Kansai Electric Power Company presented the E7 Group and its commitment to sustainable development. In addition, Mr. Francois Roussely, Chairman of Electricité de France presented on the Internationalisation of the Electricity Industry and its Contribution to Sustainable Energy Development. The E7 position paper was also the focus of the Open Forum discussions. (see E7 Observer, N°19 - 1998 - E7 Buenos Aires Special Issue)

Since the Kyoto Conference, the CCWG has been conducting broad studies on questions such as Joint Implementation, the Clean Development Mechanism, and emissions trading.

In November 1999 at COP5 in Bonn, the CCWG assembled partner utilities from developing countries in a concurrent closed workshop to discuss the draft seed document of the Position Paper on CDM and the Other Flexible Mechanisms – E7 and its Partners from Around the World. During the session, the E7 and its partners examined possible recommendations for the practical implementation of the flexible mechanisms as envisioned under the Kyoto Protocol. In addition, the Group discussed how co-operation between developed and developing countries could promote the undertaking of actions to help meet energy demands through achieving sustainable energy development and managing greenhouse gas (GHG) emissions.

In November 2000, the CCWG and its partner utilities from developing countries presented their recently completed Position Paper on CDM and the Other Flexible Mechanisms – E7 and Its Partners from around the World at COP6 in The Hague, Netherlands. At the same occasion, the CCWG and its partners also unveiled the Impact of Climate Change on the Strategies of the Electricity Business paper. These two position papers formed the backbone of the discussions at the E7's Open Forum that was held on November 22nd, 2000 within the COP6 site. The theme of the Open Forum was "Electric Power Industry Co-operation on Climate Change" and featured speeches from Mr. Chicco Testa (Acting Chairman of the E7 and the Chairman of ENEL), Mr. Christian Stoffaës (representative of Mr. Francois Roussely, Chairman/CEO of EDF and Chairman of the Board of the E7 Fund for Sustainable Energy Development), Mr. Ensour (Chairman of CEGCO, a Jordan Utility), and Ms. Margot Wallström (Commissioner for Environment, European Commission). For Ms. Wallström's and Mr. Ensour's speeches, please refer to the COP6 issue of the E7 Observer (N°24).

The CCWG also hosted a Closed pre-Forum Workshop with the active participation of E7 members, partner utilities from around the world, and various international organisations. The two position papers were also examined during this event.

In November 2001 at COP7 in Marrakech, the E7 held another open forum on the "Successful Implementation of the CDM: Putting CDM Projects into Practice.". The Forum panel featured Mr. Stoffaës (Executive Director of the E7 Fund for Sustainable Energy Development), Mr. Hosoya (Director of Environmental Affairs, TEPCO), Dr. Töpfer (Executive Director of UNEP), Mr. Clini (G8 Task Force on Renewables), Mr. Black-Arbelaez (Andean Centre for Economics in the Environment), Ms. Koskimäki (European Commission), and Mr. Clerc (Right to Energy).

As part of its efforts to determine the winning conditions for CDM project development, the Climate Change Working Group held a workshop with partner utilities from Algeria, China, Indonesia, Jordan, Morocco, Russia, Spain, Thailand, and Zimbabwe, as well as representatives from international organisations such as BP, CO2e.com, IEA, OLADE, UNEP, UNFCCC and a member of the CDM Executive Board, to discuss the status of the CDM negotiations, the potential role of industry, and candidate CDM projects in partner countries. The workshop also served as an input-gathering session for a submission of the E7's recommendations on the fast-track, small-scale project procedures of the CDM. These recommendations, and other aspects within the CDM that may affect electricity project implementation, were presented and discussed at the World Summit on Sustainable Development (Johannesburg, September 2002) and at an E7 Open Forum at COP8 in October 2002.

In May 2002, the Climate Change Working Group developed the E7 Greenhouse Gas Statement, which is based on both existing and new E7 a Climate Change-specific policies.

Unlike the specific tasks and predetermined duration of the other E7 Working Groups, the Climate Change Working Group has been mandated to pursue its work, along with its partners from around the world, in the climate change arena for years to come. The CCWG will continue to play an active role at the forefront of our Earth's climatic concerns.

3. REFERENCES

Gutowski, W.J., Jr., Wilby, R.L., Hay, L.E., Anderson, C.J., Arritt, R.W., Clark, M.P., Leavesley, G.H., Pan, Z., Da Silva, R., and Takle, E.S., 2000 : Statistical and Dynamical Downscaling of Global Model Output for US National Assessment Hydrological Analyses, *11th Symposium on Global Change Studies*, Long Beach, CA, January 9-14, 2000.

IPCC, 2001 Climate Change 2001 : the Scientific Basis. Contribution of Working Group I to the Third Assesment Report of the Intergovernmental Panel on Climate Change.Cambridge University Press, Cambridge, 881pp.

Mearns, L.O., Bogardi, I., Matayasovszky, I., and Palecki, M., 1999: Comparison of Climate Change Scenarios Generated from Regional Climate Model Experiments and Statistical Downscaling, *Journal of Geophysical Research*, **104,** 6603-6621.

Murphy, J., 1999: An Evaluation of Statistical and Dynamical Techniques for Downscaling Local Climate. *Journal of Climate*, **12,** 2256-2284.

Wilby, R.L., Conway, D., Jones, P.D., 2002: Prospects for Downscaling Seasonal Precipitation Variability Using Conditional Weather Generator Parameters. *Hydrological Processes*, **16**, 1215-1234.

Xu, Chong-yu, 1999: From GCMs to River Flow: a Review of Downscaling Methods and Hydrologic Modelling Approaches, *Progress in Physical Geography*, **23**, 2, 229-249.

Yarnal, B., Comrie, A.C., Frakes, B., and Brown, D., 2001: Developments and Prospects in Synoptic Climatology. *International Journal of Climatology,* **21,** 1923-1950.