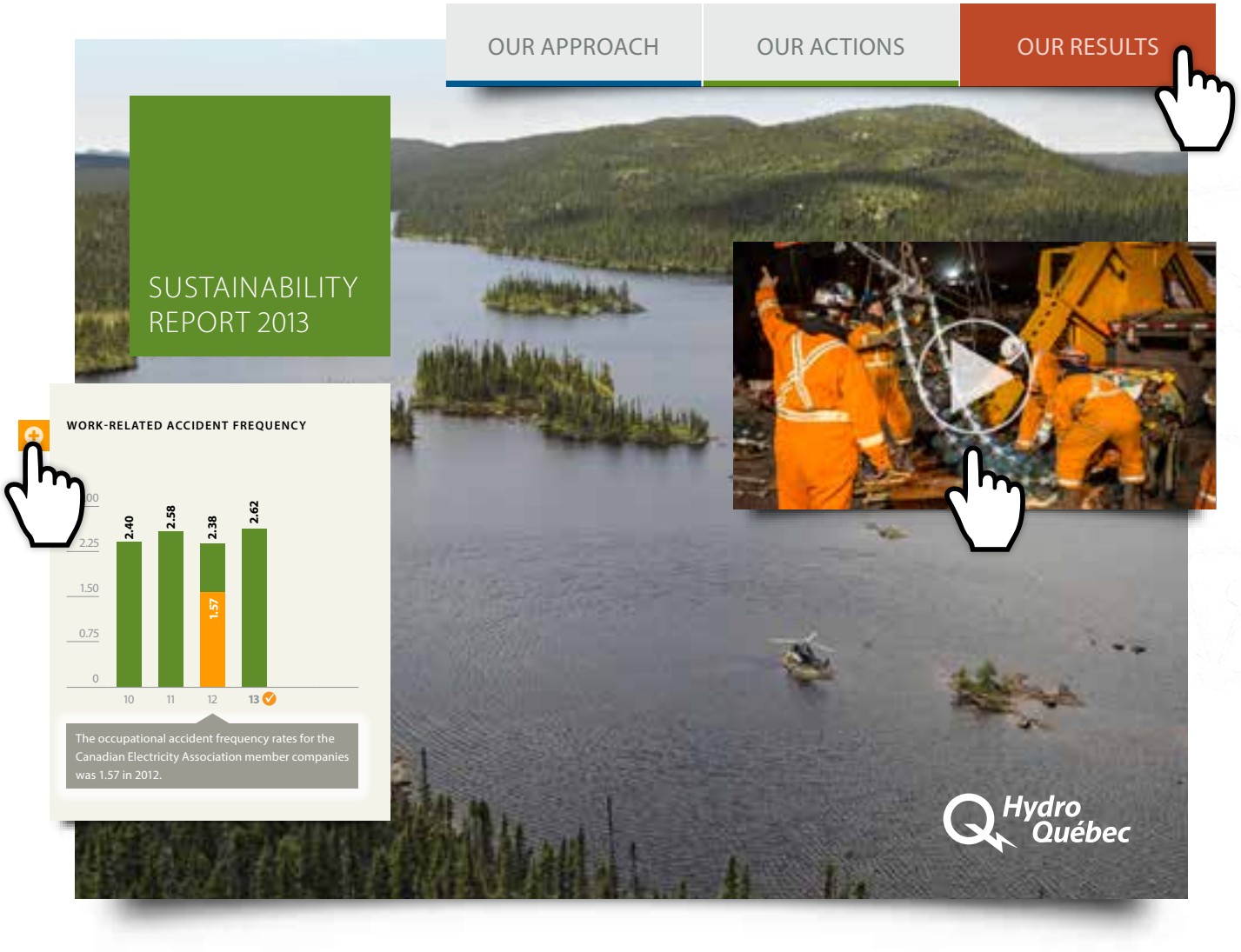
# SHEDDING LIGHT ON THE QUEBEC ELECTRICAL INDUSTRY

ASSOCIATION DE L'INDUSTRIE ÉLECTRIQUE DU QUÉBEC

2015

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# MESSAGE FROM THE PRESIDENT

The Association de l'industrie électrique du Québec (AIEQ) is proud to present the second edition of its *Light* magazine.

This magazine presents an overview of the sector's economic situation. Herein, you will discover a dynamic industry which is rapidly growing in foreign markets.

Furthermore, we have mapped out the Quebec electrical industry. In addition to highlighting its strengths, this mapping showcases the undeniable know-how of its institutions. As a matter of fact, the Quebec electrical industry represents a rich and complete value chain of diverse suppliers.

Finally, we have addressed some of the areas of Quebec's expertise, specifically in terms of the social acceptability of projects.

We hope you will enjoy our magazine.

Happy reading!

Daniel Laplante
President & Chief Executive Officer of AIEQ

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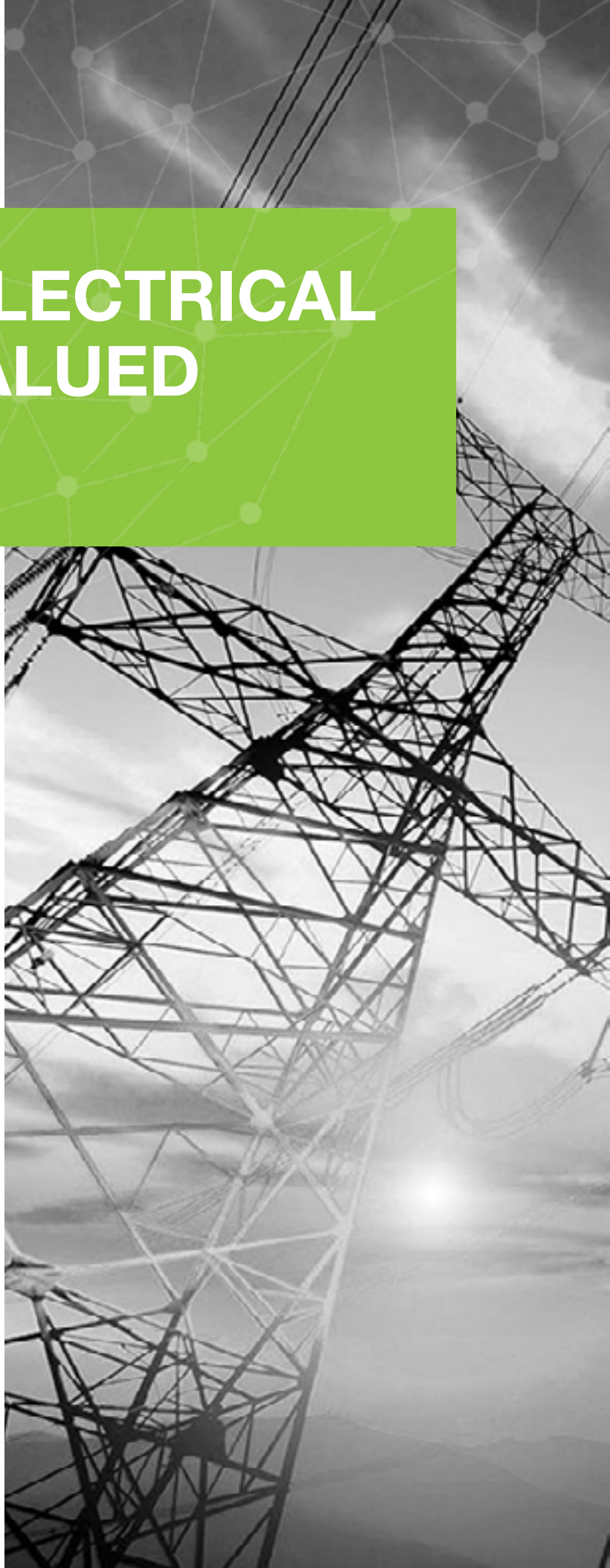
# THE QUEBEC ELECTRICAL INDUSTRY: A VALUED ASSET



## VALUE CHAIN MAPPING AND STATISTICAL PROFILE

Hydro-Québec plays a central role in the Quebec electrical power sector. Not only has this institution grown into one of the largest producers of renewable energy worldwide, it also created and developed a new industrial sector which, over the years, became a major component of the Quebec economy. This sector, comprised of a large number of companies, of various sizes and spread throughout different fields of expertise, has contributed largely to Hydro-Québec's great achievements which became, over the years, more than just a client but a true partner committed to further advancing the entire sector in order to achieve the highest standards of quality and competence. The Quebec electrical industry is a strong industrial sector, currently holding a leading role in Quebec's manufacturing industry.

## DEFINITION OF THE QUEBEC ELECTRICAL INDUSTRY

The Quebec electrical industry consists of a “group of inter-connected companies such as purchasers, equipment and other components manufacturers, specialized or non-specialized sub-contractors, input suppliers, companies of related sectors and special service providers”.

The industry is comprised of companies that can be grouped into four broad categories:

- Electricity producers, transmission providers and distributors.
- Manufacturers of equipment used in electricity generation, transmission and distribution.
- Electrical equipment manufacturers.
- Engineering consulting firms specialized in electricity generation, transmission and distribution.

Other companies can be included in the following two categories:

- Other service companies related to electricity generation, transmission and distribution.
- Manufacturers of electricity powered transit equipment (ex.: cars, trains, tramways, etc.).

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## DETOUR LAKE GOLD MINING PROJECT IN ONTARIO

Detour Gold Corporation hired BBA to complete a feasibility study as well as detailed engineering, equipment purchasing and technical support for an open-pit gold mine complete with “greenfield” gold recovery process installations. The project was designed to become the largest Canadian gold mine, with a capital of $1.5 billion.

The project site was a former mining operation with existing excavations, both open-pit and underground. The swampy overburden conditions and remote location were additional factors contributing to the project’s complexity. Many scheduling, procurement and innovation initiatives had to be deployed that stretched the limits of any previous design in the mining industry.

BBA’s mandate included design, construction management and commissioning of a new 180-km, 230-kV transmission line between the Detour Lake substation and the Hydro One Pinard substation.

BBA received the Engineering for a Better Canada Award and an Award of Excellence during the 2014 Canadian Consulting Engineering Awards Gala for its work on the Detour Lake project.

## WINTER WORKS FOR HIGH-VOLTAGE ELECTRICAL LINE

The high-voltage power line was initially connected at 115 kV to provide power for construction and start-up services. Once the 180-km power line was built, it was connected to a 230-kV substation for full ramp-up. The high-voltage transmission line had to be installed during the winter so that construction machinery could reach the site more easily while minimizing disturbance to wildlife, vegetation and waterways.

Notable project complexities included:

- Fast-track mode: 90% of materials were purchased before the design was completed and construction drawings were issued to the contractor on a just-in-time basis.
- 180 km of power lines built in seven months: 140 km in winter 2011 and 40 km in spring 2012.
- Construction of a 149-km winter road and installation of 2,250 wooden poles for 920 km of cable for power lines.
- Numerous government reviews, each of which involved BBA as technical lead.

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## STATISTICAL PROFILE
## AN INDUSTRY SHOWING A STRONG RECOVERY SINCE THE LAST RECESSION

In 2012, the Quebec electrical industry had a Gross Domestic Product (GDP) of $13.4 billion, representing 4.4% of the total provincial GDP. It employed more than 37,000 people and included 460 institutions.

### A statistical profile of the Quebec electrical industry for the year 2012

**Quebec Electrical Industry**
37,000 employees
460 institutions
GDP: 13,58 billion dollars

**Power Generators, Carriers and Distributors**
23,948 employees
78 institutions
GDP: 12 billion dollars

**Power Generation Equipment Manufacturers**
2,481 employees
66 institutions
GDP: 0.55 billion dollars

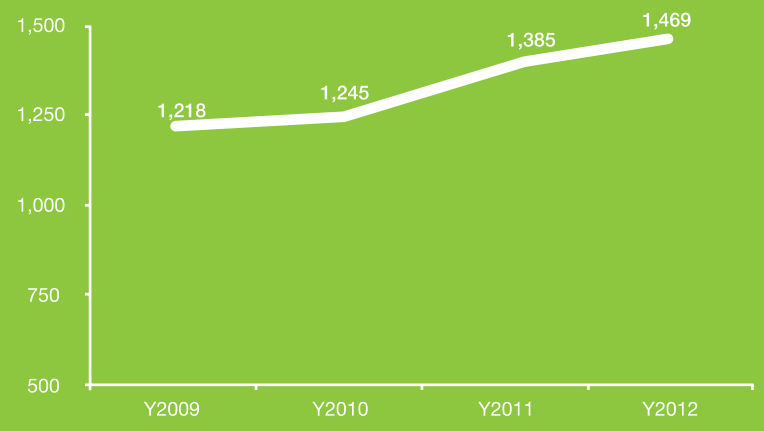
**Electrical Equipment and Other Component Manufacturers**
9,447 employees
279 institutions
GDP: 1.03 billion dollars

**Engineering Services**
2,000 employees
40 institutions

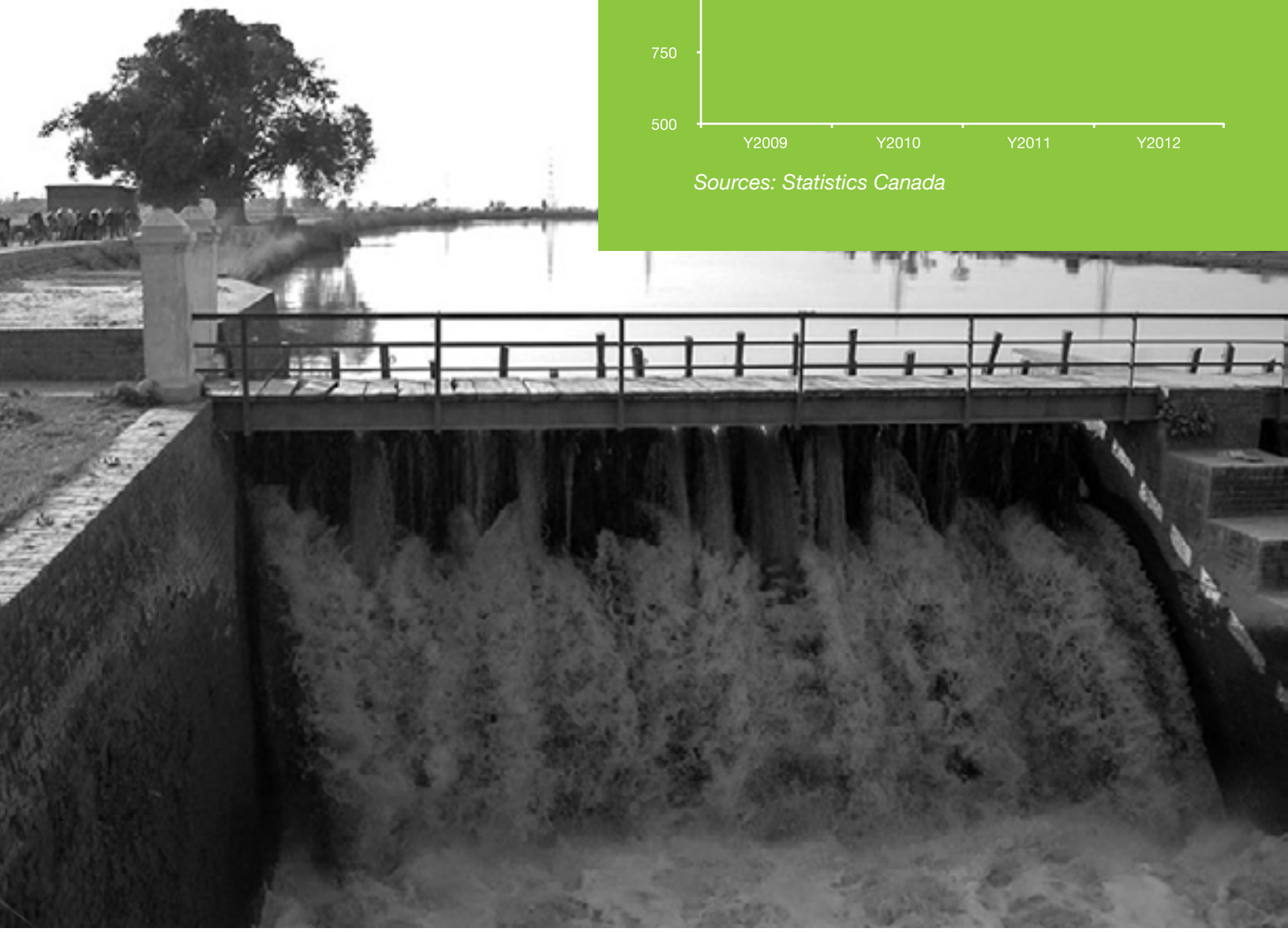
*Sources: Statistics Canada, AIEQ and AICQ*

Since the 2008-2009 recession, the Quebec electrical industry's GDP has resumed its expansion. Additionally, the electrical industry's manufacturing sector has grown at a compounded annual rate of 7.3% since 2009.

## GDP of the Quebec electrical industry manufacturing sectors (in 2007 $ million)




*Sources: Statistics Canada*

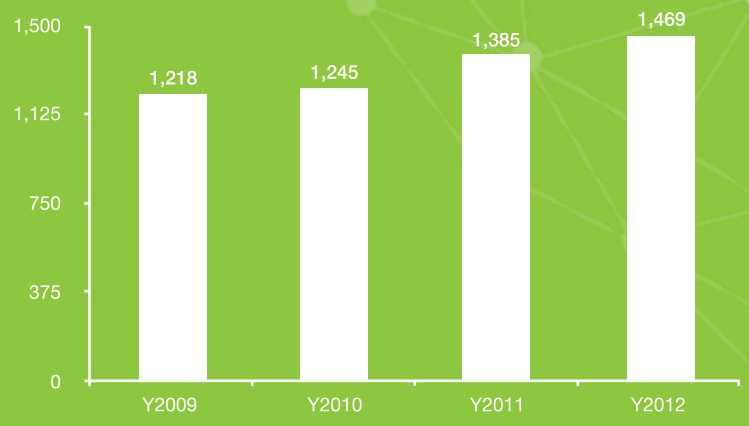





*Sources: Statistics Canada*

## GDP – Electricity generation, transmission and distribution (in 2007 $ million)

Difficulties in the Quebec manufacturing sector and the arrival of shale gas in the United States caused the sector of electricity generation, transmission and distribution to slow down. However, in spite of this situation, this sector is growing at an annual rate of 2.5%.




*Sources: Statistics Canada*

## Manufacturing shipments Electrical sector (in $ million)

Since the economic recovery, the electrical industry manufacturers' exports increased at an annual rate of 7.5%. Hence, it grew from a little more than $1.2 billion to almost $1.5 billion.

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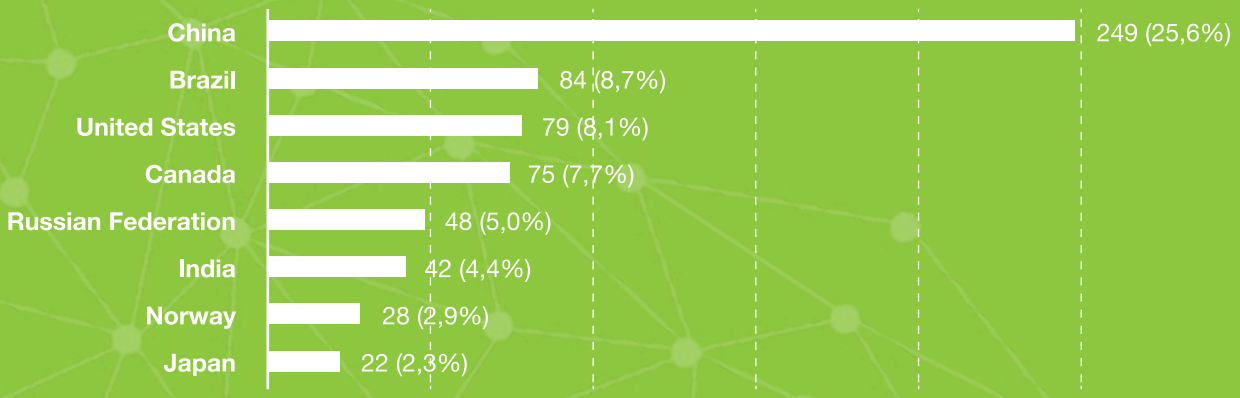
## MAJOR INFRASTRUCTURE PROJECTS RECENTLY COMPLETED IN QUEBEC

Canada is ranked 4th among countries with the largest installed capacity of hydropower worldwide, following Brazil, the United States and China. Quebec alone has more than 37,000 MW of installed capacity and ranks 7th.

### Countries with the largest installed hydropower capacity in 2012 (in GW)




*Sources: Energy Information Administration*

Taking only Hydro-Québec into consideration, the power station parks include 61 hydroelectric plants, 20 of which have a capacity of more than 500 MW, and 2 thermal power plants. The hydropower facilities also include 26 major reservoirs with a storage capacity of 175 TWh and 761 dams and control structures.

Since 2005, there have been numerous achievements in the major electrical infrastructures. In fact, more than 4,000 MW of new hydropower capacity has been added to Hydro-Québec's generation park:

- Toulnustouc (526 MW)
- Eastmain-1 (480 MW)
- Péribonka (385 MW)
- Mercier (51 MW)
- Rapides-des-Cœurs and Chute-Allard (139 MW)
- Eastmain-1-A and Sarcelle, as well as the partial diversion of the Rupert River to the Robert-Bourassa reservoir (918 MW)
- Romaine Complex (1,550 MW)


*Sources: Hydro-Québec*

**Hydro-Quebec: New power generation capacity 2005-2020**

Wind power also experienced a strong expansion during this same period. In fact, Hydro-Québec was awarded contracts for nearly 40 wind farms, either currently in operation, under construction or planned. At present, operational parks connected to Hydro-Québec's main network have an installed capacity of more than 2,000 MW.

These recent achievements have been important to the Quebec electrical industry. Despite the decline in activities, related to the 2008 recession, the industry has recovered its momentum since 2010 and returned to pre-down-turn levels.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# MAPPING OF THE VALUE CHAIN

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# MAPPING OF THE VALUE CHAIN

## Component Characteristics

The value chain of the Quebec electrical industry includes eight components whose characteristics contrast markedly. The differences in size, scope of action and positioning within the competition of each market, significantly impact the relationship between the players. Their interests are diversified and, in general, it is the existence of practical conditions related to project completions, that makes their efforts converge.

**Electricity Producer**
The main Quebec electricity producer is Hydro-Québec Production, which has an installed capacity of 36,000 MW, of which 35,125 MW is hydropower. Rio Tinto is the main private producer of electricity in Quebec, with a generation capacity of 2,000 MW. There are also several private electricity producers, either from hydropower or wind sources.

**Electricity Transmission Provider**
Hydro-Québec TransÉnergie operates the largest electricity transmission network in North America, markets its transmission capacity and manages energy movements throughout the Quebec territory (TransÉnergie has 33,900 km of lines, 516 posts and 17 interconnections).

**Electricity Distributor**
Hydro-Québec Distribution is the main electricity distributor in Quebec. Many other regional or local electricity distributors exist in the province.

**Product Suppliers**

Product suppliers are mainly composed of major equipment manufacturers. Due to the significant initial investment needed to build the electrical infrastructure, this economic sector is dominated by major manufacturers, often belonging to multinational corporations. They manufacture the large equipment required for hydropower plants. They basically supply the “generation” component with products such as alternators, turbines, generators, wind turbines, etc. Even if they are very active in the “generation” phase, they also supply the “transmission” and “distribution” components.

Among the suppliers, we also find a group of diversified manufacturers, comprised mainly of medium-size companies. This group of SMEs is generally innovative and capable of great flexibility. Consistent with all other manufacturing sectors, companies in this component had to adapt in the face of stronger competition, mainly from Asia and Europe.

**Service Providers**
Consisting primarily of engineering firms, the service providers operate upstream in the chain during the operation phase of production, installation and construction, but are also very present downstream (maintenance, upgrading, repair, etc.). The engineering firms have transformed considerably in the last few years, due to numerous mergers and acquisitions. Change was essential in order to deal with market globalization and ensure competitive services on an international level. Quebec engineering firms have an excellent reputation worldwide and are active in nearly 200 countries, on all continents. These firms account for an important part of the engineering services exported from Canada, which is one of the four major exporting countries worldwide in this sector, after the United States, England and the Netherlands.

**Construction Contractors**
Because of their reputation and vast experience, construction contractors have been able, so far, to maintain their position in the Quebec market. They are also very active across Canada.

**Consumers**
On the other hand, corporate consumers are companies related to electric transport (electro-mobility), home automation and intelligent networks (an information-focussed aggregate of applications made possible by the automation of the electricity network and the infrastructure of automation and communication). Intelligent networks, either affect electricity suppliers' operations, the network structure, or the way the end user interacts with the network infrastructure.

**The Sub-Sector Partner**
This sub-sector was added to the outskirts of the chain and is composed of organizations, research centers and universities, working in partnership with the industry during the research and development phases or acting as overall coordinators. For example, in Quebec, we have the opportunity to benefit from an institution called Institut en génie de l'énergie électrique. This Institute consists of 9 universities, committed to electrical engineering education, and 16 industrial members representing the most active corporations in the electrical energy field. We should also mention that Hydro-Québec is the only electric utility in North America to have a research centre the size of IREQ. The company invests a yearly average of $100 million in its innovation projects. The IREQ team is made up of approximately 500 people: scientists, technicians, engineers and specialists pooling their efforts and expertise to support Hydro-Québec in every facet of its operations, from electricity generation to consumption.

## Various Degrees of Maturity

The Quebec electrical industry benefits from an invaluable competitive advantage: its ever-growing complete value chain and the emergence of new players from highly innovative sectors, especially in regards to electric transport and electro-mobility.

This chain gives the sector, and the Quebec economy, a clear advantage.

The electrical industry value chain originated a few decades ago. It has been able to retain its major components and sectors. There exists an ecosystem of strong skills in Quebec, which has been the foundation of the electric power industry's international reputation.

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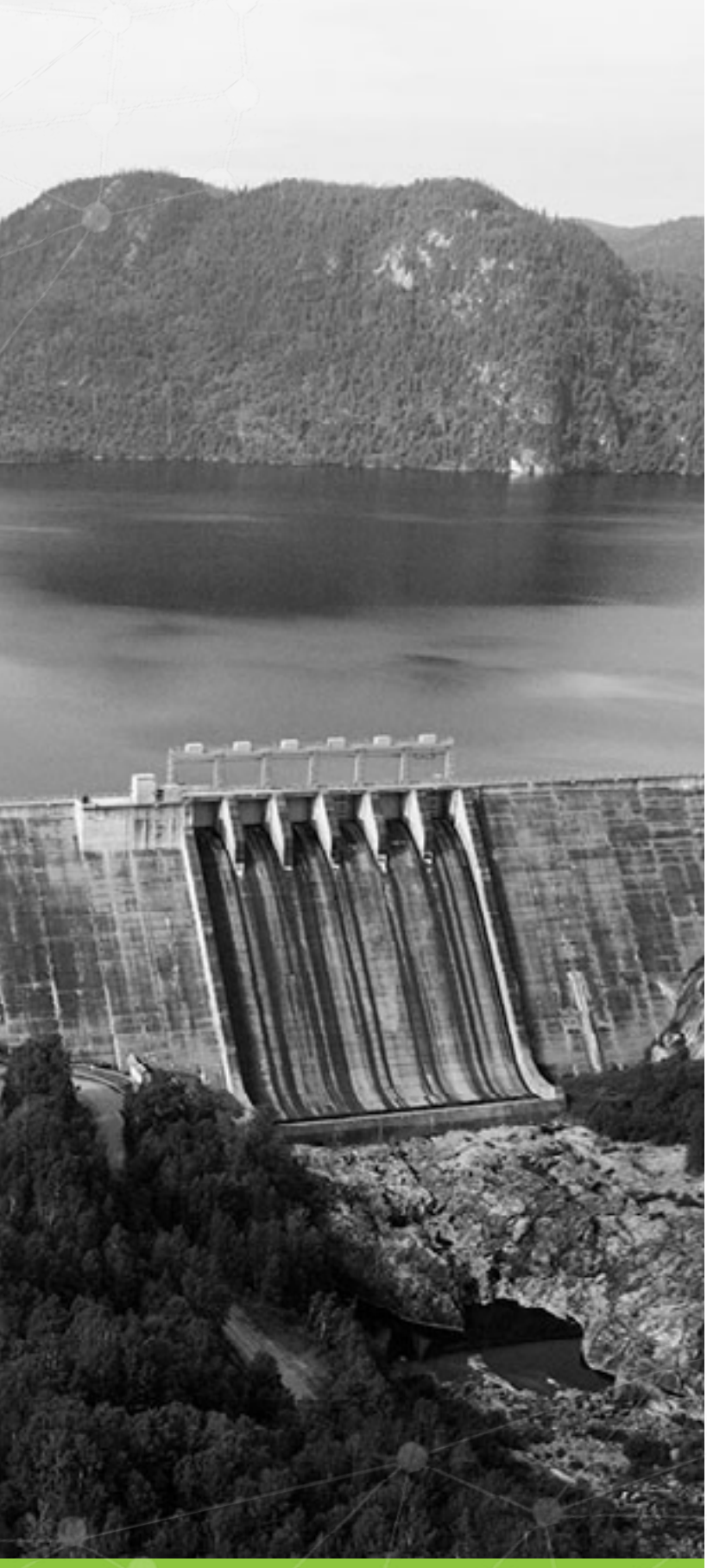
# ENVIRONMENTAL ANALYSIS AND SOCIAL ACCEPTABILITY

## 30 YEARS OF EXPERIENCE IN MAJOR INFRASTRUCTURE PROJECTS

Environmental expertise is highly developed in Quebec and has acquired a strong reputation. It has been in place for many years and most beneficial in the design and construction of generation infrastructures, transmission and distribution of electricity. Due to the magnitude of power generation projects, such as the hydroelectric complex of the Romaine, the Quebec electrical industry has been acclaimed worldwide for its excellence in the design and completion of power plants, transmission lines and electrical substations. Its rigorous approach in the analysis of environmental impacts, as well as the careful planning of each step to ensure social acceptability, contributed to shape Quebec's solid reputation. Environmental analysis experts in Quebec have also been active in mining projects, road transport infrastructures and municipal service infrastructures.



Most of the Quebec-based engineering firms have a strong team of engineers, biologists, chemists and technologists dedicated to environmental analysis. These teams work in close collaboration with electricity producers and carriers.

Over the years, these professionals have enhanced their expertise by taking advantage of environmental studies carried out during previous projects, which contributed to establish some of the international standards on the subject. The first large-scale hydropower projects completed by Hydro-Québec already date back to the 1970's. This proven assessment method and the in-depth knowledge of the Nordic biophysical environment enabled the Quebec electrical industry to:

- Systematically analyze the environmental and social restrictions involving a potential area for the development of a power plant or transmission line project.
- Carry out comparative analysis to determine which project has the least impact on the environment.
- Propose different scenarios, each including advantages and disadvantages, and select from this exhaustive analysis the project with the least impact, both on the biophysical and human environment.

It is a challenging process, given that the analysis requested from the developer must address environmental, as well as social and economic impacts arising from the proposed project:

- Physical and meteorological environment
- Soil and soil productivity
- Vegetation
- Water quality and quantity
- Fish and fish habitat
- Wetlands
- Wildlife and wildlife habitat
- Habitats of species-at-risk or special-status species
- Atmospheric emissions
- Greenhouse Gas Emission (GHG)
- Acoustic environment
- Human settlement and resource harvest
- Heritage resources
- Navigation and safety
- Lands and resources use for the Aboriginal populations
- Sociocultural wellbeing
- Human health and aesthetics
- Infrastructure and services
- Employment and economy

## THE ENVIRONMENTAL IMPACT STATEMENT

During this process, the Environmental Impact Statement (EIS) is the central focus of the environmental analysis. The EIS is the ideal instrument, designed to properly identify, understand and analyze the environmental, social and economic aspects. It must enable the government and the responsible administrative authorities to make an informed decision for a proposed project. In addition to describing the overall impact, the EIS must also address the concerns expressed by the relevant public and meet all legal and regulatory obligations. For years, companies within the Quebec electrical industry have been performing Environmental Impact Statements on a regular basis, which has greatly improved their expertise.

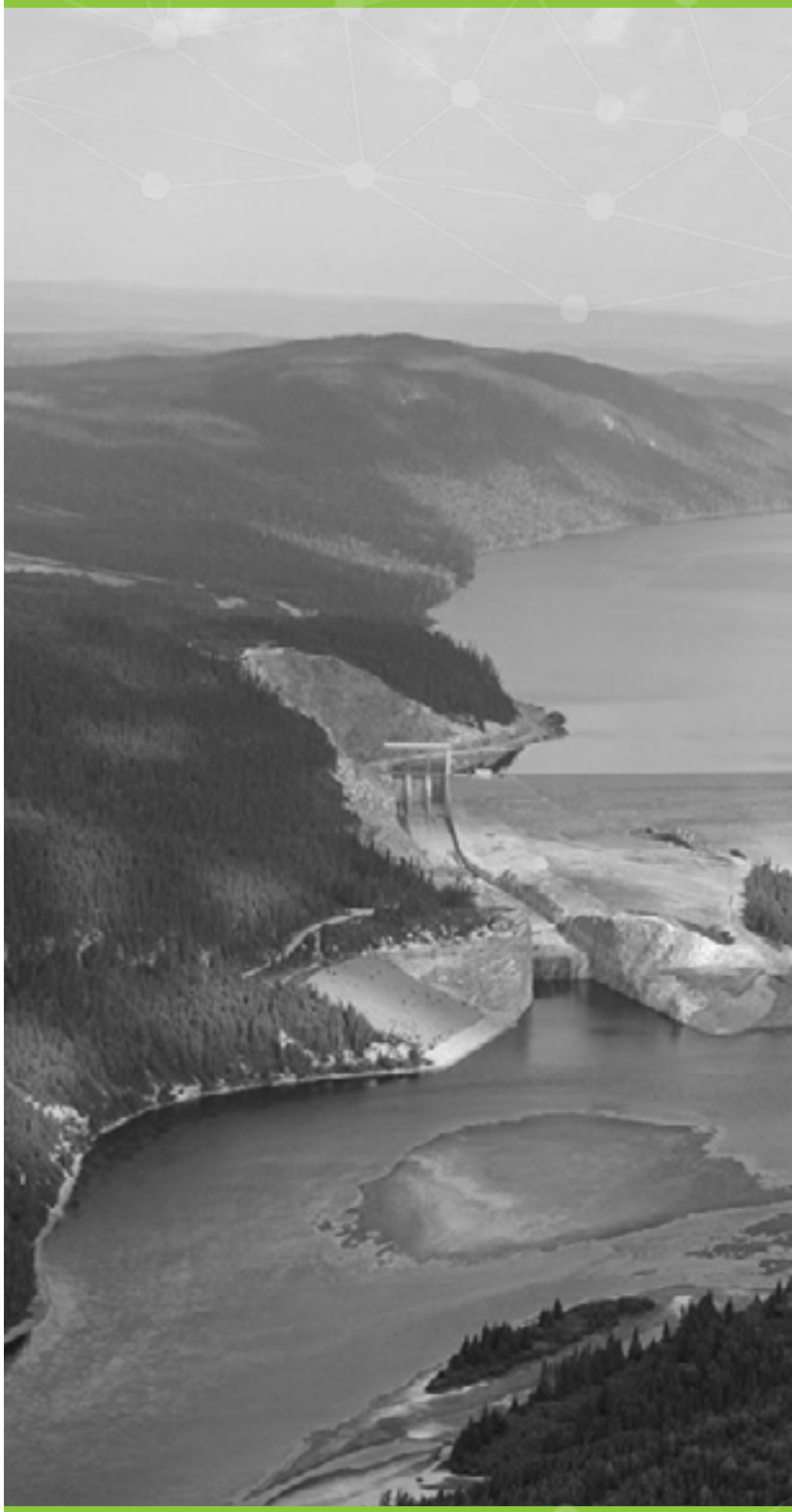
To conduct an EIS presents a great challenge and becomes significantly more complex as our knowledge grows. Over time, the EIS has turned into a strategic management tool used to guide business decisions. In this context, professionals responsible for the evaluation of the environmental impacts of a major project must have an extensive multi-field knowledge. Some of the issues they face include the overlapping of laws, the efforts to cooperate with different public sector groups and the adoption of new regulatory requirements or policies.

## A MAJOR ELECTRICAL INFRASTRUCTURE PROJECT MUST FIRST BE ACCEPTED BY THE PUBLIC

Social acceptability represents a large portion of the environmental analysis. It is absolutely essential to the success of an infrastructure project. To obtain the support of the public, the developer must meet with the relevant public groups and introduce the project well before construction begins. He must listen carefully and understand their concerns and requests and then, if necessary, amend the initial proposal. The developer must also undertake to maintain an active presence on the site after the completion of the installation.

This approach is very important in Quebec, especially with the resurgence of major electricity generation projects since 2000. In fact, more than 4,000 MW of new hydropower capacity has been (or will be) added to the Hydro-Québec power generation park between 2005 and 2020.

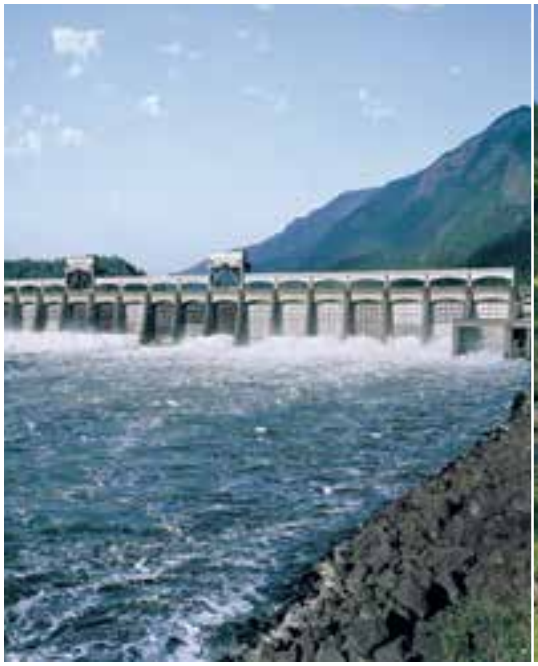
In addition, we must consider an extra 30 wind farms currently in service and offering an installed capacity of more than 2,000 MW.



## THE NEW CHALLENGES OF THE ENVIRONMENTAL ANALYSIS

The field of environmental analysis is constantly evolving. In addition to greater scientific knowledge, the impacted public also has concerns and various requests. At the beginning, environmental issues were the main arguments used to expose the negative impacts caused by major infrastructure projects; but now, landscape is becoming more and more important. The recent social debates surrounding projects of wind farms, liquefied natural gas terminals, pipelines and power transmission lines attest to that. Requests expressed by the most critical groups on the landscape concern both aesthetics and maintaining of the quality of life. More than ever, developers and environmental professionals must take these type of concerns into account.

The engineering training offered in Quebec's universities pays close attention to environmental issues. The objective is to offer training that is both dependable and inclusive in leading-edge environmental engineering, process engineering, as well as in the management of quality and sustainable development. They also aim to give students, who already possess a scientific method, a more complete training, making them aware of issues with respect to the environment, sustainable development and security.



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# MAJOR INFRASTRUCTURE PROJECTS STIMULATING INNOVATION

Even if the field of hydroelectricity is one hundred years old, its know-how is constantly evolving and demonstrates a creative vitality, which easily rivals the emerging technologies. From project-to-project and contract-to-contract, professionals of the Quebec electrical industry continue to learn and improve. In addition, progress made in the area of sustainable development in James Bay, and acclaimed by the World Bank, improved the acceptability of new projects. This expertise, gained over the years, is very useful in the realization of major projects because, above all, it allows us to meet the pre-established timelines and respect the initial budgets. It is a great challenge, especially when considering projects of great magnitude, such as the Romaine hydroelectric complex which is currently underway.

Since 2005, Hydro-Québec completed major projects and contributed to the renewed expertise found in Quebec. New electrical infrastructure projects always present challenges and force us to innovate.

For example, Hydro-Québec uses, more and more frequently, the 3D-CATIA digital software for its projects. This tool allows one to enter all information related to most disciplines necessary for the design and implementation of a project and create a virtual model. This has proven very useful in work follow-ups and reliable schedule performance. Another example of recent innovation is the completion of the plastic concrete waterproof wall of the Péribonka power plant. This project is located on the Péribonka River, downstream from the Rio Alcan Chute-des-Passes plant. This site, whose potential has been known for several years, is located over a very deep geological fault which needed to be sealed. Therefore, the project included the installation of a plastic concrete wall, 110 meters deep, beneath the dam, to ensure the dam's watertight integrity: the first of its kind in the world. Péribonka is a 70 meter deep underground power plant.

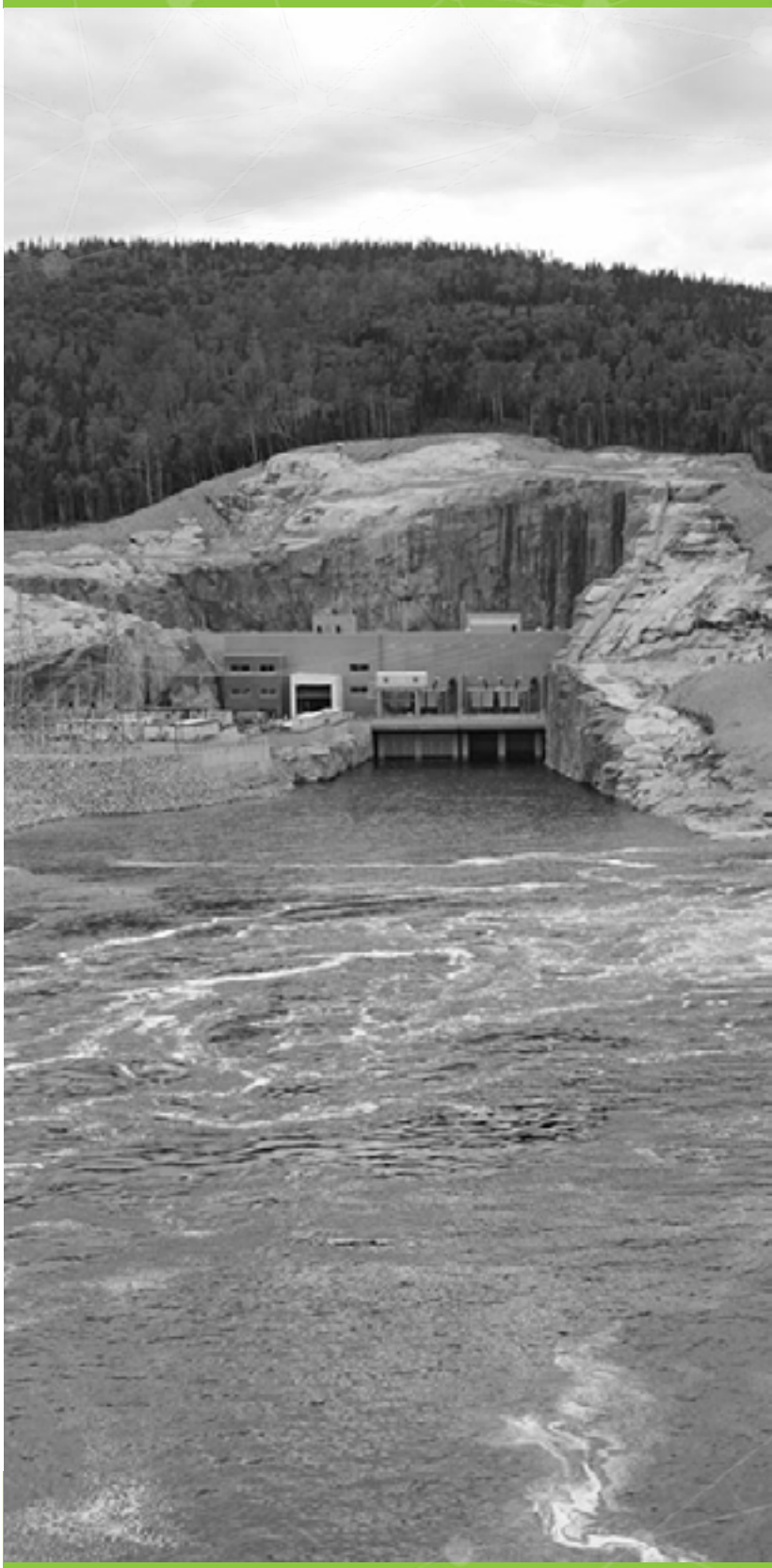
Furthermore, in order to fully benefit from the partial diversion of the Rupert River into the La Grande River, the Sarcelle control structure (built during Phase 1 of the James Bay project in the early 1980's and located at the outlet of the Opinaca reservoir, downstream of Eastmain) was equipped with a plant comprised of 3 bulb-type turbines of 50 MW, under a net available head of approximately 11 meters. It was the first bulb-type turbine power plant built by Hydro-Québec. Because it is equipped with a variable-pitch propeller turbine called Kaplan, the bulb offers an interesting generation capacity even though the discharge and the net available head vary significantly.

Technological innovations also include the electric power transmission system. This system is in high demand, especially during the colder months of winter, when it reaches its peak with a utilization rate of 95% and even occasionally up to 100%.

This large scale system is complex, widespread and relies on the majority of technologies available in major carrier systems:

- Transmission of very high voltage (735 kV)
- Interconnections of direct current
- Dynamic shunt compensation
- Series compensation
- Static excitation systems with power stabilizers
- Major network automation backup

These technologies are the main distinctive elements on which Hydro-Québec's network relies. It is also in Quebec that some of the largest transformers in the world are manufactured, with a nominal capacity ranging from 100 MVA to 1,200 MVA.



## LA ROMAINE HYDROELECTRIC COMPLEX: A HUGE CHALLENGE FOR THE INDUSTRY

The power generation project currently underway in Quebec is the hydroelectric complex on the Romaine River, north of the Havre-Saint-Pierre municipality. This 1,550 MW infrastructure project, with an average annual output of 8.0 TWh, began in 2009 and will be completed by 2020.

With 4 hydropower generating stations, 11 retaining structures, 2 transmission lines and 230 kilometers of road infrastructure (including 8 bridges), La Romaine hydroelectric complex is a major undertaking. Significant technical and logistical challenges also arise from this Can$6.5 billion project.

For example, at the Romaine-2 site, where the construction of 6 embankments and a 109 meter high dam are projected, Hydro-Québec used steel pillars downstream of the power plant rather than concrete columns, in order to adequately support the range of transformers.

Just like the Romaine-1 site, the Romaine-2 site will use a technology that was developed in Europe: the construction of reservoir structures with an asphaltic core. This method was tested on a smaller scale in 2008 on the Nemiscau River dam, during the construction of Eastmain-1-A - Sarcelle - Rupert. Hydro-Québec usually builds till core dams but the till found on the site either did not meet the standards or would have been too expensive to ship over a long distance. The construction of an asphaltic core wall saves time and money on till transportation. Let us not forget that Romaine-2's main dam, with a height of 109 meters, will be the highest structure of its kind in America. The reservoir structures of Romaine-1 will use the same technology.

Romaine-3 projects also pioneered a new technology by using a 3D virtual model during the invitation to tender, as opposed to traditional plans. Hydro-Québec predicts that traditional plans will eventually be replaced by 3D virtual models, which facilitate cooperation among engineers and enable them to work together as a network.

## THE ENVIABLE POSITION OF QUEBEC

Quebec relies on hydropower not as a source of energy but also because it is flexible and allows the transmission network to adjust to the fluctuating demand.

Furthermore, the opening of the North American electricity market increases Quebec's infrastructure value because of its interconnections with several neighboring networks. Originally designed to meet basic domestic needs, while taking into account the variations of multi-year hydraulic inputs, hydroelectric power plants equipped with large reservoirs see their mission broadening to include demands coming from the Northeast American market.

It is actually possible to take advantage of the hydropower generators' flexibility to adjust to hourly and immediate variations. This new reality prompts Hydro-Québec to improve the performance of existing power plants, aiming to reliably meet higher and more frequent demands, while decreasing the required maintenance. For example, in the Outardes-3 power plant, the groups' power was increased by 35% and their performance also improved. This modernization allows for a better exploitation of the Outardes River, where several power plants exist, for peak demands as well as the integration of chains of environmental variable generation such as wind energy.

These examples reflect the enthusiasm of companies, all members of the Quebec electrical industry, who were involved in the realization of Hydro-Québec's major infrastructure projects and contribute in maintaining its competitive advantage.

# Powering our lives

Whether it's designing a hydroelectric plant, constructing a wind farm, or integrating a power transmission and distribution grid, our team has the skills and experience to help your project vision become reality. Our engineers and specialists are with you every step of the way, providing services in all aspects of project management, process design, permitting, procurement, and construction management.

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- **transmission + distribution**
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2. static compensators at the - 735 kV Chenier substation, Mirabel, QC
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