# Technological innovation at Hydro-Québec

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My talk is an excerpt from a presentation I gave a few months ago to Hydro-Québec's board of directors in an aim to review the status of R&D within the company. The term "technological innovation" was being used to emphasize the need for economically quantifiable results.

Why does Hydro-Québec have an R&D centre? This was one of the questions brought up to the board of directors, just as in other companies which can still afford the luxury of having a research centre in electricity.

## I. Background

Historically, Hydro-Québec has been at the forefront of a few technological breakthroughs. Some examples from the 1960s include the 735-kV transmission system, the design of a multiterminal 450-kV DC line linking James Bay to Boston, and the under-river crossing for this line.

Hydro-Québec saw changes to its status, and, in particular, when research was made a part of its corporate objectives. This was no chance occurrence; in fact, because development projects were basically hydro-based and hydroelectric resources were located far away from the loads centres in Montreal and Quebec City, there were few technical characteristics to deal with, such that expertise was developed over the years especially in large-scale transmission systems.

In terms of R&D expenditure, Hydro-Québec ranked among the top 15 Canadian companies in 2000 with a budget of about CAN$100 million, which represents about 60 million euros. The budget for 2002 was $110 million and was broken down as follows:

- $54 million for technological innovation, i.e. projects that meet the divisions' objectives;
- $14 million for strategic innovation and prospecting that is not directly covered by the divisions' budgets;

- $5 million for chairs and contracts with universities;
- $37 million for technical support to the divisions, i.e. support for technologies already implemented within the divisions.

Hydro-Québec is the only North American electrical utility to still have an integrated research centre of such size. But in the eyes of some at Hydro-Québec, this makes us a relic. Others, however, believe that this allows us to remain at the technological forefront to ensure the company's future.

Other solutions were retained elsewhere in Canada. In Ontario, for instance, electrical R&D was privatized in 2000. A joint venture was set up with a British firm. It ranks 44th among research centres in Canada, with R&D expenditure of CAN$42 million in 2001. In British Colombia, Powertech is a wholly owned subsidiary of BC Hydro. It is not very active and its annual budget is about CAN$12 million.

## II. Achievements

Over the last 30 years, Hydro-Québec has had some success, especially in terms of commercialization, with the following:

- Power system software and simulators;
- Air gap measurement on transmission lines;
- System for detecting dissolved gases in transformers;
- Lithium-metal-polymer battery;
- Motorized systems designed at the time for electric vehicles.

One of Hydro-Québec's more recent and noteworthy achievements is MATH, a software program that simulates fluid flow in turbines. It will allow us to improve the design of the curve of turbine blades and increase the output of in-service turbines by 1%. This is strategically important for a company such as Hydro-Québec, whose generating facilities are 95% hydroelectric.

## III. Scope of activity

### 1. Background

IREQ was founded in 1967 and began operating in 1972. At the time, it was a quasi-university institute specializing in electrical engineering. In 1985, a valorization and commercialization company was set up to make use of the developments originating from IREQ. It had limited success. In 1987, an electrothermal and electrochemical research laboratory was created. Its area of specialization would be energy applications, on the end-user side, along with energy use technologies.

The same period saw a major restructuring to set up a client/supplier approach between R&D and IREQ and Hydro-Québec's divisions or business units. This was followed by a period of little change, and then a period of progressive downsizing of R&D personnel. The client/supplier approach was given up in 1999-2000. In fact, seen in a slightly humorous vein, you could say that we had come to a point where we were maintaining a research centre with several hundred staff members who provided "high-end plumbers" to the project engineers in the various divisions for $50,000 projects. It had become a very large and costly in-house consulting service. In the late 1990s, we came to the conclusion that it was pointless to keep such a large research centre for such small projects. We needed to target greater breakthroughs, more ambitious projects, allow the imagination to rule by taking greater risks but with more control than in the past.

### 2. Current scenario: innovation that serves the company's needs

Here is the current framework in which we are attempting to give meaning to technological innovation at Hydro-Québec.

R&D in the electrical industry exists outside of Hydro-Québec, such as in small and medium-sized businesses, in universities, in government research centres, in industrial research centres (e.g. ABB, General Electric, Alstom, Siemens), and obviously within public utilities.

At Hydro-Québec, we are naturally aiming for profitability within our divisions and business units by cutting costs, increasing sales, developing reliability and creating new avenues of growth. Within this context, R&D is first and foremost centered around its core area: innovation projects. This function is structured into four portfolios which

form partnerships with universities and other research centres. Their objective is to implement new products and practices thanks to a support service and testing laboratories.

The emphasis on R&D within small and medium-sized businesses is based on partnerships as well as access to emerging technologies through the venture capital provided by our subsidiary Hydro-Québec Capitech, which currently has about CAN$200 million invested in 38 companies. Capitech is also a way to gain access to a thousand business plans from worldwide companies seeking its financial backing. Without Capitech, we would not have access to small and medium-sized businesses and to their technological development projects. The subsidiary allows Hydro-Québec to acquire technologies and to have its divisions benefit from them.

Furthermore, a group of strategic innovation projects, i.e. not directly related to the needs of Hydro-Québec's divisions or business units, may lead to marketable innovations and therefore growth prospects for Hydro-Québec. In this respect, we have a subsidiary, Industech, which invests CAN$200-300 million primarily in two companies:

- Avestor, which markets a lithium-polymer battery being developed for the past 15 years;
- TM4, which is responsible for the marketing of technologies associated with the development of a wheel motor project (rather than the motor wheel, it is the miniaturization of the motor, which we have succeeded in developing, which may result in applications).

## 3. Redesigning innovation management

Outside of projects, R&D involves a considerable amount of upfront work: e.g. technological vision, prospecting, technological road maps. Innovation is the core and to capture its value, we must:

- Center research on topics that are of strategic importance to the divisions;
- Reinforce the managerial role by bringing up issues of project direction and selection at the highest level;
- Develop an integrated innovation management process, from ideas to application, so as to not pursue projects which have no application within the divisions;

• Emphasize innovation that targets core trades.

**4. Technological innovation: a lever of growth**

We have four innovation project portfolios: generation, transmission, distribution networks, and energy use by end users. The net discounted value for these projects is about CAN$566 million for an annual cost of about $100 million. Each project's net discounted value must be determined but does not necessarily constitute a selection criterion. An "80/20" rule applies, where 20% of the projects represents 80% of the discounted value.

There are 74 projects that are currently active. Their average length, from idea to application, is 4.5 years, the average payback period is 6 years, and the average budget is $4 million, not including implementation costs.

**5. Redesigning innovation management**

Four teams were set up to manage the portfolios. The research institute was restructured so that it is centered around expertise that uses a matrix-based approach, with those with the know-how on one side, and those that issue orders on the other. A technology valorization division was set up to handle marketing and intellectual property management. Innovation portfolios were set up. Finally, integrated innovation management processes were developed.

A stage-gate™ process is used to set up projects and shelve them if required. The major difference was that of being able to put an end to projects which had no application. Grids are now used to evaluate a project and invest the necessary funds if the project is considered to be useful. If the project has no practical application, funds and human resources are reallocated to promising projects.

A portfolio management process ensures that the projects are of high quality and that there is a backlist available if research is stopped.

Lastly, an industrialization and marketing process is used when a technological breakthrough is achieved and patents are filed. All of this is managed by a "platform team." Every month, each portfolio is reviewed and the project stages analyzed by a committee which I co-chair with one of the managers from the unit involved. The

brainstorming sessions by the committee members allows recommendations to be made to the platform team in each area. This allows innovation areas to be identified, a multi-year development plan to be proposed, projects to be realized, ensure that intellectual property is protected, etc.

Each team has a team leader. Thus, there are 74 team leaders from IREQ or the division involved who manage researchers, engineers, technicians and specialists from various Hydro-Québec units corresponding to the project's progress. At each stage of the process, the project leader produces a report to the platform team.

## 6. Portfolio management objectives

The portfolio management objectives are as follows:

- Allocate resources so as to maximize the portfolio's value;
- Ensure that there is a balance;
- Ensure that there is a sufficient number of projects;
- Make sure that innovation is in line with the divisions' business strategies.

A portfolio's composition is reviewed on a regular basis by determining the share of innovation, the share of means (which should be reduced) and the share of financial resources earmarked for prospective monitoring. Another criterion used to achieve a balanced portfolio is the type of innovation involved. Are we targeting innovation that can be easily attained over the short term – known as incremental innovation – or major or radical innovation that involves some technological risk but has greater added value?

Finally, the last criterion is that of spinoffs, over the short, medium and long term. These are the three "filters" through which the portfolios are assessed.

We regularly monitor innovation spinoffs using 10-year net discounted value forecasts of our projects.

## 7. Project-based management

This is the stage-gate™ process: from ideas to implementation, resources are allocated in stages based on decision points. Several aspects are assessed at each stage such as, of

course, technological data, as well as commercialization prospects, implementation risks, intellectual property, legal issues, etc.

## 8. Implementation and expertise

Some 50 projects have already been implemented, for which those in charge of technological innovation, including IREQ, continue to support the divisions in several areas. In addition to researchers involved in the innovation part, there are equipment testing laboratories, for the support and expertise part, which can test equipment not related to projects associated with technological breakthroughs.

Prior to this, there is the road map process which mirrors to some extent what is being done at EPRI; it is used to determine major technological changes so that we can anticipate the factors that will influence technology within each division. It allows us to determine the areas which the company should be monitoring and helps identify, for the next 20 years, future technological developments likely to affect Hydro-Québec's technology. Based on this, the potential losses and gains can be determined for each project.

## 9. Expertise

Expertise is a crucible of ideas, a doorway to researchers' imagination. Good ideas for new projects start there. We try to ensure that researchers each have 10 to 15% of their time free for developing projects that could be included into a portfolio.

## 10. Capitech

Capitech, as a venture-capital company, tries to conduct "profitable" technological monitoring, which has become difficult in today's venture capital market. Capitech allows us to be active on the market and to make emerging technologies available to the divisions, invest in niches that meet the divisions' needs. We are aiming for a return that is higher than the average compared to similar venture-capital companies. Capitech's authorized capital is CAN$420 million, of which $200 million has already been invested, mostly in U.S. companies.

## 11. Industech

Industech is pursuing technological breakthroughs made during the 1980s when we were involved in research on electric vehicles. This accounts for the development of

battery technology and a 50% share in Avestor. The target market over the short term is telecommunications and, over the long term, vehicles and electrical power systems.

TM4, a wholly owned subsidiary of Hydro-Québec, is developing motorized systems. Outside of automobiles, other applications for motorized systems involve decentralized energy generation, such as motors used for wind turbines.

## IV. Issues

Our issues stem from our road map with its outlook 20 years from now, our venture capital with its outlook 15 years from now, and the actual projects with their outlook seven years from now. The idea is to cover everything that may affect Hydro-Québec's technological future.

Our challenge is to realize the major innovation spinoffs for the company while keeping track of the changes begun in technological innovation management.