3

Impacts of Hydroelectric Development:

Thoughts, Conclusions and Lessons Learned

3 Impacts of Hydroelectric Development: Thoughts, Conclusions and Lessons Learned

Chapter 2 looked at the knowledge acquired in the past 30 years on the impacts of hydroelectric development on the biophysical and social environment. Although that chapter mainly considered the results of the environmental monitoring and follow-up carried out at the La Grande complex, many other studies conducted by Hydro-Québec and its partners have contributed to expanding the knowledge discussed. Much of the data obtained by these studies, whether for the Grande-Baleine, Manic-Outardes, Robertson or Sainte-Marguerite-3 projects, corroborated the information gathered at the La Grande complex. Changes in water quality and fish methylmercury levels, for example, are the same in all the reservoirs studied. The method of harvesting natural resources by Aboriginal people has generally developed along the same lines.

La Grande-1 hydroelectric development, viewed from downstream.

Hydro-Québec has learned a great deal in the past 30 years about how to carry out projects with the greatest possible respect for the environment, and about remedial, mitigation and compensation measures, maximizing economic spinoffs, etc.

It is now possible to draw conclusions and lessons based on facts which, in view of their scientific value, can guide future hydroelectric development projects in comparable environments. This chapter presents the principal conclusions emerging from the research and follow-up studies on the biophysical and social environments, and then points out lessons and formulates recommendations for carrying out environmental studies in connection with hydroelectric projects.

3.1

Principal conclusions: Biophysical environment

Aquatic environment

In northern Québec, a hydroelectric generating station reservoir, whatever its size, constitutes an ecosystem whose biological productivity compares favorably with that of a natural lake or terrestrial ecosystem of the same area. For the first five years of its existence, a reservoir shows a water quality slightly below that of a natural lake, but nonetheless favorable to the biological environment; moreover, biological productivity increases during these years. After 10 years, reservoir water quality is comparable to that of neighboring natural lakes. The composition of fish communities evolves in favor of lake-dwelling species, and fishing yields are generally a little higher than in neighboring natural lakes. These results have also been observed in other reservoirs in Canada, Finland and Sweden.

In rivers where the flow is reduced or increased, water quality changes very little and remains favorable to primary production and to wildlife in general.

Water quality and biological productivity in environments comparable to those studied should no longer be considered subjects of major concern requiring intensive research. In some cases, where well-founded doubts exist, baseline monitoring and follow-up studies should be conducted, but only on the parameters considered most relevant for water quality and biological productivity.

The phenomena of erosion and sedimentation must be evaluated with the greatest possible accuracy, as must any necessary remedial measures.

Changes in flow, temperature and salinity in the estuaries of James Bay and the coastal environment affected by the freshwater plume have had no observable impact on the aquatic wildlife that uses these areas on a regular basis, as this wildlife adapts well to changes.

Mercury

Mercury exists under natural conditions, but approximately 50% of the mercury emissions observed today are human in origin: they stem mainly from the combustion of fossil fuels like coal, industrial and mining activities, and waste incineration. Québec produces relatively little in the way of emissions, but it receives mercury produced beyond its borders and carried by the wind. Reservoir impoundment and the ensuing organic decomposition promote the methylation of mercury and its bioaccumulation in the food chain. The extent of the phenomenon depends on the amount of organic decomposition. Maximum mercury levels in reservoir fish are three to six times higher than levels in fish in natural lakes, and are reached after a period of 5 to 10 years, depending on whether the species feed on other fish or not. Levels return to their initial values after a period of 20 to 30 years. The same pattern has been observed in other reservoirs in Canada, the United States and Finland. There is no evidence that piscivorous animal or fish species are affected by these levels.

Mercury and health

Exposure to mercury is not necessarily linked to the flooding of reservoirs. There is some health risk for major consumers of fish, regardless of the place of origin of the fish. However, this risk can be controlled when it is properly understood by the authorities and consumers. The Cree Board of Health and Social Services of James Bay set up an information program under the terms of the Mercury Agreement. This program has shown that it is possible to considerably reduce mercury exposure before it reaches the intervention threshold, and to do so without overly reducing the consumption of fish, an essential dietary component, simply by avoiding certain species and fishing spots. The scientific and social value of this lesson is significant; it alone is enough to justify the human and financial effort expended by all the players involved in the past 20 years.

Terrestrial environment

The transformation of a terrestrial environment into an aquatic environment constitutes a major change. The loss of a terrestrial environment leads to the displacement or death of the nonmigratory animals that inhabited it. However, the riparian environments lost through flooding are partially replaced by the riparian environments that form on the exposed banks of reduced-flow rivers. The biological diversity of reservoir islands is comparable to that of islands in natural lakes; even the reservoir drawdown zone is used by a variety of wildlife. The development projects studied did not harm the migratory species of interest; the populations of these species (caribou, for example) even increased to the point where the hunt had to be expanded. The new body of water forms a much more stable, productive environment than the land space lost. On the basis of biomass production, the loss of terrestrial environment is largely offset by the gain in terms of aquatic environment.

3.2

Principal conclusions: Social environment

In the early 1950s, well before the launch of the La Grande project, the advent of paid labor and government programs in the fields of health, education and social services, combined with the high cost of transportation in the region, gave rise to a more sedentary lifestyle among Aboriginal peoples. This trend affected the traditional way of life, centred around hunting, fishing and trapping: fewer and fewer families spent the winter in the bush, and animal populations living near the villages were overharvested.

Starting in 1972, for a period of about 20 years, the construction of the La Grande complex and, to a greater extent, the provisions of the various agreements (especially agreements with the Crees) accelerated the settlement process already under way. The combination of a large number of factors related to the complex (impoundment of a portion of the trapping territory, building of roads, establishment of Aboriginal businesses, paid labor, etc.) and the agreements (self-government, land use regime, assistance programs for hunters, compensation, creation and modernization of villages, etc.) played a part in accelerating the evolution of Aboriginal societies (especially the Crees) to the point where they increasingly resemble the industrialized society of the South. According to a number of experts, this evolution—in many ways similar to that observed after other hydroelectric and road-building projects in northern Canada and Scandinavia—was of overall benefit to the Crees and other Aboriginal peoples on several levels.

The rapid modernization of Aboriginal societies is not without its problems, of course. In addition, unemployment has grown considerably since the 1990s as growth in the service sector and construction activities arising from the implementation of the JBNQA have slowed down, and this has worsened the social problems. Considering the remote location, the population growth and the relative lack of resource diversity, few economic sectors can support sustainable development. For this reason, the future of the territory will largely depend on the desire for cooperation among the various players.

These comments apply mainly to the northern part of the territory. It should also be mentioned that considerable efforts have been made to promote employment and other regional economic spinoffs in the Abitibi–Témiscamingue, Saguenay–Lac-Saint-Jean and North Shore regions.

3.3

Lessons and recommendations drawn from the environmental studies

The need for targets

The environmental monitoring and follow-up show that impact assessment in the initial project phase is nearly always exaggerated. However, this observation relates more to the biophysical environment than the social environment, which does not always receive adequate attention in impact assessments.

In addition, environmental studies look at too many elements whose importance is not adequately defined and recognized by all of the parties concerned. Such studies are required by law; however, it is not always clear how these requirements should be interpreted or applied. The same holds true for measures intended to mitigate the negative effects or increase the positive effects of a project.

We believe that the selection and relevance of elements to be considered in environmental studies must be based at the outset on the broadest experience possible. The analysis must take into account all the results of previous follow-up studies in order to allow a judicious selection of elements to be used and eliminate needless ones. The negative effects that are clearly known may be assumed without the need for repeated observation through long and costly studies. It is important, instead, to emphasize mitigation and compensation measures.

Measures designed to make a project more acceptable and more profitable must be understood in their broadest sense, and must play a part in every stage of a project. Some mitigation measures must be defined at the time of project planning and design, in order to eliminate the negative effects anticipated or reduce them as much as possible. Subsequently, compensation and enhancement measures serve to offset any residual negative effects and improve the state of the biophysical and social environments. In many cases, it is preferable to wait for the results of the environmental follow-up before implementing the measure.

All these stages must be carried out in partnership with the community.

The need to learn from the past

For northern environments comparable to those studied in Québec, the data from the environmental follow-up and the resulting mathematical models are now reliable enough that changes in water quality and fish communities can be predicted, as can the release and bioaccumulation of methylmercury following the creation of reservoirs and changes in the hydrological regimen. For these elements, it is no longer necessary to take hundreds of samples over long periods of time. A few checks before and after facility construction are sufficient to verify the accuracy of the predictions.

The studies must focus on the habitats of species to which particular value is attached. Inventories must be kept to the essential and used only to determine the scope of these habitats. Natural resources valued by the users must be the priority for study. The Aboriginal people's know-how and their traditional knowledge of their environment must be put to maximum use. The studies must serve to develop mitigation or compensation measures, rather than simply determining impacts that are not easily quantifiable, that will rarely be agreed upon by the parties concerned, and that might involve lengthy, costly and inconclusive studies.

In terms of monitoring physical and biological changes in a modified environment, anything that cannot be either verified or measured according to recognized scientific methods should be rejected. The same principle should apply to selecting and implementing mitigation and compensation measures.

Collaborative efforts

The scope of environmental studies sometimes goes beyond the direct needs of the project at hand. Although this can be useful and contribute to the advancement of knowledge, it also makes the project considerably more expensive to build and the lead time quite a bit longer.

Research of this nature must be recognized for what it is by all players, and its costs shared equitably among the public authorities concerned. Care must also be taken to ensure that this research helps to improve the project evaluation process.

Perceptions of issues

Environmental elements that are highly complex and difficult to study because they react to a large number of factors often become controversial issues in environmental studies. This type of issue is usually the subject of heated debate in the scientific community and should come more under the heading of long-term research than impact assessment. Often, the project developer has no choice but to conduct lengthy and costly studies, without any assurance that the results will be deemed satisfactory. These studies deplete considerable funds, which would be much better used for mitigation and compensation measures designed to improve the well-being of the communities concerned.

All parties must recognize from the outset that an environmental impact assessment must lead to a decision that meets time, space and cost requirements. The whole process must not start anew each time. In addition, the efforts devoted to environmental studies must be equivalent for all types of projects that have impacts on natural resources.

Hydro-Québec has faced a number of issues during environmental studies to obtain authorization for projects. These issues often included perceptions, unverified hypotheses and facts all mixed together, so that it became difficult to determine the real importance of the issue. Some examples are climate, biodiversity, mercury and health, greenhouse gases, cumulative effects and most of the issues affecting local communities. The possible effects related to these issues were not all of the same importance, but they all sparked more or less the same reactions, described below.

- **Climate**

  At the time the La Grande project was launched, a number of authors had predicted that the climate of the northern hemisphere would be altered by the creation of the reservoirs. It took many years of studies to demonstrate that reservoirs, just like large natural lakes, affect only the climate of the area immediately surrounding them, i.e., a zone that rarely exceeds 20 kilometres or so for a lake the size of Lac Saint-Jean, which measures approximately 1,000 km^2 in area (Météoglobe Canada, 1991).

  In 1990, some scientists were predicting that freshwater flow regulation related to the hydroelectric developments would have notable impacts on the North Atlantic climate (Misak, 1993). Fortunately, this alarmist prediction proved wrong. Other scientists concluded that, even if this freshwater regulation extended to all the rivers and streams in the watersheds of Hudson Bay and James Bay, there would be no reason to connect this phenomenon to changes in the North Atlantic climate and that, if there were such an impact, it would be impossible to detect (Leblond et al., 1996).

  Today, the scientific data on reservoirs' effect on climate are sufficiently accurate and reliable for this phenomenon to no longer be considered an issue in northern Québec and comparable environments.

- **Biodiversity**

  The impact of hydroelectric developments on biodiversity is another controversial topic, though not in the case of the La Grande complex. It is easy for some authors to present biological diversity as a stable condition which no development ought to modify, without even offering any practical proposals for measuring the changes or maintaining the diversity. Presented this way as a serious concept, biodiversity becomes a powerful weapon in the hands of anyone who opposes a project.

  Hydro-Québec approaches biodiversity by instead evaluating the effects of its developments on the habitats of vulnerable species and species of economic value so as to determine whether these effects could have notable consequences on biological diversity in a given region. The studies reveal that no species has been threatened by the developments that have been built and that the new environments compare very favorably with neighboring environments that were not affected by the developments (see the section on terrestrial environment).

  A concerted approach must be targeted at the very beginning of the environmental studies. The species to be considered and the scope and limits of the studies required of the developer must be clearly stated at the outset.

- **Mercury and health**

  It has taken more than 20 years of studies to better understand the problem of mercury and show that this problem also exists in natural lakes, and that it is even preferable, in terms of health, to eat moderate amounts of fish with low levels of mercury than not eat any at all.

The studies must continue to consider everything that may constitute a health hazard. In addition, the studies and any ensuing measures and activities must be the responsibility of all parties concerned and not only the developer. In this respect, the example of the Mercury Agreement should be followed.

- **Greenhouse gases**
  The studies show that many natural ecosystems, for example the ecosystems of lakes and swamps, are at the root of substantial greenhouse gas emissions. Reservoir emissions are exaggerated when no allowance is made for the emissions that would occur naturally in any case.

  To be able to determine the net volume of a reservoir's greenhouse gas emissions, the volumes of emissions from the drainage basin before and after reservoir creation must be known. Reservoir emissions reach their maximum two years after flooding, then decrease for about ten years and finally stabilize at a level comparable to that of a natural lake.

  At the La Grande complex, we estimate the gross volume of greenhouse gas emissions at 33 tonnes of CO_2 equivalent per terawatthour (on the basis of data collected at the end of 1999). Emissions from the complex are thus 14 times lower than those of gas-fired power plants, and 28 times lower than those of coal-fired power plants with a comparable energy output.

  To allow an accurate quantification of the net volume of greenhouse gas emissions given off by reservoirs over a long period, Hydro-Québec has embarked upon an additional, five-year research program (2000–2004) covering the whole drainage basin of the La Grande complex. The different means of electrical generation are to be compared using an analysis based on life cycle, that is, an analysis that takes into account emissions due to facility construction and operation, in particular reservoir emissions, as well as the extraction and transportation of fuels. This method highlights the advantage offered by hydroelectricity, as emissions from the extraction and processing of fossil fuels are much greater, per unit of energy generated, than reservoir emissions.

3.4

Conclusion

We have tried to outline the scope and diversity of Hydro-Québec's activities in the complex environmental domain. The studies conducted and the knowledge acquired represent a major scientific contribution to the understanding of the biophysical and social environment in northern regions. Indeed, what would we know about northern Québec today, were it not for a decision made in 1971 to develop its hydroelectric potential?

Hydro-Québec is proud to have played a part in developing the analytic methods and environmental protection and enhancement measures on which current practices are based. The company believes it is able to forecast, with a very acceptable degree of accuracy, the impact of its northern projects and above all, whenever applicable, to carry out its projects with a minimum of harmful effects and a maximum of favorable environmental impacts.

In the past 30 years, Hydro-Québec has gained considerable environmental know-how. This know-how, acquired through the competence of its personnel and partners and through enormous investments, is intended to be of use to all those who must decide on future hydroelectric development projects. In this regard, particular efforts should be made to disseminate this know-how in English.

We hope the lessons and recommendations presented here will be found worthy of consideration and give rise to much-needed reflection.

Air Creebec, a Cree enterprise based at the La Grande airport.