

A New Energy Policy for Québec

RENEWABLE
ENERGIES



2016-2025 Energy Policy

RENEWABLE ENERGIES

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Ministère de l'Énergie et des Ressources naturelles

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INTRODUCTION

In 2006, the government adopted the *Québec Energy Strategy 2006-2015: Using Energy to Build the Québec of Tomorrow*, which hinged primarily on the revival and acceleration of the development of Québec's hydroelectric potential, the establishment of a wind power option, the diversification of sources of supply of natural gas and oil, and the promotion of greater energy efficiency.

The time has come to review the Québec government's energy-related priorities and orientations. To this end, it is necessary to examine the needs and expectations in respect of the different energy options that are underpinning Québec society's economic vitality and development. At the same time, this marks an opportunity to reassess the relevance, performance and efficiency of the tools that Québec has adopted to ensure the sound governance, development and responsible use of energy resources.

BACKGROUND DOCUMENTS

The series of background documents that the Ministère de l'Énergie et des Ressources naturelles is making available is intended to sustain reflection that will clarify the situation and challenges specific to contemporary Québec. The background documents seek to delineate the focus of reflection in light of success achieved at home and abroad and to raise questions that enable us to make enlightened choices over the coming decade.

This fascicle presents the role of renewable energies in Québec's energy portfolio. It also addresses the economic, technological, environmental and social questions related to the current market and the increased development of Québec's energies in the coming years.

The document is divided into three parts. The first part presents the general setting in which renewable energies will be developed the years ahead, in Québec and in the world. The next section presents the sectors that supply Quebecers with electricity. It describes the demand, the various power generation channels, the transmission and distribution grids, the governance framework, pricing and the contribution of the energy sectors to Québec's development. The third section contains information on sources of renewable energy that can replace fossil fuels and explores sources of exploitable heat and bioenergies. Considerable attention is paid to innovation.

Each section ends with findings, issues and questions to help define the place that should be held by each sector in the efforts to guarantee a diversified, stable, safe, accessible energy supply that is respectful of communities and that reflects the support capacity of our ecosystems.

Québec is changing. It must reposition itself bearing in mind its energy consumption profile, the global and continental context and the values that Quebecers cherish from the standpoint of economic development, environmental protection and social justice.

DESCRIPTION OF THE CONSULTATION PROCESS

The Québec government will adopt by the end of 2015 an energy policy covering the period 2016 to 2025. The policy will define the orientations that will enable Québec to:

- participate in a rapidly changing worldwide energy and economic context;
- maintain and, indeed, broaden its leadership in the realm of renewable energies;
- enhance its performance in the realms of energy efficiency, behavioural progress and education pertaining to energy and technological innovation;
- pursue the transition to a low-carbon economy;
- make energy resources a lever of wealth creation and social development in all regions.

The policy will stem from a mobilization and consultation approach that calls upon all Quebecers and stakeholders in Québec society.

In the fall of 2013, the Commission on Energy Issues in Québec visited Québec's regions to ascertain the concerns and collect the reflections of individuals and organizations interested in the environmental, economic and social issues related to energy. A report containing 57 recommendations was drawn from the 460 briefs, 300 presentations, 250 contributions on the Internet or in person during the 47 public consultation meetings, three workshops with the Aboriginal communities and numerous meetings between the commissioners and experts from the universities or public bodies.

As announced on November 7, 2014, the approach will continue with the placing online of five thematic background documents, which will broaden reflection by calling upon the round-table forums comprising Québec, Canadian and international experts.

The round-table forums will explore the following themes:

- energy efficiency and innovation;
- renewable energies;
- hydrocarbons.

At the same time as the experts' deliberations, the public will be invited to comment online on the observations, challenges and questions submitted to the experts. Meetings open to individuals and organizations wishing to express their viewpoints to the representatives of the MERN will be organized for each theme. Aboriginal representatives will also be invited to share the viewpoints of their communities.

On the strength of the outcome of the extensive reflection and debate, the government will make public in the fall of 2015 its 2016-2025 energy policy.

INTERNATIONAL SITUATION

Historically, recessions have been followed by periods of strong, generalized growth worldwide. The 2008 crisis was an exception, since its scars still mark many regions, including North America, where Québec has major trade partners. This situation has led to significant and ongoing differences in growth among countries which now characterize the global economy. These disparities are reflected in seesawing indicators that attest to the fragility of the economic recovery.

Forecasters tell us that the economic recovery will soldier on, despite the risks hanging over it. They predict that the global gross domestic product (GDP) will continue to increase modestly in the years ahead, thanks largely to the growth of emerging countries which, despite some lagging, should surpass that of the developed countries.

The extent to which these changes in global GDP will influence the dynamics of the energy markets will be increasingly defined, over time, by countries that are not members of the Organisation for Economic Co-operation and Development (OECD), particularly Asian and Middle Eastern countries. Through this interconnection, global energy demand will increase, but less significantly than was predicted at the beginning of the century.

The energy resources called on primarily to meet needs from now to 2035 will be fossil fuels. This is due to the fact that technology is providing ever-expanding access to these resources, which makes them increasingly available to meet market demand. Recent advances illustrate this well, as they are opening up the exploitation of non-traditional hydrocarbons, especially in North America, and expanding the reserves of black gold and natural gas available to very thirsty markets.

The abundance of fossil energy resources does nothing to promote the development of renewable energies. Recently, this connection has been doubly proven as the 2008 recession guided energy choices toward fossil fuels that are already very attractive in their abundance. This led to a slowdown in the growth rate of investments in the renewable energy sector worldwide, a trend that may continue if the recent drop in oil prices lasts.

Although the shift to renewable energies appears to be a difficult endeavour, it is nevertheless imperative that we take it, since it constitutes a major environmental and safety issue for our planet, as well as for public health and finances. The challenges for achieving it are still imposing, but fortunately there are some encouraging factors.

- **2015 Climate Change Conference in Paris:** France will host the 21st Conference of the Parties to the United Nations Framework on Climate Change. The objective of the conference is to achieve the first legally binding, universal agreement on climate to keep the global temperature increases within 2°C. This international agreement, which will come into effect in 2020, will seek to have all countries – developed and developing countries alike, including the biggest greenhouse gas emitters such as the United States, Canada and China – commit for the first time to a universal agreement on climate. This agreement will serve as an unprecedented accelerator for investment in the renewable energies sector worldwide.
- **European countries turning away from coal and nuclear energy:** Some European countries such as Germany and France have firmly committed to reducing their consumption of coal and nuclear energy, which is pushing them to rely more on renewable energies, especially wind and solar power.

- **Drop in the production cost of wind and solar power:** The economic development of countries with high sunshine rates, along with technological innovations, has reduced the generation costs of the wind and solar power sectors so they compare increasingly well with other energy sectors, renewable or otherwise. In contrast to this trend, the generation costs for hydroelectric energy are increasing.

BOX 1

FORECASTERS AT THE INTERNATIONAL ENERGY AGENCY PREDICT THAT IN THE NEXT TWO DECADES:

- The global demand for electricity will increase significantly.
- The global demand for oil, coal and natural gas will continue to grow, with fossil fuels remaining the most-used energy resources.
- The world energy mix will change: fossil energy will continue to dominate while nuclear energy will increase slightly and renewable energies will remain stable.
- Major technological breakthroughs may be achieved in the renewable energies sector, particularly in solar power, in various parts of the world, including Québec.
- The United States will exploit all their energy resources to achieve energy independence, which is within their grasp.

Note: Consumption projections are presented in greater detail in the fascicle on world and continental trends, which can be found at www.politiqueenergetique.gouv.qc.ca.

QUÉBEC'S SITUATION

The economic setting in Québec reflects that of the planet. The relatively important role of natural resources and commodity products, including aluminum, and the tertiarization of its economy mean that Québec is suffering from the economic backlash of the slow US and world recovery.

Energy security, a strategic issue for all economies in the world, is an essentially economic issue for Québec. Our wealth of renewable energy resources and privileged access to the fossil resources of western Canada and, more generally, North America, shelter us from the uncertain geopolitical context surrounding major oil-producing countries.

While access to different forms of primary energy is not a problem, the trade balance associated with fossil-based products, refined or otherwise (crude oil, gasoline, distillates, coal, natural gas, etc.) is. With the tertiarization of the Québec economy, oil is in less and less demand for the creation of value in the industrial sector, but in greater and greater demand to transport people and merchandise: 75% of the oil consumed in Québec is used for transportation.

Québec's economic fabric is changing, along with its socio-economic determinants. The housing stock is responding to the reduction in household size, low interest rates and the aging of the population. Commercial spaces are detaching and moving away from residential areas, while more and more rural dwellers are migrating to the urban centres. The number of vehicles per inhabitant is increasing, and the share of the household and societal budget dedicated to energy is a source of concern in many quarters.

With regard to the environment, Québec has succeeded in achieving the target it set under the Kyoto Protocol in 2012 to reduce its greenhouse gas (GHG) emissions by 6% in comparison to its 1990 figures. It has made a commitment to pursue its efforts to achieve a 20% reduction by 2020, and it will closely monitor the efforts of the international community at the Paris Climate Conference in fall 2015. The commitment to fight climate change and its funding through the cap-and-trade system set up in conjunction with California will be defining factors for the next energy policy, since the generation, transmission and consumption of energy are responsible for over 75% of Québec's GHG emissions (in 2011). The solutions to these energy issues involve land management, sustainable mobility, electrification of transportation, climate change, energy efficiency and recourse to bioenergy.

In addition fighting climate change, Québec is working to maintain its biodiversity and reduce its polluting emissions. In 1992, it signed on to the Earth Summit agreements, including the Convention on Biological Diversity. The government ascribes to the International Union for Conservation of Nature (IUCN) standards for protected areas and the Strategic Plan for Biodiversity for the decade 2010-2020, updated in Nagoya in 2011. This plan commits the parties to protect 17% of terrestrial and inland water and 10% of coastal and marine areas by 2020 (Target C11). In Québec, these targets, which play out differently in different regions and based on land ownership, may interfere with energy development projects.

Even though Québec enjoys an enviable record in terms of polluting emissions, the fight against acid rain (fuel regulation), the reduction of industrial oily wastewater and urban air quality, it continues to pursue ever-more ambitious targets that call on the energy sector to innovate and improve.

Due to our hydroelectric generation capacity and the vast swaths of forest in our territory, Québec's energy profile is almost unique in the world. With the end of the nuclear energy experiment, the decommissioning of a few old thermal power plants, the development of major wind power installations and the use of biogas and forest biomass, Québec electricity is more than 99% renewable. The widespread use of electricity for heating and the intensive production of aluminum are the result of the availability of this green electricity in large quantities and at competitive prices.

In the transportation sector, Québec's consumption profile is similar to that observed elsewhere in the world. Petroleum products are far in the lead, leaving a few meagre shares to natural gas and other gaseous fuels (propane and hydrogen), and to electric transportation such as the Montréal metro and light electric vehicles.

The particular energy situation in Québec – where, along with our wide open spaces and our language, hydroelectricity enjoys the status of a proud national symbol – makes our relationship to the environment and to energy infrastructures quite distinctive, at least within North America. This is how well-organized social movements have succeeded, in the past, in making the government back down from various plans such as the construction of a natural gas power plant and shale gas exploration in the St. Lawrence valley. Today, even major hydroelectric projects are challenged by many groups concerned about the environment and territorial integrity.

The Québec government's priorities are the economy, job creation and stabilizing public finances. The government relies on energy to sustain the competitiveness of Québec businesses and promote regional development. Despite Québec's enviable balance sheet due to the very nature of our territory, with its plentiful renewable energy, the government is reiterating its commitment, in solidarity with the other nations, to continue to fight climate change. Two major projects will contribute to the achievement of its economic priorities: the revival of the Plan Nord and the Québec Marine Strategy. Energy plays a major role in both. Access to competitive energy that respects the environment in the north is one of the conditions that attracts private investment to the Plan Nord. At the same time, some of the marine infrastructures Québec needs to support its development and energy security will be dedicated to the transportation of energy products.

In addition to these two major projects, the government plans to improve employment and productivity by supporting innovation and making strategic use of Québec's electricity surpluses. The promoters of electricity-intensive industrial projects will benefit from a reduction in the applicable rates over a well-defined period if this will attract investment without harming Québec businesses working in the same field. The government is counting, in particular, on the wind, aluminum and electric vehicle component industries to strengthen Québec's industrial base.

Finally, Québec's forest and farming bioresources will round out the array of energy resources that Québec society can count on for sustainable prosperity. Research and development into new technologies in this sector may offer access to markets such as the equipment, biomaterials and high value-added molecule markets that offer extremely lucrative potential.

PART A

RENEWABLE ELECTRICITY
GRID

SECTION 1

ELECTRICITY GOVERNANCE

For a century, the social, industrial and economic development of Québec have been stimulated by the abundance of its water resources. During the economic crisis of the 1930s, however, many voices were raised in Québec against private electric companies, which were accused of abusive practices such as providing poor service, refusing to serve numerous rural regions deemed to be insufficiently lucrative and setting excessive rates that went hand-in-hand with exorbitant dividends for their largely foreign shareholders.

Consequently, Québec's premier at the time, Adélard Godbout, decided to expropriate the electric and gas assets of Montreal Light, Heat and Power, which held the monopoly. The nationalization plan came into effect with the adoption of the Act to Establish the Québec Hydro-Electric Commission on April 14, 1944. From the terms of this law sprang the idea of a social pact under which the Québec Hydro-Electric Commission, the forerunner of Hydro-Québec, would offer rates that were stable, standard across Québec and as low as permitted by the requirements of sound financial administration.

In 2000, this pact was enshrined in the Act Respecting the Régie de l'énergie as follows:

- The obligation for Hydro-Québec to offer Québec consumers a 165 TWh pool of heritage electricity at the price of \$0.0279/kWh, a price that has been indexed since 2014
- The prohibition to change the cross-subsidization among the different classes of customers, which benefits residential customers
- The standardization of electricity rates across the entire territory of Québec, regardless of distance from generation sites or the dispersion of the clientele served

The creation of Hydro-Québec ushered in major new energy projects. In 1963, the government decided to acquire the majority of the private power grids through Hydro-Québec, with the exception of some 80 municipal and cooperative power grids that existed at the time, which already belonged to the community.

STAKEHOLDERS

In Québec, the government corporation Hydro-Québec dominates the renewable energy sector. As an electric company, Hydro-Québec is involved in hydroelectric power generation, as well as the transmission and distribution of electricity. It encourages energy efficiency and pursues initiatives to promote the electrification of transportation.

Since 2000, in the wake of changes to the Act Respecting the Régie de l'énergie, the regulatory framework for electricity has relied on the regulation of electricity transmission and distribution activities in accordance with North American practices and the deregulation of power generation activities (competition).

BOX 1

HYDRO-QUÉBEC

Hydro-Québec, a government corporation, generates, moves and distributes electricity. It is comprised of four main divisions:

- Hydro-Québec Production generates the electricity to supply the Québec market, including the heritage pool, and sells electricity on the wholesale market.
- Hydro-Québec TransÉnergie operates the biggest power transmission grid in North America to serve its customers inside and outside Québec, that is, the customers of the power transmission grid. It sells its wheeling capacity and manages the movement of energy within Québec.
- Hydro-Québec Distribution operates the power distribution grid and provides Quebecers with a reliable power supply. The division launches initiatives for the effective use of electricity and manages relations with customers – Québec households, institutions and businesses.
- Hydro-Québec Équipement et services partagés (HQESP) and the James Bay Energy Corporation (JBEC), Hydro-Québec subsidiaries, are active in construction projects and service offers. HQESP and JBEC design and carry out construction projects and generation and transmission equipment repair projects for Hydro-Québec. HQESP also offers services in real estate management, materials management, provisioning, transportation and more to all Hydro-Québec divisions and units.

Since 2000, under the Act Respecting the Régie de l'énergie, Hydro-Québec Distribution has been the entity in charge of the power supply for Québec markets. It is supplied by Hydro-Québec Production and by private generators to serve its customers.

Other than the extensive heritage pool, Québec's electric power generation activities are governed by the rules of free competition. Hydro-Québec Production is, however, the only entity that builds hydroelectric works of over 50 MW, which limits the competitive field to small hydroelectric plants and other generation channels.

Quebecers are attached to Hydro-Québec, but they regularly question the business structure of the government corporation (Distribution, TransÉnergie, Production and HQESP/JBEC divisions), the scale of the profits generated, the rules of functional separation between the corporation and the government and certain of its business practices (e.g., access to information).

BOX 2 THE RÉGIE DE L'ÉNERGIE

The Régie de l'énergie is an economic regulation organization with the mission to reconcile the public interest, consumer protection and equitable treatment of the power carrier and the distributors.

It is a semi-judicial body at the centre of the regulatory framework. The Régie de l'énergie replaced the Régie du gaz naturel, which dealt solely with natural gas distributors.

Before the creation of the Régie in 1997, the government was responsible for the regulations applicable to Hydro-Québec. The Régie de l'énergie was created to address certain perceived shortcomings in the array of roles played by the government (definition of guidelines, adoption and application of regulations, shareholder). Since all the expertise was concentrated in the same organization, it was difficult to get a second opinion or to take public opinion into consideration in decision-making.

The Régie's mandate is defined in the Act Respecting the Régie de l'énergie. It has jurisdiction mainly over Hydro-Québec, in its transmission and distribution activities, as well as over the natural gas distributors Gaz Métro and Gazifère. The nine municipal electric power distributors and the Coopérative régionale d'électricité de Saint-Jean-Baptiste-de-Rouville also come under the jurisdiction of the Régie (handling of consumer complaints).

The Régie sets the rates for electric power transmission, the rates applicable by Hydro-Québec Distribution and those of the gas distributors. It authorizes the investment envelope for Hydro-Québec's distribution and transmission divisions. It individually authorizes the budgets for investment projects of over \$25 million for the power carrier and over \$10 million for the distributor. With regard to the distributor, the Régie approves the supply plan, the call for offers procedure, and the granting of electricity supply contracts signed with the suppliers, as well as the budget for the general energy efficiency plan. The Régie also monitors the prices of petroleum products.

The Régie has no jurisdiction with regard to the generation of electricity.

Québec's regulatory framework for electricity is similar to those in effect in other Canadian administrations (see Appendix 1), especially the one in British Columbia. The need for an energy commission is acknowledged, but the nature of the Régie's responsibilities is regularly questioned when stakeholders feel, for example, that electricity generation activities should be regulated, that the advisability of investments in certain transmission proposals should be examined along with the associated generation proposals or that the organization should have greater environmental accountability.

At the same time, government interventions in the form of economic, social and environmental concerns offloaded on the Régie give some participants in the Régie's work the impression that the organization's expertise is being gradually eroded.

Proposed electricity generation and transmission projects are subject to challenges in terms of energy rationale, energy choices, environmental impact and economic and financial justification. The expertise in these fields is scattered among diverse institutions.

The environmental questions related to certain electricity generation or transmission infrastructure projects are governed by sections 22 and 31.1 of the Environment Quality Act. In some cases, the Minister of Sustainable Development, Environment and the Fight against Climate Change (MDDELCC) can also request a hearing with the Bureau d'audiences publiques sur l'environnement (BAPE).

BOX 3

THE BUREAU D'AUDIENCES PUBLIQUES SUR L'ENVIRONNEMENT

The Bureau d'audiences publiques sur l'environnement is a neutral, public organization that reports to the Minister of Sustainable Development, Environment and the Fight against Climate Change. Its mission is to provide information about the ecological, social and economic perspectives of sustainable development for government decision-making purposes.

To achieve its mission, the BAPE informs, surveys and consults the public on projects or questions submitted to it by the Ministry about the quality of the environment. It then produces investigation reports which are made public. Since the founding of the organization, its investigation commissions have examined proposals submitted to it by applying a broad concept of the environment that is comparable to sustainable development.

For Hydro-Québec generation proposals, the government grants authorization after considering the energy, economic and financial rationale and taking available energy options into consideration. It is the government's responsibility to provide final or, in some cases, conditional authorization for these infrastructure projects.

BOX 4

THE GOVERNMENT OF QUÉBEC

The government of Québec has maintained a role and significant powers in relation to Hydro-Québec and the Régie de l'énergie. It has effectively kept its prerogatives concerning the generation of electricity by Hydro-Québec, power exports and the capacity to determine the supply required from certain power generation channels.

The government can also require Hydro-Québec Distribution to issue calls for offers for supplies from a particular power generation channel. In this case, the competitive process replaces financial justification.

Federally, the National Energy Board is a regulatory body that authorizes the construction and operation of international electric power transmission lines (interconnections)¹ and issues export licences.

ISSUES

Many different organizations are involved in examining proposed projects, based on their respective areas of expertise. This makes it difficult to conduct a simultaneous and integrated analysis of the energy, economic, financial and environmental dimensions and results in more complex decision-making in order to make the best choices.

¹ The jurisdiction of the National Energy Board may also extend to interprovincial power transmission lines deemed to be under federal jurisdiction.

QUESTIONS

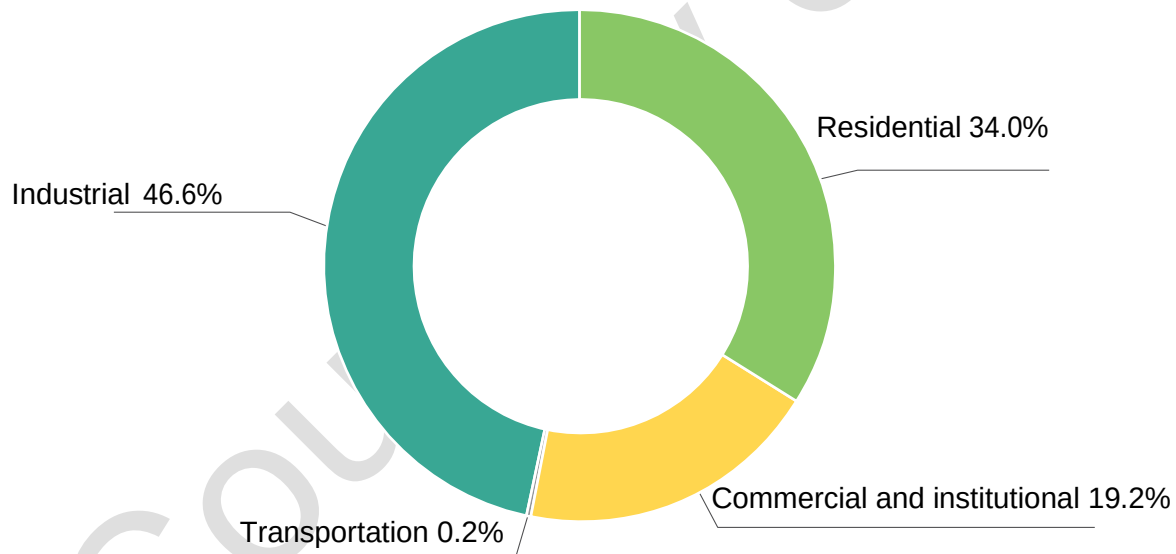
- Is the regulatory framework in effect in Québec sufficient to allow the government to effectively play its role in terms of electricity rates and supply planning?
- Are the powers and activities assigned to Hydro-Québec under its empowering legislation appropriate for responding to the issues arising from the current energy situation and the challenges it raises?
- Should the role of the Régie be expanded to cover all facets of hydroelectric infrastructure projects, including the timeliness and environmental impacts of the proposed project, issues currently under the jurisdiction of the BAPE?
- How could all authorization processes required for electric infrastructure projects be better integrated, including that of the Commission de protection du territoire agricole du Québec (CPTAQ)?

SECTION 2

CONSUMPTION

Hydro-Québec Distribution is Quebec's main electric power distributor, with 4.2 million subscribers as of December 31, 2014. Since the 1970s, the increased number of electrical devices in homes and the sound competitive position and inherent benefits of electricity, including its renewability, have guided consumer choices, including the conversion of oil heating systems to electric systems.

Figure 2.1
Final electricity consumption, by sector, in 2011



Note: Total electric consumption in 2011 was 186 billion kWh.
Source: Ministère de l'Énergie et des Ressources naturelles

Québec is one of the largest per-capita energy consumers in the world, just after Iceland and Norway which, like Québec, have abundant hydroelectric resources. Québec's historic decision to develop its hydroelectric industry and the very low cost of this energy are valuable assets for households and businesses. For this reason, electric heating is widespread in the residential sector and many high-energy-consuming industries, such as aluminum smelters, have set up operations here.

According to Statistics Canada, 70% of Quebecers use electricity as their main source of heating. Space heating accounts for 61% of all residential electricity consumption, far ahead of hot water, lighting and appliances.²

² MERN. (2015). *Politique énergétique 2016-2025 — Efficacité et innovation énergétiques*, 50 p.

According to Hydro-Québec Distribution,³ electricity sales are expected to post an average annual growth rate of 0.7% (about 1.3 TWh a year), reaching 184.1 TWh by 2023. The projected growth in electricity consumption is therefore low in Québec. Consumption levels are sensitive to the strength of the economy. For some years now, Hydro-Québec Distribution has observed stagnation and even a decline in electricity sales in several industrial sectors. From 2007 to 2014, electricity sales to major industries have declined by 8.0 TWh. As for sales to residential and commercial customers, growth remains modest.

In 2013, small and large industrial clients consumed 38% of the electricity sold in Québec by Hydro-Québec, or 65.7 TWh (Table 2.1). To this consumption can be added the electricity generated by certain major corporations in the pulp and paper and aluminum sectors. These industrial self-generators, such as Rio Tinto Alcan, Produits forestiers Résolu and Société en commandite hydroélectrique Manicouagan, generated and consumed 20.9 TWh in 2013.

Table 2.1

Sales of electricity by Hydro-Québec Distribution to the industrial sector in 2013

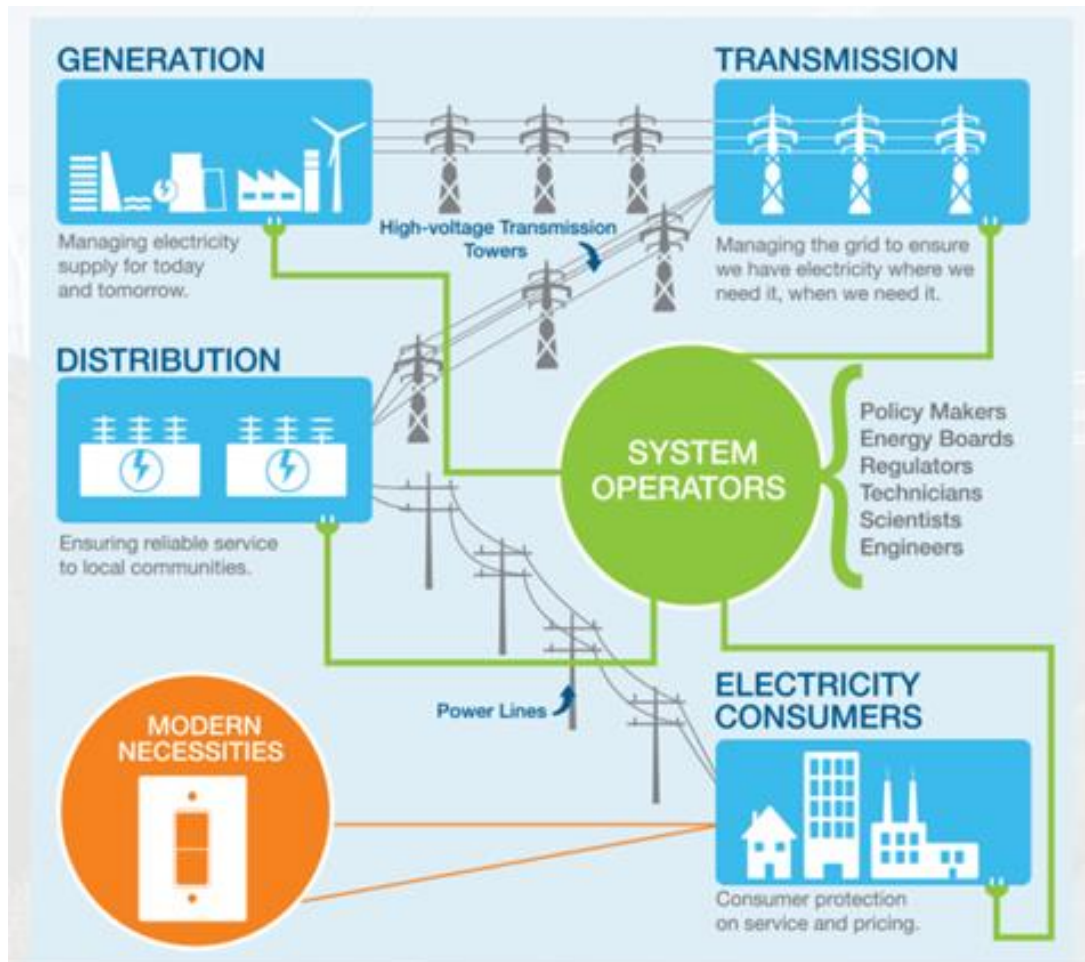
Industry category	Sales (TWh)	Share (%)
Small and medium businesses	8.8	13.4%
Big businesses	56.9	86.6%
Aluminum smelters	22.8	34.7%
Pulp and paper	14.1	21.5%
Petroleum and chemicals	5.6	8.5%
Mines	3.5	5.3%
Iron and steel smelting and refining	7.4	11.3%
Other	3.3	5.0%
TOTAL INDUSTRIAL	65.7	100.0%

Source: Hydro-Québec Distribution. (2014). *État d'avancement 2014 du Plan d'approvisionnement 2014-2023*, 49 p.

³ Hydro-Québec Distribution. (2014). *État d'avancement 2014 du Plan d'approvisionnement 2014-2023*, 49 p.

Figure 2.2

Electricity – from power generation plants to consumers



Source: Canadian Electricity Association. How the Electricity System Works. <http://powerforthefuture.ca/the-value-of-electricity/how-the-system-works/>

ISSUES

We have to encourage informed consumption habits and choices that are conducive to better electricity use. Planned changes should improve the situation of households, institutions and businesses, as well as being beneficial for the whole of Québec society.

QUESTIONS

- What place does electricity hold in Québec's energy mix?
- In Québec's energy and economic situation, what measures will encourage smarter consumption without restricting access to energy for low-income households?
- In the residential sector, how can we fix the peak demand problems that hinder the adoption of electric heating in new and existing buildings and still pursue a policy of progressive independence from fossil energies?
- What electric conversion efforts should be deployed and in which sectors?

SECTION 3

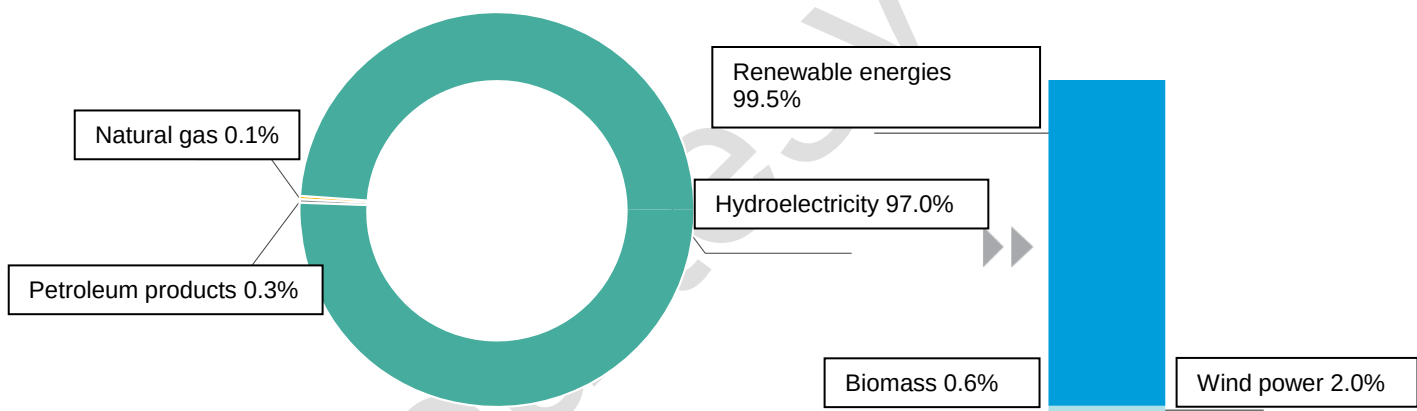
GENERATION AND SUPPLY

CURRENT GENERATION CAPACITIES

Since the closure of the Gentilly-2 power plant, almost all the electricity generated in Québec now comes from renewable resources (Figure 3.1). Hydroelectricity, the legacy of the development of the territory's abundant hydraulic power, is the dominant form. Wind power and biomass co-generation are more recent and much less extensive in terms of existing generation capacity.

Figure 3.1

Share of electricity generated in Québec, by primary energy source (2013)

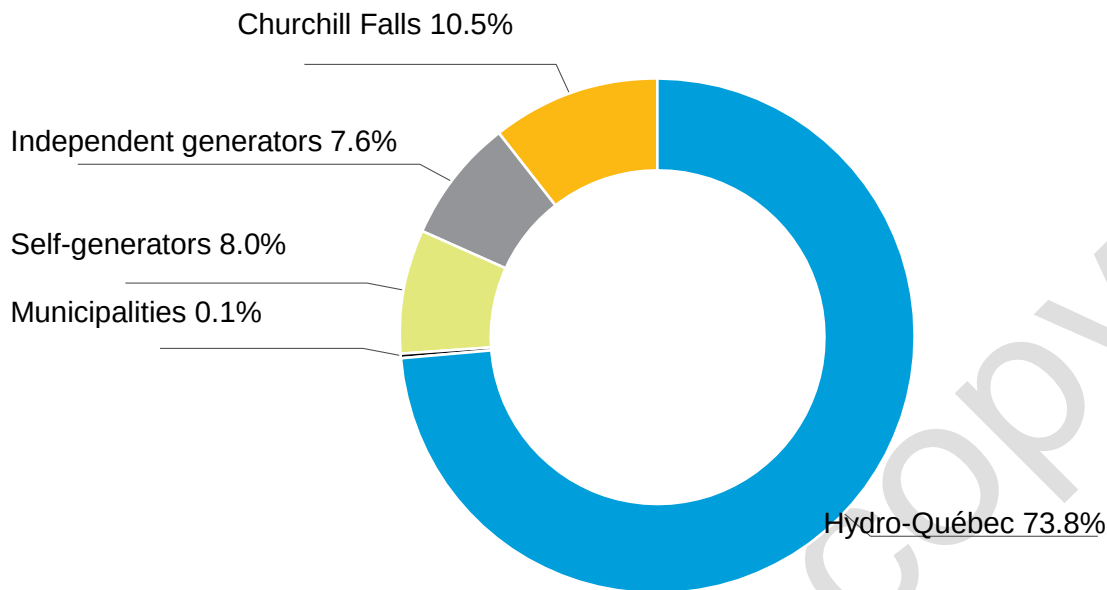


Source: Ministère de l'Énergie et des Ressources naturelles, données préliminaires.

The generation of electricity in Québec is dominated by Hydro-Québec's Production division. For decades, Québec has been developing its enormous hydroelectric potential. Today, the cost of the electric power supply from Hydro-Québec Production is very low, in the order of \$0.02/kWh.

Figure 3.2

Distribution of electrical output available, by type of generator, on December 31, 2013



Note: The total installed output available on December 31, 2013, was 43,731 MW.
Sources: Ministère de l'Énergie et des Ressources naturelles and Hydro-Québec.

Québec's industrial self-generators have a hydroelectric generation capacity of 3,965 MW, while the private and municipal generators total 415 MW. Private generators also operate electric power generation plants that use biomass, for a total of nearly 249 MW, and biogas plants with a total capacity of over 35 MW.

The wind power capacity of the private and municipal generators was 2,399 MW on December 31, 2013, 5.5% of the installed generation capacity in Québec, and it is expected to reach over 3,900 MW by 2017. The thermal generating capacity supplied by fossil fuels accounts for 1,589 MW, or 3.6% of Québec's installed capacity.

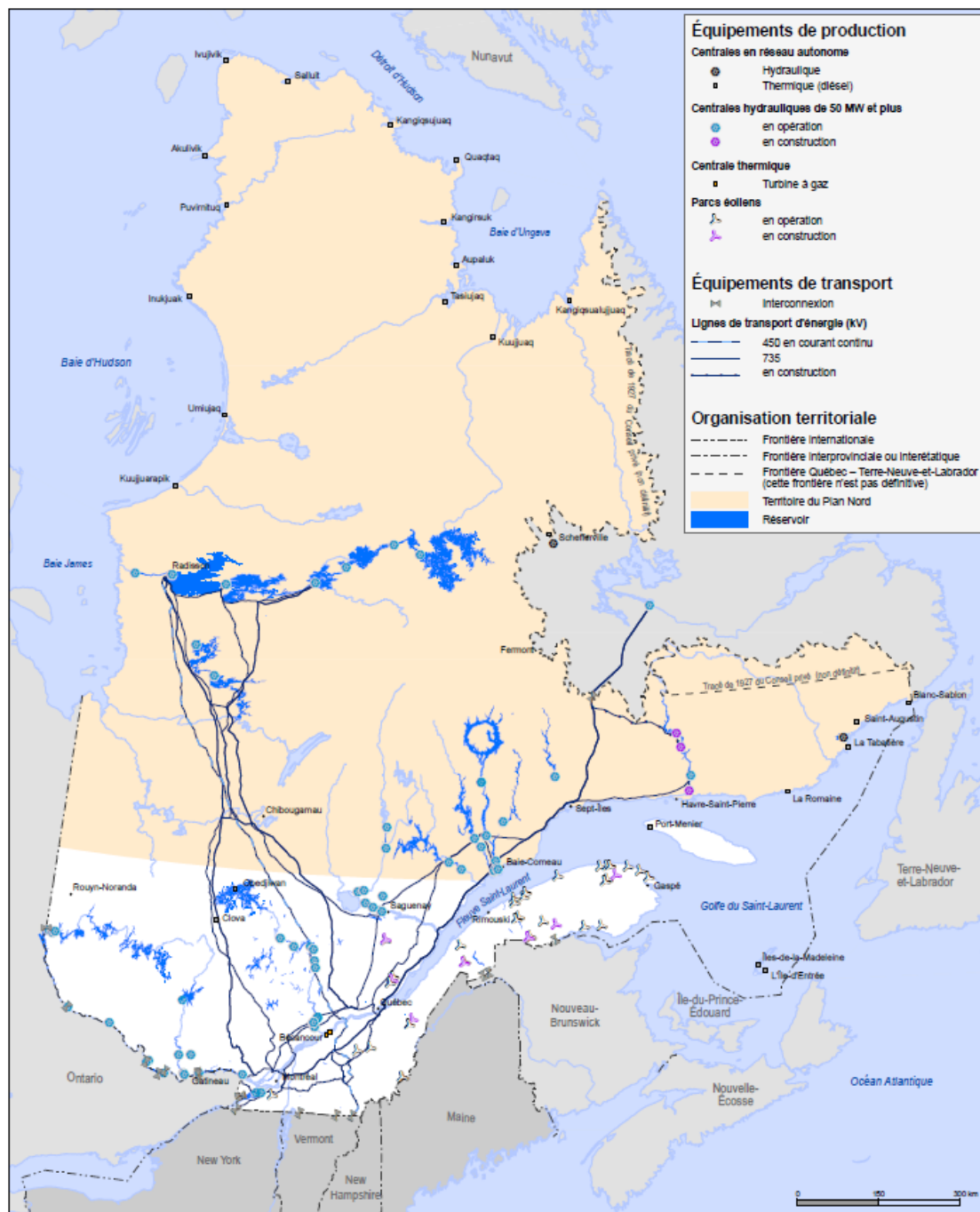
Hydro-Québec Production has a thermal power plant that supplies energy to the grid during peak demand. TransCanada Energy (TCE) also owns a 547-MW electric co-generation plant that operates on natural gas. Under an agreement with Hydro-Québec Distribution, this plant is currently closed.⁴

In remote sectors in Plan Nord territory, in the Haute-Mauricie and on the Îles-de-la-Madeleine, which are served by off-grid systems, Hydro-Québec Distribution operates generation equipment comprised of 24 thermal plants and 2 small hydroelectric plants.

⁴ Régie de l'énergie. (2014). Decision related to the request for approval of changes to the 2009 agreement on the temporary suspension of deliveries from the TCE plant, D-2014-086, R-3875-2014.

Figure 3.3

Capacity of main electrical generation and transmission equipment in Québec



Source: Ministère de l'Énergie et des Ressources naturelles.

POTENTIAL OF ELECTRICITY SECTORS

HYDROELECTRIC ENERGY

Nearly all the main hydroelectric plants are located in Plan Nord territory. They are connected to major consumption centres by high-voltage lines that cover hundreds of kilometres. There is still significant potential for hydroelectric development in Québec: it is generally assessed at 45,000 MW, of which nearly 20,000 MW offers potential economic interest in the current climate. This availability offers leverage for the development of northern Québec.

These estimates do not include the potential offered by developing technologies, such as marine turbines that use the speed of a current to generate energy.

WIND ENERGY

The wind energy sector's electric power generation capacity, developed by private promoters, sometimes in association with local and Aboriginal communities, has grown rapidly after four calls for offers. By the end of 2017, when all the wind farms that were contracted are in service, Québec's wind energy capacity will have attained nearly 4,000 MW, which is 10% of the total installed capacity.

Québec enjoys impressive wind energy potential, at nearly 8 million megawatts. Overall, 85% of this total potential is in the Nord-du-Québec region.⁵

SELF-GENERATION AND NET METERING

The self-generation of electricity at the residential and small-business level allow customers to inject surplus electricity, obtained from an installation of 50 kW or less, back into the system in exchange for credits. Hydro-Québec Distribution offers to “store” the electricity generated by its customers against a time when the customer's demand surpasses what it is generating. The terms and conditions of application for this program in Québec are comparable to those found elsewhere in North America. In Québec, as of April 1, 2014, net metering had 69 subscribers with 512 kW installed (0.001% of Québec's total capacity) in the form of solar photovoltaic panels and micro wind turbines. The low electricity rates in Québec discourage this type of generation. Despite some expressed interest, none of the self-generation subscribers use hydroelectricity as a source of generation, since the regulatory framework is not favourable for this (Watercourses Act).

SUPPLY COSTS

The average⁶ cost of the hydropower contracted from Hydro-Québec Production by Hydro-Québec Distribution is very low – less than \$0.03/kWh. This cost, which reflects the low cost of the heritage pool, is expected to increase due to the indexation on the inflation of the cost of heritage electricity since 2014. The marginal cost⁷ of hydroelectric power supply is actually \$0.062/kWh, or double the average.

If the need surpasses the volume of the heritage electricity pool, Hydro-Québec Distribution has to fall back on a call for offers process in which all sectors and all promoters can compete, including the energy

⁵ Héliqua Énergie Inc. and AWS Truewind LLC. (2005). *Inventaire du potentiel exploitable du Québec*, 60 p. (document prepared for the Ministère des Ressources naturelles et de la Faune du Québec).

⁶ The average cost is the average of the costs of all contracted supplies.

⁷ The marginal cost is the cost of the most recently contracted supplies.

efficiency sector. The government can, by regulation, ask Hydro-Québec Distribution to proceed with a call for offers for the purchase of a pool of energy from a specific sector, such as the wind energy sector or biomass co-generation. This is post-heritage electricity.

The average cost of post-heritage electricity is currently \$0.098/kWh, clearly higher than the cost of the heritage pool. On the other hand, Hydro-Québec Distribution's latest call for offers for the provision of a pool of 450 MW of wind power, with deliveries to begin in 2016, established a lower marginal cost, in the order of \$0.063/kWh in 2014 dollars.

Table 3.1

Average cost and marginal cost of Hydro-Québec Distribution's power supplies in 2013

Sector	Average cost (¢/kWh)	Marginal cost (¢/kWh)
Large hydroelectric plants	2.9	6.2 ¹
Small hydroelectric plants	8.1	8.1
Wind turbines ^P	8.6 ²	9.7 ²
Biomass ^P	9.9	10.5

1 Reflects basic contracts (350 MW) and cyclable contracts (250 MW) made with Hydro-Québec Production.

2 Before the commissioning of installations built under the last call for offers for wind power electricity (\$0.063/kWh).

P Partial data.

Sources: Hydro-Québec Distribution. *Approvisionnement en électricité*, R-3905-2014, HQD-6, document 1, 17 p.

Hydro-Québec Distribution. *Achats d'électricité*, R-3905-2014, HQD-6, document 2, 9 p.

Table 3.2

Expected annual surplus in Hydro-Québec Distribution's supplies over client demand, now to 2023

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Surplus (TWh)	5.3	6.6	6.4	7.2	7.5	6.8	5.0	4.7	3.8	3.0
Percentage of total supplies	2.7%	3.4%	3.3%	3.7%	3.8%	3.4%	2.5%	2.3%	1.9%	1.5%

Source: Hydro-Québec Distribution. (2014). *État d'avancement 2014 du Plan d'approvisionnement 2014-2023*, 49 p.

HYDRO-QUÉBEC DISTRIBUTION'S SUPPLY-DEMAND BALANCE

The supply currently available to Hydro-Québec Distribution comes from electrical availability purchased by guaranteed contract from various generators, which exceeds the demands of its customers. This leads to surpluses, the cost of which is passed on to the consumers.

It must be remembered, however, that the concept of energy surplus is volatile. In fall 2013, for example, Hydro-Québec Distribution evaluated its cumulative energy surplus for the period from 2014 to 2023 at 75

TWh.⁸ After a review in spring 2014, the estimate was adjusted to 60.6 TWh.⁹ Finally, the review in fall 2014 downgraded the surplus to 56.3 TWh.¹⁰ Furthermore, the implementation of a few major industrial projects could bring the distribution into balance.

The situation is completely different for Hydro-Québec Distribution's power balance sheet, however. Hydro-Québec Distribution predicts an electric power deficit as early as winter 2015-2016 during peak periods. In Québec, power needs arise during cold periods when all the installations accessible to Hydro-Québec Distribution are called on, including some imports from neighbouring power grids. The distributor's peak periods involved a limited number of hours, in the order of a few dozen hours per year.

BOX 5

CONCEPTS OF ELECTRIC POWER AND ENERGY

Electric power

Power is a rate of energy, generated or consumed, at a specific time. Power is measured in (W). A watt is the power generated or consumed when a joule is transferred uniformly for a second.

For a consumer, for example, a 100-watt bulb requires electric power of 100 watts to operate, and 10 100-watt bulbs require 1 kW (1,000 watts) of power to operate simultaneously.

For Hydro-Québec, power reflects the effort that the power generating plants at its disposal deploy at each moment to meet customer needs.

Electric energy

The quantity of electric energy that we consume is the sum, over a period of one hour, of the power consumed at each moment. Energy is therefore measured in watt-hours (Wh).

For the consumer, this is the electricity invoiced by Hydro-Québec, which is measured by a meter. So for 10 100-watt bulbs operating for an hour, the electric energy totals 1 kWh (10 bulbs x 100 watts x 1 hour).

For Hydro-Québec, the energy delivered is equal to the power of the generating plants in operation multiplied by the period of operation.

Power needs during winter (2013):

- Hydro-Québec: 39,031 MW
- Municipal and private grids and cooperatives: 1,077 MW

⁸ Hydro-Québec Distribution. (2013). *Plan d'approvisionnement 2014-2023 — Réseau intégré*, R-3864-2013, HQD-1, document 1, 39 p.

⁹ Hydro-Québec Distribution. (2014). *Prévision de la demande — Ajustements de mai 2014-2023*, R-3864-2013, HQD-6, document 2.

¹⁰ Hydro-Québec Distribution. (2014). *État d'avancement 2014 du Plan d'approvisionnement 2014-2023*, 49 p.

Table 3.3

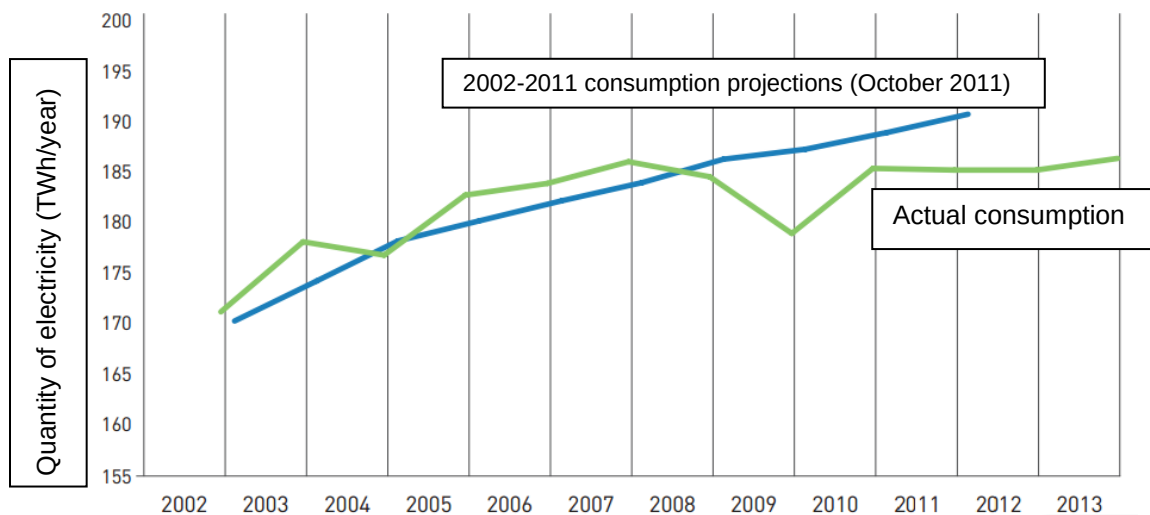
Additional power needs required to meet the demands of Hydro-Québec Distribution customers during the winter peak¹¹

	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023
Additional power required according to Hydro-Québec Distribution projections (MW)	0	600	1,050	1,500	1,650	2,050	2,400	2,800	3,150

Source: Hydro-Québec Distribution. (2014). *État d'avancement 2014 du Plan d'approvisionnement 2014-2023*, 49 p.

Figure 3.4

Balance between consumption projections for 2002-2011 and actual electrical consumption by Hydro-Québec Distribution customers



Sources:

2002 data – Dossier R-3748–2010 – Plan d'approvisionnement 2011-2020 – submitted to the Régie de l'énergie on November 1, 2010.

2003-2012 data – Dossier R-3864–2013 – Plan d'approvisionnement 2014-2023 – submitted to the Régie de l'énergie on November 1, 2013.

2013 data – Hydro-Québec Distribution. Dossier R-3470-2001 – Approvisionnement additionnel et stratégie proposée – submitted to the Régie de l'énergie on October 25, 2001.

CHOICE OF FUTURE ELECTRICITY GENERATION CHANNELS

In addition to the efforts to reduce GHG emissions related to the generation of electricity worldwide, the recent rise of certain types of renewable energy is related to their declining generation costs and increased efficiency. Ongoing research and technological advances will contribute, eventually, to making these technologies competitive in comparison to the mature electricity generation channels.

¹¹ Winter period, when the need for power is at its highest.

Traditional fossil fuel power plants

In the United States, thermal power plants supplied by natural gas are the generation channel with the lowest generation costs for new facilities. The abundance of shale gas at low prices benefits this sector, for which two-thirds of the generation costs are related to the natural gas supply. According to the US Ministry of Energy, the generation cost for a modern combined cycle power plant ranges from US\$0.073–\$0.089/kWh.¹²

The competitive advantage of natural gas thermal power plants leads to the transformation of generation installations: thermal plants fed by coal or petroleum products have been replaced by natural gas plants. In New England,¹³ for example, natural gas plants accounted for 46% of generation capacity in 2013, compared to 15% in 2000.

Hydroelectric plants

In Canada, the provinces with hydroelectric potential are pursuing the development of this sector, especially for its environmental benefits. Currently, four major hydroelectric projects are planned or underway, including the Romaine Complex project in Québec.

Table 3.4

Main hydroelectric power projects in Canada

Province	Project	Power (MW)	Energy (TWh)	Production cost (\$/kWh)
Newfoundland and Labrador	Muskrat Falls ¹⁴	824	4.9	0.077
Québec	Romaine ¹⁵	1,550	8.0	0.075
Manitoba	Keeyask ¹⁶	695	4.4	≈ 0.10
British Columbia	Site C ¹⁷	1,100	5.1	0.087 – 0.095

¹² U.S. Energy Information Administration. (2014). *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014*, 12 p.

¹³ ISO New England, (2014). *2014 Regional Electricity Outlook*. www.iso-ne.com/aboutiso/fin/annl_reports/2000/2014_reo.pdf

¹⁴ Letter dated April 1, 2011, from NALCOR ENERGY to Lower Churchill Hydroelectric Generation Project Joint Review Panel related to the request for information on March 21, 2011. If the Muskrat Falls costs had to be assumed solely by the insufficient growth in internal demand in Newfoundland and Labrador, the cost would be \$0.143/kWh.

¹⁵ Testimony of Thierry Vandal, CEO of Hydro-Québec, at the Commission parlementaire de l'agriculture, de l'énergie et des ressources naturelles, February 12, 2013. This cost includes anticipated output.

¹⁶ MANITOBA PUBLIC UTILITIES BOARD, *A Final Order with Respect to Manitoba Hydro's Application for Increased 2010/11 and 2011/12 Rates and Other Related Matters*, January 17, 2012, 232 p.

¹⁷ B. C. HYDRO, *Site C Clean Energy Project – Backgrounder*, January 28, 2013, 4 p.

Wind power

According to a study carried out in 2005,¹⁸ the Hydro-Québec grid's intermittent energy integration capacity was 10% of the grid's peak power. On this basis, the 2006-2015 Energy Strategy projects wind power integration in the order of 4,000 MW by 2015.

Since then, technological advances in wind power generation and grid balancing equipment, as well as integration experiences elsewhere in the world, have suggested possible wind power integration of up to 20%. The intermittency of the wind power can be compensated by the current system at no cost and with no major constraints.¹⁹ This ratio is likely even higher for grids with flexible means of generation, such as hydroelectric plants and modern natural gas plants.

The high integration (up to 35%) of wind power in some regions (Denmark, Germany and Sweden) relies on four premises:²⁰ the availability of interconnections (rapid exports of surpluses to neighbouring grids), sufficient deployment of the transmission grid, stable wind power technology and the limitation of wind power generation in "critical situations" (e.g., when demand is very low).

In the United States, the generation costs for energy generation channels that were until recently said to be "emerging" are dropping rapidly. From 2009 to 2014, for example, the generation cost (before subsidies or tax credits) for wind power dropped by 58%, reaching a range of US\$0.037–\$0.081/kWh,²¹ and photovoltaic solar power dropped by 78%, to US\$0.072–\$0.086/kWh.²²

These conditions have led several public utilities to sign long-term purchasing contracts on very advantageous terms, sometimes lower than their average supply costs. The supplies from these emerging channels are helping reduce the electricity rates offered to US consumers, which are much higher than those in Québec.

Two trends are also contributing to the emergence of these sectors in many US states:

- State and federal adoption of electricity generation targets based on renewable sources, combined with tax incentives for promoters
- The decentralization of electricity generation, in part thanks to regulations and purchasing programs that promote self-generation and micro-generation

Biomass thermal power generation

In Québec, recent experiments involving biomass electricity supply have encountered difficulties generating the target pools. The 2003 call for offers achieved 19 MW of the expected 100 MW, while the 2009 call for offers generated 52.9 MW of the 125 MW sought. The most recent initiative, which was a 300 MW purchase program, was extended by a year.

¹⁸ Hélimax Énergie Inc. and AWS Truewind LLC. (2005). *Inventaire du potentiel exploitable du Québec*, 60 p. (document prepared for the Québec Ministère des Ressources naturelles et de la Faune du Québec).

¹⁹ U.S. Department of Energy. (2008). *20% Wind energy by 2030 – Increasing wind energy's contribution to U.S. electric supply*, 228 p.

²⁰ H. Holttinen. (2004). *The impact of large-scale wind power production on the Nordic electricity system*, VTT Publications, 82 p.

²¹ Lazard. *Lazard's Levelized Cost of Energy Analysis – Version 8.0*, September 2014, 19 p.

²² Geographic location is one of the factors that explain the variability of wind power generation costs.

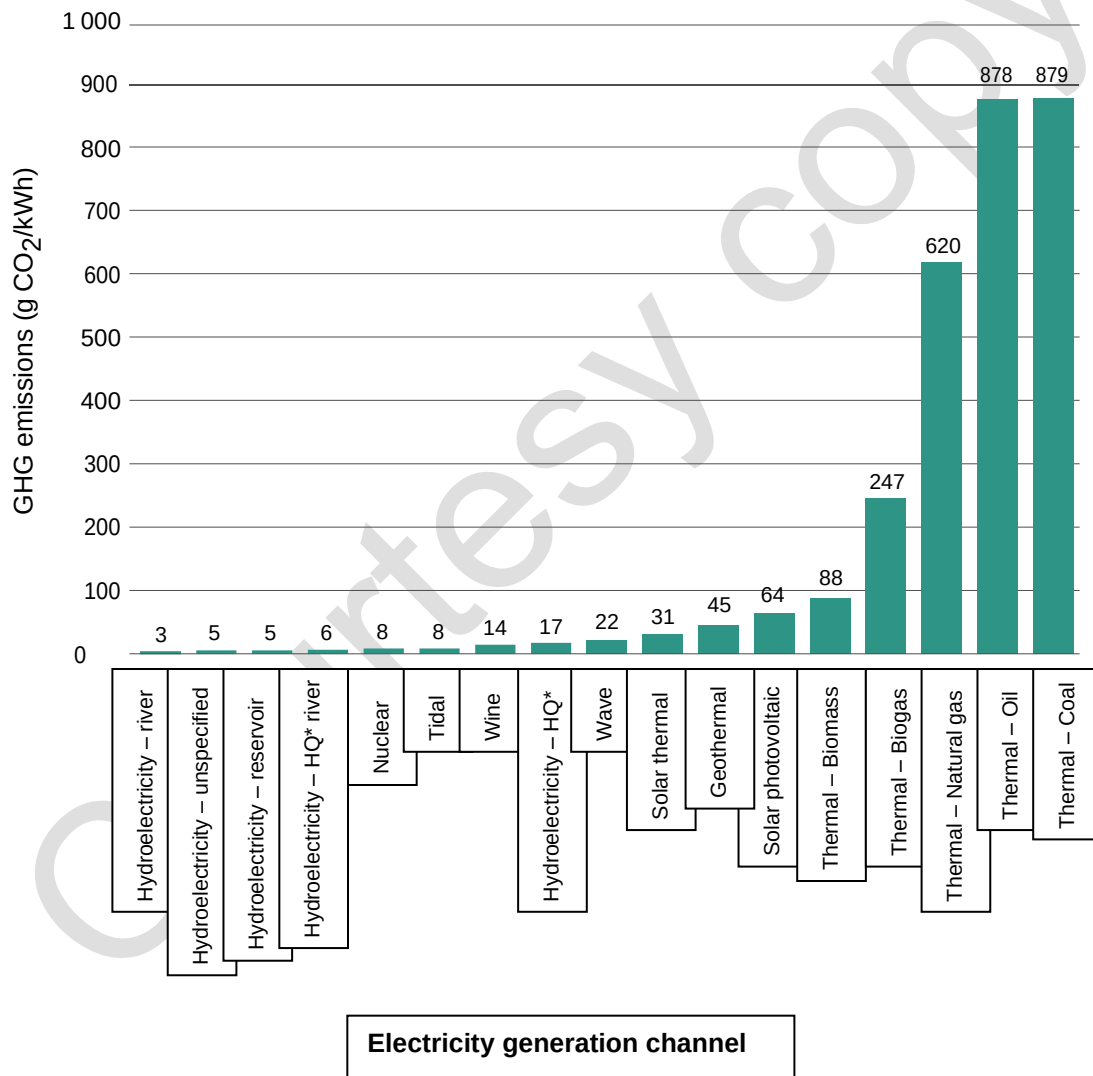
Fight against climate change

The competitive position of the various electricity generation channels does not fully include the environmental costs of developing them, especially in terms of greenhouse gas (GHG) emissions. This omission benefits thermal sources that use fossil energy.

Renewable energy sectors emit few GHGs: from 3 to 17 g CO₂/kWh for a river hydroelectric project or a reservoir project. These emissions are minuscule compared to thermal power plants fed by natural gas (620 g CO₂/kWh) or coal (879 g CO₂/kWh).

Figure 3.5

GHG emissions for different electricity generation channels



*HQ: Hydro-Québec

Source: CIRAIG. (2014). *Comparaison des filières de production d'électricité et des bouquets d'énergie électrique*, Technical Report, 52 p.

ISSUES

- In terms of the fight against climate change, Québec needs to define the place that the various electricity generation channels will hold in the future, taking into account the resources at our disposal and the regional development objectives we are pursuing.
- In 2041, Hydro-Québec Production will come to the end of the purchase contract from the Churchill Falls hydroelectric plant. These purchases, in the order of 30 TWh a year, represent a fairly significant portion of the heritage electricity pool. Hydro-Québec Production will enter negotiations with the Churchill Falls (Labrador) Corporation Limited to continue the supply after that date.
- The scope of decentralized generation in some US states raises regulatory and rate-related questions concerning access to energy transmission and distribution infrastructures and their shared costs. Electric utilities are demanding that their regulatory bodies force self-generators to contribute financially to electric power transmission and distribution infrastructures.
- Biomass co-generation is experiencing problems related to financing and the long-term availability of biomass at reasonable prices.
- Emerging renewable energy generation channels, in the Québec context of generation that is already 99% renewable, cannot rely on official green energy certification to bolster their development.
- To get the support of the public, the authorities need to rely on a good understanding of energy issues, particularly the distinction between the quantity of electricity required each year (quantity of water available to our dams) and power needs (capacity of the turbines to deliver electricity at any given moment), as well as an understanding of the environmental issues associated with the various electricity generation channels.

SOCIAL ACCEPTABILITY OF ELECTRICITY GENERATION PROJECTS

- Despite the environmental virtues, electricity generation projects based on renewable energy are subject to local and national challenges.
- The current energy surplus situation encourages people to envision the cessation of hydroelectric, wind power and biomass co-generation projects. The repercussions of some projects on the land (roads, dams, flood zones, etc.) also help call into question the pursuit of major renewable electricity generation projects.
- The development of new generation capacities, even when they are renewable, exacerbates the competition among traditional and emerging generation channels, as well as between the energy efficiency sector and the efforts that should be deployed primarily to reduce the gross demand for energy.

QUESTIONS

- What are the advantages and disadvantages of entrusting to Hydro-Québec Production, in whole or in part, the responsibility for the development of major hydroelectric power plants?
- How should the recourse to new supplies for Hydro-Québec Distribution be overseen? Under what conditions and based on what criteria?
- In the management of Hydro-Québec Distribution's supplies, what importance can be placed on energy surpluses?
- What are the advantages and disadvantages of decentralized electricity generation and greater recourse to self-generation on a very small scale (net metering) in Québec?
- What legislative changes would be required so that the use of hydro power in the domain of the state (e.g., permit conditions) is better attuned with the realities of economically viable micro-generation, either off-grid or in integrated grids?
- As major hydroelectric plants get further and further from consumption centres, is it still appropriate to develop major projects further and further north?
- How can the wind energy industry in Québec reduce its power generation costs? What means should be deployed to promote a strong wind energy sector in Québec?
- What would be the advantages of pairing wind power with hydroelectric plants that are in place, under repair or under development, particularly those located in Plan Nord territory?
- In Québec, how might the opening of the retail market reserved for the provision of emerging energy elicit new developments by promoters who agree to supply consumers directly?
- Would the introduction of an optional green rate, reserved for certain types of energies (e.g., wind, solar), be viable in Québec when 99% of the supply is already deemed to be renewable?
- What should Hydro-Québec Production's role be as a promoter of emerging energy channels?

SECTION 4

TRANSMISSION AND DISTRIBUTION OF ELECTRICITY

TRANSMISSION OF ELECTRICITY

The TransÉnergie division of Hydro-Québec provides the lion's share of electric power transmission in Québec. The integrated transmission grid operated by TransÉnergie extends over more than 33,900 km. The vast size of the transmission grid is due in particular to the distance between the hydroelectric generation plants, located in Plan Nord territory, and the consumption centres located in southern Québec.

The TransÉnergie transmission grid is also interconnected with adjacent power grids. The table below shows the neighbouring grids that are interconnected with Québec. The maximum power wheeling capacity in megawatts is shown in export mode (from Québec to the neighbouring state) and import mode.

Table 4.1

Capacity of interconnections between the Québec transmission grid and the adjacent power grids

Administrations	Export capacity (MW)	Import capacity (MW)
Ontario	2,735	1,970
New England	2,275	2,170
New York	1,999	1,100
New Brunswick	1,029	785

Source: Hydro-Québec. (2013). hydroquebec.com/transenergie/fr/reseau-bref.html

In addition to the TransÉnergie grid, other, smaller electric power transmission grids were developed in the past to meet the needs of self-generating industrial companies. These grids still exist, including those developed by Rio Tinto Alcan and Énergie La Lièvre S.E.C., but in some cases they now meet non-industrial needs.

The grid has been accessible to third parties since May 1997. At that time, Québec opened its wholesale electric power market by allowing Québec redistribution grids to source their suppliers from providers other than Hydro-Québec Distribution.

The Régie de l'énergie is responsible for the reliability of electric power transmission in Québec, in particular through the adoption of reliability standards and the oversight of those standards. Essentially, Québec's reliability plan is harmonized with those of the other North American governments.

To monitor the reliability of the service, both Distribution and TransÉnergie examine certain performance indicators that are submitted to the Régie de l'énergie.

Table 4.2

Average duration of blackouts and scheduled interruptions on the Hydro-Québec TransÉnergie transmission grid

Performance indicator	Year				
	2009	2010	2011	2012	2013
Average duration in minutes	168	70	109	55	126

Source: Hydro-Québec TransÉnergie. (2014). *Indicateurs de performance et objectifs corporatifs*, R-3903-2014, HQT-3, document 2, 26 p.

Table 4.3

Average duration of blackouts and scheduled interruptions on the Hydro-Québec Distribution grid

Performance indicator	Year				
	2009	2010	2011	2012	2013
Gross continuity index ¹ (minutes)	169	201	313	291	474
Standardized continuity index ² (minutes)	125	120	133	120	126

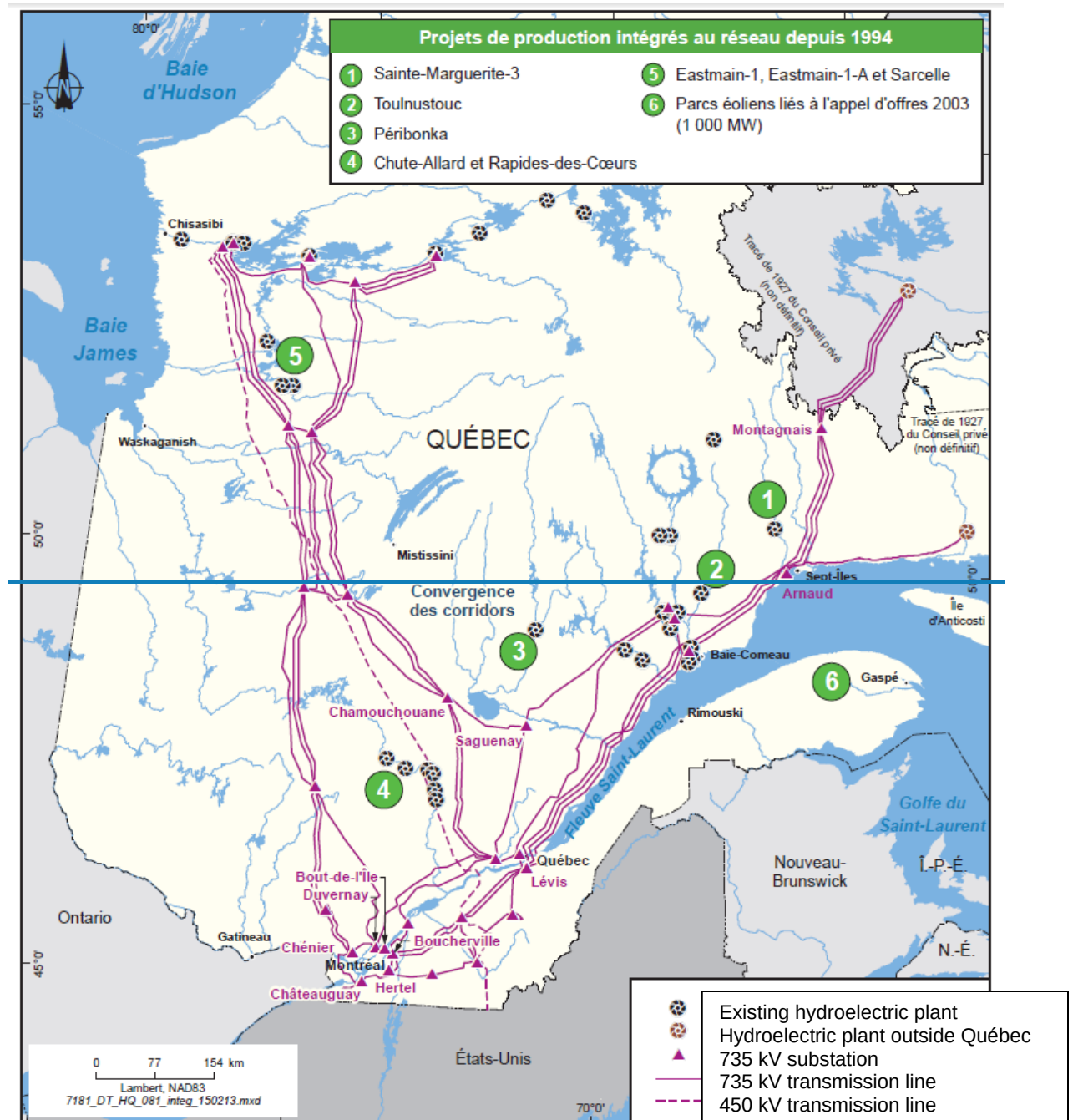
Source: Hydro-Québec Distribution. (2014). *Efficience et performance*, R-3905-2014, HQD-2, document 1, 33 p.

¹ The "gross" and "standardized" continuity indices give the average number of minutes of service interruption per customer with (gross) and without (standardized) exceptional events.

² *Idem*.

Figure 4.1

Map of generation projects integrated with the transmission grid from 1994 to 2014



Source: Hydro-Québec.

DEVELOPMENT PLANNING FOR THE ELECTRIC POWER TRANSMISSION GRID

Since 1994, the year the last line from James Bay was put into commission, nearly 5,000 MW of new generation has been integrated into the grid³ in compliance with the reliability criteria, without adding new transmission lines (see Figure 6). The generation projects carried out during these years were integrated with the grid by adding series compensation, which lent itself well, at that point in the development of the grid, to the gradual integration of small and medium projects.

Transmission demand is constantly expanding, related to new generation sources, new interconnections or new transmission service contracts. The same is true for the distributor's current needs, which are increasing year over year, in summer as well as winter. In this situation of growing need, TransÉnergie has to add to the main 735 kV grid the infrastructures required to maintain its reliability and availability, in order to provide a quality electric supply to Québec customers.

As the grid develops to meet new needs, power wheeling on the 735 kV lines is increasing. Since the grid is integrated – that is, since the transmission lines are connected to each other by 735 kV substations – the completion of any major generation project influences a large part of the grid. This will be the case, for example, with the 1,550 MW generation at the Romaine Complex, which is under construction on the Côte-Nord and the 2,000 MW associated with call for offers 2005-03 to provide wind energy.

All this new generation increases the load on the lines in the Côte-Nord corridor, to the point that part of this power is now transferred to the east and west James Bay corridors, since the grid is integrated. The result is an increase in power wheeling over all the 735 kV lines which funnel the generation toward the regions of Montréal and Québec City.

In short, the TransÉnergie transmission system is under increasing demand and has to accommodate growing power transmission while still guaranteeing the quality of the service. To meet this growing demand, TransÉnergie will have to add infrastructures to its transmission grid. At the same time, it is constantly monitoring the management and maintenance of its assets to secure their longevity.

³ The 5,000 MW includes 640 MW of power installed at the Romaine-2 plant, brought into commission in December 2014.

BOX 6

THE FEDERAL ENERGY REGULATORY COMMISSION, THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION AND THE NORTHEAST POWER COORDINATION COUNCIL

The Federal Energy Regulatory Commission (FERC), an independent federal agency in the United States, regulates electric power transmission as well as the wholesale of electricity among US states. In April 1996, under the 1992 Energy Policy Act, the FERC issued orders 888 and 889, which opened up the wholesale electricity markets and made the transmission grids accessible to third parties.

Consequently, companies that want to do business on US wholesale markets have to offer services comparable to those received and non-discriminatory access to their transmission grid, known as **open access**.

To meet the reciprocity requirements and allow Hydro-Québec to continue selling electricity on the US market, the government took the required actions in 1997:

- On March 5, 1997, by order in council 276-97, the Québec government approved Hydro-Québec's Regulation 659 establishing transmission rates, to open the Hydro-Québec transmission grid to wheeling on May 1, 1997.
- On May 7, 1997, by order in council 618-97, the government authorized Québec's municipal electric power redistribution grids to purchase their electricity from suppliers other than Hydro-Québec. With this order in council, the government opened up Québec's wholesale electricity market.

Finally, the FERC is responsible for investigating complaints about the practices of market participants, for example, the exercise of market power.

In 2006, after changes were made to the Act Respecting the Régie de l'énergie, the government granted the Régie the responsibility to ensure the reliability of electric power transmission in Québec. To fulfil this responsibility, the Régie can, under the Act and with the authorization of the government, conclude an agreement with an organization that demonstrates its expertise in the development of electric power transmission reliability standards and the execution of inspections or investigations to enforce the application of these standards.

After receiving authorization from the government, the Régie de l'énergie signed an initial agreement on May 8, 2009, with the North American Electric Reliability Corporation (NERC) and the Northeast Power Coordinating Council Inc. (NPCC) for the development of electric power transmission reliability standards applicable in Québec. This agreement made it possible for the Régie to adopt reliability standards.

The NERC, a not-for-profit organization, is the recognized electric power reliability organization in North America. The NERC is subject to the oversight of the FERC in the United States and of provincial energy regulatory bodies in Canada. The NPCC, another not-for-profit organization, is responsible for promoting and improving the reliability of interconnected power grids in north-eastern North America.

Finally, on November 24, 2014, the Régie de l'énergie signed a second agreement with the NERC and the NPCC to implement a compliance and enforcement program for the reliability standards in Québec. Through this agreement, the NPCC and the NERC will, on behalf of the Régie de l'énergie, oversee Québec entities that are subject to the electric transmission reliability standards.

DISTRIBUTION OF ELECTRICITY WITHIN THE TERRITORY

Hydro-Québec Distribution is the entity responsible for distributing electricity to customers in Québec. To fulfil this mission, the Act Respecting the Régie de l'énergie grants Hydro-Québec Distribution a heritage pool of electricity of 165 TWh, basically equal to Hydro-Québec Production's electric generation in 2000, at the time the Act came into effect.

The main distribution grid extends nearly 115,000 km and serves 4,179,850 subscribers (2014). It is completed by nine municipal grids and one cooperative grid. Together the ten members of the Association des redistributeurs d'électricité du Québec (AREQ) serve about 156,000 mainly residential customers (2013). They have 13 small power plants that total 29 MW of installed power and they purchase most of the electricity they distribute from Hydro-Québec Distribution at the LG big business rate reserved for commercial and institutional clients. Annually, this represents about 4.5 TWh, or 2.2% of Québec consumption.

SMART GRIDS

The new meters and smart power grid technology offer new avenues for exploration. Smart meters are not used anywhere in the world as a "real time" interface, however, because the frequency of meter readings is too slow, with several minutes between each reading. Other technologies (wi-fi, FM waves, etc.) offer more promising options for establishing real-time "smart grid" management.

Large corporations (Google, Samsung) are investing to make domestic equipment "smart." The energy aspect is also being monitored closely, given the potential energy savings that these technologies can offer. The cyber-safety of the power grid and confidentiality continue to be concerns, however.

BOX 7

THE SMART GRID

A smart grid is an electric grid modernization project to establish advanced communications between the customers' electric equipment and the electricity grid. It is not a single technology. A smart grid includes efficient management of electricity, through new billing options, advanced supply and demand metering, increased oversight and automation of the grid and more extensive storage and energy purchase and resale.

For example, setting up a smart grid allows customers to return surplus electricity generated by wind turbines, solar panels, electric vehicle batteries and other means of energy generation and accumulation. Decentralized generation (closer to consumption points) provides better protection to customers in the event of blackouts related to transmission line malfunction, for example. Smart grids are linked to a multitude of small sources of electricity generation scattered across the territory.

Recent innovations in smart grids, along with projected advancements, will transform that way we conceive of electric transmission and distribution grids.

The range of smart grid applications include:

1. Advanced metering
2. Demand response and proactive consumers
3. Storage and auxiliary services (centralized power generation, transmission and storage grid)
4. Grid monitoring
5. Grid automation

Smart grids are gradually being deployed in industrialized countries. Québec must follow suit by determining the functions that will offer the most benefits to Québec society (financial, competitive technological position, business cluster support, export market, etc.).

OFF-GRID SYSTEMS

The off-grid systems are located in vast, sparsely populated areas. In Québec, they are located in five different territories: the Îles-de-la-Madeleine, Nunavik, the Haute-Mauricie, the Basse-Côte-Nord (including Anticosti Island) and Schefferville. These territories boast a total population of about 35,000 inhabitants, in 30 communities made up of Attikameks, Whites, Crees, Innus, Inuits and Naskapis. In 2012, the off-grid systems had over 17,600 subscribers and produced 412 GWh, with power needs reaching up to 93 MW.

To meet these needs, the off-grid systems are supplied by two hydroelectric power plants (Ménihek and Lac-Robertson) and by 24 thermal plants,⁴ with total installed power of 164 MW. Due to the price of fuel, the cost of operating the thermal power plants is very high (see Table 4.4). Furthermore, most of the power plants are reaching the end of their useful life, which means they will require investments to guarantee their longevity.

⁴ Including hydroelectric power plants La Tabatière, St. Augustine and Blanc-Sablon, which provide backup in case of breakdowns and maintenance of the network Lac- Robertson.

Table 4.4

Generation cost for off-grid systems operated by Hydro-Québec Distribution (2012)

Territory served	Total annual cost (\$M)	Generation cost (¢/kWh)
Îles-de-la-Madeleine	33.7	6.6
Nunavik		
Akulivik	109.7	35.1
Aupaluk	119.4	45.0
Inukjuak	77.7	10.8
Ivujivik	132.4	51.3
Kangiqsualujuaq	78.8	14.0
Kangiqsujaq	85.2	19.3
Kangirsuk	78.9	21.3
Kuujuuaq	86.0	5.3
Kuujuuarapik	70.4	7.7
Puvirnituq	66.2	9.3
Quaqtaq	95.4	32.4
Salluit	65.0	12.3
Tasiujaq	90.6	25.3
Umiujaq	95.9	33.7
Basse-Côte-Nord		
La Romaine	41.9	8.6
Lac-Robertson	40.5	7.2
Port-Menier	74.3	15.3
Schefferville	35.1	18.7
Haute-Mauricie		
Opitciwan	49.2	4.9
Clova	61.7	18.3

Source: Hydro-Québec Distribution. (2013). *Plan d'approvisionnement 2014-2023 des réseaux autonomes – Annexes R-3864 – 2013, HQD – 2, Document 2, 86 p.*

Hydro-Québec Distribution's basic mission in the off-grid systems is to meet its customers' needs at a lower cost. To achieve this, Hydro-Québec Distribution acts first on demand and second on its supply capacity. To maintain service reliability, the distributor continues to plan its supply strategy taking into account, on one hand, all management means at its disposal – including energy efficiency interventions, rates, use of mobile generators and, ultimately, increased capacity – and on the other hand, the specific context of each system.

Studies on pairing wind and diesel power in the Îles-de-la-Madeleine are underway. The results will establish benchmarks for the conditions required for this type of project in other systems, especially with regard to the location of the wind turbines.

On October 9, 2014, Tugliq Energy Co., in conjunction with the Canadian Minister of Natural Resources, the Québec Minister of Natural Resources and the MP for Ungava, issued a press release marking the commissioning of the very first industrial wind turbine in Plan Nord territory. The 3-MW turbine will allow the Raglan Mine to reduce its annual diesel consumption by 2.5 million litres.

During the same period, Cree United Power Inc. signed a cooperation agreement for the construction and operation of an off-grid hybrid power plant (wind-diesel-biomass) in the Whapmagoostui First Nation community.

In Inukjuak, after several studies, the community is seeking financing to pursue a hydroelectric development project (called Innalik) on the Inukjuak River.

At a meeting of the Energy Ministers of Québec and Ontario, on October 10, 2014, the two provinces agreed that they would share their experiences related to the financing and operation of off-grid connection projects in First Nations communities, especially as concerns negotiations with the Canadian government and other subsidizing bodies.

FINDINGS

- The terms of service for connection applications, which have been determined based on relative proximity to the grid, are difficult to apply in northern Québec where the transmission grid is almost non-existent, except around the hydroelectric plants.
- The supply for many communities and industries is provided at high cost, using diesel plants, which limits economic development. In this situation, a connection application may require the expenditure of several tens if not hundreds of millions of dollars from the applicant.
- In some regions where the transmission grid is saturated, financial repercussions limit the connection of major new loads and may lead to the transfer of an investment project to another region. This puts economic development at a disadvantage in areas where the grid is saturated.
- Proposed transmission line projects are facing more and more restrictions and opposition, especially from the host communities. Social acceptability is an issue for every new project, in the field of electricity or any other field.
- The ice storm crisis in 1998, which demonstrated the fragility of the grids when exposed to extreme climatic conditions, led to the implementation of corrective measures (looping, choice of pylons, etc.).

Industrial processes require a higher quality wave that is not available everywhere. Some parts of the grid, especially in rural areas, are served with single-phase operation.⁵ These limitations influence the quality of the service offered.

BOX 8

USE RECONCILIATION PROJECT

In fall 2014, the Québec Minister of Energy and Natural Resources announced the creation of a “social acceptability project.” Making provisions for the various social acceptability and use reconciliation issues is extremely complex and requires specific expertise.

The goal of the social acceptability project is to help the government to take into account the expectations and interests of the communities when planning and carrying out projects. Initially, the MERN will take stock of the situation objectively, to create a clear portrait of the practices, existing tools and their efficiency, and the governance of the development projects in the area. Attention will be focused in particular on common success factors for projects that received community support and, at the other end of the scale, factors that impeded other projects.

⁵ A single-phase electric line transmits energy on a single cable, in comparison to a triphase line, which is equipped with three conductors and can carry more electricity, using phase displacement of the current among the cables.

ISSUES

- The transmission grid is not accessible to all communities and all industrial projects in northern Québec.
- Power transmission and distribution infrastructure projects can come up against social acceptability problems.
- All Québec consumers must be assured of the safety, reliability and robustness of the power grids.
- Service quality varies in some parts of the territory.
- Supply reliability for consumers connected to the off-grid systems must be assured but recourse to fossil energy must also be reduced.
- Isolated communities should also benefit from energy efficiency interventions and additional generation capacities to ensure the adequacy of their energy resources.

QUESTIONS

- How can the regulatory provisions concerning connection to the power grid be reconciled with connection applications in northern Québec?
- What changes could be made to the connection rules to provide optimal choices to society and to promote economic development while still protecting consumers of electricity?
- What role can the government play in serving northern Québec, particular in terms of its commitment to participate in infrastructure development? Where required, what should the terms be for government participation?
- Should Hydro-Québec set an example and eliminate the petroleum products that are used in its power generation installations that supply the off-grid systems? To this end, what role could be played by photovoltaic power and other decentralized power generation channels?
- When part of the transmission grid is saturated, what conditions should be applied to avoid excessive costs for the applicant which could impede the development of a region?
- How should the local social acceptability of power transmission projects be defined and how can its achievement be encouraged?
- When an investment is made in power transmission or distribution, how can we ensure that all options have been considered, including targeted energy efficiency interventions?
- What are the benefits of maintaining the municipal and cooperative power redistribution grids instead of consolidating them with the main grid operated by Hydro-Québec Distribution?

Service quality

- How can wave quality be guaranteed across the entire territory?
- What costs and benefits would be associated with extending triphase service to the entire territory?
- To what extent are the power transmission and distribution grids resistant to extreme climatic conditions?
- How could decentralized power generation help improve service quality in connection with the consequences of climate risks?
- What efforts should Québec make to bury the power transmission and distribution grids? What technologies are used in this field around the world, and what are their implementation costs?

Smart grids and digital development

- What place will smart grid functions hold in the Québec and North American power sector?
- What smart grid functions are of interest to Hydro-Québec (e.g., grid reliability) and consumers, and what should the government's role be in choosing certain smart grid functions (technological competitiveness, support for an industrial cluster)?
- What role will home automation play in consumption management, and what will be the repercussions on power grid management?

SECTION 5

ELECTRICITY RATE SETTING

RESIDENTIAL RATES

The rate for Hydro-Québec's residential customers is among the most competitive in North America. As Table 5.1 shows, Montréal is in first place. Under current laws, the municipal grids and the cooperative grid have to sell electricity at a rate equal to or lower than Hydro-Québec's rate for comparable customer groups. This practice contributes to the standardization of electricity rates for all residents of Québec.

Table 5.1

Average rate charged to residential customers

City	Rate billed in 2010 (¢/kWh)	Rate billed in 2014 (¢/kWh)
Montréal	6.88	7.06
Vancouver	7.79	9.71
Moncton	11.66	12.06
Ottawa	11.00	13.45
Toronto	11.82	13.78
Winnipeg	7.08	7.89
Boston	16.82	20.42
New York	22.82	30.74
San Francisco	21.14	26.15

Source: Hydro-Québec. (2014). *Comparaison des prix de l'électricité dans les grandes villes nord-américaines — Tarifs en vigueur le 1^{er} avril 2014*, 78 p.

Considering the various forms of energy consumed by Canadian households, including natural gas, for which the price has dropped since non-traditional reservoirs have been put into production, Québec households enjoy the third-lowest energy prices for residential purposes in Canada, almost equal to those in British Columbia.

Table 5.2

Total average energy expenditures per household (2012)

Provinces	Expenditures
Newfoundland and Labrador	\$2,770
Prince Edward Island	\$2,916
Nova Scotia	\$2,703
New Brunswick	\$2,468
Québec	\$1,685
Ontario	\$2,071
Manitoba	\$1,577
Saskatchewan	\$2,063
Alberta	\$2,359
British Columbia	\$1,675

Source: Statistics Canada. (2014). *Survey of Household Spending* — 2012.

BOX 9

SOCIAL RATES

Despite these enviable rates, electricity is a major budget item for Québec households (Figure 5.1). An analysis of the changes in Hydro-Québec Distribution's residential customer accounts seems to reveal that more and more Québec households are struggling to pay their electricity bill. The portion of this expense ranges from 1.7% for the wealthiest households to 3.3% for less fortunate households. This latter figure may hide significant disparities within this income quintile, however.

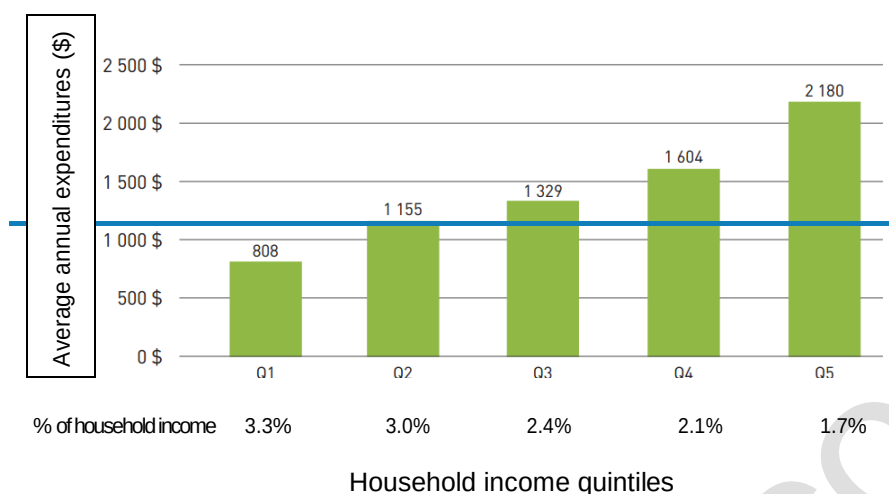
Hydro-Québec Distribution already offers support measures for low-income households, including payment agreements that reflect household financial capacity and energy efficiency measures.

To respond to this concern, some countries make low-income households eligible for social rates:

- In France, the basic needs electricity rate ("*tarif de première nécessité*") offers certain reductions to eligible customers based on household composition and equipment, in order to determine the subscribed power. For a household with two or more people in community housing, the lump sum reduction can be up to 140€ (about \$200).
- In Wallonie (Belgium), the social rate for electricity grants eligible households the lowest commercial rate on the market. The commission sets the applicable rate twice a year.

Figure 5.1

Electricity expenditures of Québec households, by income quintile in 2012



Source: Whitmore, J. and P. O. Pineau (2014), *État de l'énergie au Québec*, 33 p.

COMMERCIAL, INSTITUTIONAL AND INDUSTRIAL RATES

For big industry, Montréal is in second place, after Winnipeg, in terms of the average rate invoiced to large power customers (monthly consumption higher than 3 M kWh and a power demand of 5,000 kW.)

Table 5.3

Average rate charged to large power customers

Ville	2010 (¢/kWh)	2014 (¢/kWh)
Montréal	4.80	5.05
Moncton	6.99	7.34
Vancouver	5.32	6.66
Ottawa	9.07	13.31
Toronto	9.65	11.13
Winnipeg	4.10	4.54
Boston	11.98	13.98
New York	12.30	21.25
San Francisco	9.81	10.71

Source: Hydro-Québec. (2014). *Comparaison des prix de l'électricité dans les grandes villes nord-américaines — Tarifs en vigueur le 1^{er} avril 2014*, 78 p.

Big industry enjoys lower rates than residential and commercial customers. This situation results mainly in lower supply costs for this clientele, since its consumption profile is more consistent, and distribution costs that are practically nil, since they are supplied directly from medium- or high-voltage lines. Likewise, for a variety of economic and social reasons, some major industrial clients enjoy special contracts⁶ granted by the government.

The Québec government uses low electricity rates to attract new businesses and secure existing jobs. For major projects, the government reserves the right to grant or refuse new high power pools to businesses that request them. The 175 MW limit on Hydro-Québec's obligation to serve customers, set in 1987, was adjusted to 50 MW on April 1, 2008.

The competitive position of the regulated electricity rates paid by large energy-consuming industries in Québec appears to be beneficial, but these official data do not take into account the unregulated rate setting practices (special contracts) of certain administrations, which distort the competition facing many industries working in Québec.

For these businesses, which have until recently been given a rough ride by the strong Canadian dollar, the weight of their electricity bill constitutes a significant part of their operating costs, ranging between 20% and 30%. The government recognized this specific situation when it decided to exempt this customer group from the indexation of the heritage electricity pool price that has applied to electricity rates since 2014.

BOX 10

GERMANY: CHEAPER ELECTRICITY FOR BUSINESSES

To support the development of emerging sectors (wind and solar), Germany has introduced a rate surcharge to recover the costs of these more costly generation channels.

The European Union allows member states to recover this charge based on the type of consumer. To support the competitiveness of the big energy-consuming industries, a state can exempt them from the application of the surcharge, in whole or in part.

Big German industries will not have to pay the surcharge, which stands at 6.17c€/kWh in 2015. German industrial consumers (500 to 2,000 MWh) will enjoy a price of 8.95c€/kWh, lower than the European Union average, which is 9.76c€/kWh.

⁶ A special contract grants a customer a rate or terms of service that are different from the rates or terms set by the regulatory body. Under the Act Respecting Hydro-Québec, the government can grant a rate or terms of service to a consumer or a class of consumers under a special contract.

CROSS-SUBSIDIZATION

Cross-subsidization means charging rates that are higher than real costs to one group of consumers in order to subsidize rates that are lower than real costs for another group of consumers. In Québec, cross-subsidization is used to benefit residential customers, to the detriment of commercial, institutional and industrial customers.

The Act Respecting the Régie de l'énergie stipulates that the Régie cannot modify the rate for a class of customers to alleviate the cross-subsidization in the rates applicable to classes of consumers.

Table 5.4

Cross-subsidization among Hydro-Québec Distribution rates

	Residential	Small power	Medium power	Large power (Other)	Large power (Industrial)
Rate	D	G	M	LG	L
Percentage of real cost covered by rate	84%	116%	132%	109%	116%

Source: Hydro-Québec Distribution (2014), *Mise à jour des informations relatives au dossier tarifaire 2014-2015*, R-3854-2013, HQD-19, document 1, 25 p.

ISSUES

In the coming years, electricity rates will continue to experience ongoing pressure, arising mainly from:

- The indexation of the cost of the heritage electricity pool, supported solely by two-thirds of sales (households, small businesses, businesses and institutions).
- The cost of new supplies, which is clearly higher than the historical cost.
- Québec's lack of official recognition of the environmental virtues of certain renewable power generation channels (small hydroelectric plants, wind power, solar power), through certification, which does not allow green pricing to be rolled out in Québec.
- The search for a fair balance between pricing measures that are likely to lead to responsible consumption of electricity and measures that guarantee the access to power than low-income households need.
- The maintenance of the social electricity pact (low, stable, uniform rates) arising from the creation of Hydro-Québec and the nationalization of electric services.

QUESTIONS

- What would be the advantages and disadvantages of pricing based on the cost of the most recent supplies, compensated by lower taxes?
- Should we conduct modulated pricing experiments based on time (night, day, peak period), day (weekday, weekend) or season? What guidelines should be used to encourage consumer participation?
- What would be the advantages and disadvantages of further graduating the fee schedule for residential customers, for example, by introducing new increasing price brackets? Could having a more complex fee schedule be counterproductive?
- On what basis could we justify the provision of low-cost electricity to high-energy-consuming businesses? Following Germany's example, should high-energy-consuming businesses in Québec be exempted from financing renewable energies?
- Which components of the social electricity pact should be reviewed, to what ends, on the basis of what principles and using what means?
- Should we continue to exempt big industrial customers from the indexation of the heritage pool prices, which creates a new form of cross-subsidization, and if so, for how long?
- Since electricity prices are clearly higher for our neighbours in the north-eastern US, should our prices in Québec be raised to encourage customers to consume more efficiently or, on the contrary, should they be kept low to use as a comparative advantage and a lever for economic development?
- For the less energy-consuming sectors where energy accounts for a low portion of generation costs, how could electricity be used to re-establish their competitiveness?
- Is the introduction of social rates for low-income households, financed by other consumers of electricity, the fairest and most appropriate way to support these households in Québec's social and tax setting?
- What conditions would be required for the opening of the retail electricity market to be beneficial for Québec consumers and for the collective wealth of Québec?
- Since hydroelectricity is the form of energy with the smallest environmental footprint, what are the benefits of offering green pricing to consumers so they voluntarily choose to pay more to encourage the emergence of renewable energy channels?

SECTION 6

ELECTRICITY'S CONTRIBUTION TO THE DEVELOPMENT OF QUÉBEC

CONTRIBUTION TO QUÉBEC'S PUBLIC FINANCES

By virtue of certain laws, especially the Hydro-Québec Act, the government corporation is subject to the payment of water-power royalties, the public utility tax, a dividend and warranty costs related to debt securities. These sums, which totalled \$3.6 billion in 2014, contribute to the achievement of the government's mission, particularly in health and education.

Table 6.1

Hydro-Québec's payments to the government of Québec in 2014

Type of contribution	Amount paid
Water-power royalties	\$656 M
Public utility taxes	\$252 M
Warranty costs related to debt securities	\$205 M
Dividend	\$2,535 M
TOTAL	\$3,648 M

Source: Hydro-Québec. (2015). *2014 Annual Report*, 118 p.

The water-power royalties paid by Hydro-Québec and the private generators should exceed \$770 million in the 2015-2016 budget year. They are paid annually to the Fonds des générations set up to pay off Québec's debt.

Having access to private and government-owned water power resources, businesses have historically contributed to the industrial development of Québec through the self-generation of electricity. These self-generators were not nationalized in 1963, in light of their contribution to the economic development of Québec.

SUPPORT FOR QUÉBEC'S CULTURAL, SOCIAL AND ECONOMIC LIFE

Through its policies and programs, Hydro-Québec supports the cultural, social and economic life of Québec. For example, it helps finance collective interest projects through the Integrated Enhancement Program (*Programme de mise en valeur intégrée* or PMVI) and through the Hydro-Québec Foundation for the environment.

Likewise, to compensate for the residual effects of power transmission projects, especially on the landscape, the PMVI pays affected communities 1% of the authorized value of the target facilities. The funds are used for local initiatives to improve the environment, to improve municipal, community or leisure infrastructures and for tourist and regional development or the development of Aboriginal communities. Since the creation of the PMVI in 1985, the company has contributed \$116 million to support 1,168 initiatives. The table below shows the value of Hydro-Québec's contributions from 2010 to 2013.

Hydro-Québec's contributions to the PMVI vary annually based on the number and size of the transmission projects underway.

BOX 11

CONTRIBUTIONS AND FINANCIAL COMMITMENTS (2010-2013)

	2010	2011	2012	2013
Number of initiatives	32	45	36	26
Hydro-Québec's contributions (\$ thousand)	5,910.3	2,262.6	2,494.8	2,798.9
Community contribution (\$ thousand)	2,932.5	4,395.9	6,189.5	4,547.8
Value of work (\$ thousand)	8,842.8	6,658.5	8,684.4	6,346.0

Source: Hydro-Québec. (2013). *Rapport sur le développement durable 2013*, 72 p.

AGREEMENTS WITH LOCAL AND ABORIGINAL COMMUNITIES

IMPACT AND BENEFIT AGREEMENTS

To facilitate the social acceptability of its hydroelectric development projects, Hydro-Québec negotiates impact and benefit agreements (*ententes sur les répercussions et les avantages* or ERA) with different communities that are affected, including Aboriginal communities. These agreements foster community participation in the projects, develop economic partnership and alleviate the environmental and social repercussions.

For example, for the Romaine Complex project, Hydro-Québec concluded four agreements: one with the regional county municipality (MRC) of Minganie, a second with the community of

Nutashkuan, a third with the communities of Unamen Shipu and Pakua Shipi and a fourth with the community of Ekuanitshit.

The funds related to these various agreements are paid to the communities so they can carry out economic development, community and cultural projects, pursue their traditional activities and offer training. Furthermore, procedures are put in place to allow the community to take part in the environmental monitoring for the duration of the project.

Table 6.2

A few impact and benefit agreements (ERA) signed with communities in connection with the Romaine Complex

Community	Date	Total amount (2009 dollars)	Duration
Nutashkuan (Natashquan)	July 4, 2008	\$43.0 M	2009-2070
Unamen Shipu et Pakua Shipi	October 9, 2008	\$14.5 M	2009-2070
Ekuanitshit (Mingan)	March 27, 2009	\$75.0 M	2009-2070

Source: Hydro-Québec, internal memo

The funds will be used for economic, community and cultural development projects and will foster the practice of traditional activities and training programs for the Innu in Unamen Shipu and Pakua Shipi. Furthermore, the agreement allows the community to take part in the construction and environmental monitoring.

PAIX DES BRAVES

On February 7, 2002, Québec and the Crees concluded a 50-year general political and economic agreement. This historic agreement, known as the Paix des Braves, marks a new era in Québec-Cree relations.

The agreement also kicked off the hydroelectric work for the Eastmain-1 power plant, the Eastmain-1-A and Sarcelle power plant plans and the diversion of the Rupert River. The two projects brought \$4 billion in investments to the region and provided jobs for 10,500 people for the nine years of the work.

The commissioning of these big worksites was achieved thanks to a new spirit of cooperation and it led to substantial economic spinoffs for many Cree and Québec businesses. It also added 1,400 MW to the Hydro-Québec power grid, an increase of 15% of the electric power generation in James Bay territory.

The Québec government agreed to pay the Cree community \$23 million in 2002-2003, \$46 million in 2003-2004 and \$70 million in 2004-2005. Subsequently, the contribution is indexed based on a formula that reflects the development of economic activity in the target territory in the sectors of hydroelectricity, forestry and mining.

ELECTRICITY EXPORTS

Historically, the development of hydroelectric potential met the needs of households and businesses in Québec and, after these needs were satisfied, the needs of the adjacent markets, through exports. These two objectives are complementary.

In economic terms, hydroelectricity exports represent a major source of income for Québec. In 2014, net electricity exports increased by \$176 million, reaching \$1,529 million, up from \$1,353 million in 2013.

Table 6.3
Income from Hydro-Québec's net exports

	2010	2011	2012	2013	2014
Income (\$M)	1,034	1,134	1,233	1,353	1,529

Source: Hydro-Québec (2011-2015), *Annual Reports*.

BOX 12

SALES CONTRACT WITH VERMONT

In 2010, Hydro-Québec concluded a new long-term electric power sales contract, for from 218 to 225 MW, with eight power distributors in Vermont for the period from 2012 to 2038. This contract replaces and transitions from the current 335-MW contract that ends in 2016. That contract met about one-third of Vermont's power needs (about 2 TWh).

The new contract, which offers a variable price based on inflation and market prices for electricity, will protect Hydro-Québec Production from sharp decreases in free market prices and shelter Vermont consumers from sharp increases.

In Québec, Hydro-Québec is not the only electricity exporter: other businesses export electricity generated in Québec or move power on the TransÉnergie transmission grid to territories outside Québec. These electric power exporting companies are pursuing the same markets as Hydro-Québec.

Furthermore, new shale gas extraction technologies are accessing significant volumes of natural gas at very low prices in the United States, encouraging the replacement of coal- and oil-fired thermal power plants by plants supplied by natural gas. This situation has pushed down electricity prices, making Québec hydroelectric power less attractive for our American neighbours.

Table 6.4

Changes in New England's electricity generation mix

Type of power plant	2000	2013
Nuclear	31%	33%
Oil	22%	<1%
Coal	18%	6%
Natural gas	15%	46%
Hydro and other renewables	13%	14%
Pumped storage	<2%	1%

Source: www.iso-ne.com/aboutiso/fin/annl_reports/2000/2014_reo.pdf

Despite this, Hydro-Québec exports, to both American and Canadian markets, amounted to 26.6 TWh in 2014. Part of the export sales are related to trading and purchase-and-resale operations in which Hydro-Québec purchases energy at low prices and stores it in its reservoirs, awaiting better price conditions to sell it back to these same markets. Hydro-Québec's activities on external markets are conducted in a commercial context where its decisions are based on market conditions.

Table 6.5

Electric power exports on international power transmission lines located in Québec in 2014

Exporting company	Volume exported (millions of kWh)
Brookfield Energy Marketing Inc.	1,306.7
Emera Energy Inc.	1,359.9
Hydro-Québec ¹	20,913.5
Royal Bank of Canada	5.1
Saracen Power Ltd.	5.7
TOTAL	23,591.0

¹ Does not include Hydro-Québec exports (2,951.2 GWh) on Ontario's international lines.

Source: National Energy Board. (2015). *Exports and imports of electricity – December 2014*.

The net earnings brought in by Hydro-Québec's export transactions show that this is a significant source of income for the government, income it receives through the payment of the Hydro-Québec dividend.

Table 6.6

Contribution of Hydro-Québec's net exports to its net earnings

	2010	2011	2012	2013	2014
Contribution (\$M)	432	398	363	622	814

Source: Hydro-Québec. (2010-2015). *Annual Reports*.

Environmentally, by providing Québec's neighbours with renewable, competitive and reliable energy, Québec is helping fight climate change and pollution. Hydroelectricity from Québec often replaces power generation that is dominated by classic thermal channels in the neighbouring grids, channels which emit a lot of greenhouse gases and other atmospheric pollutants. By way of example, in 2013 alone, Hydro-Québec's net electric power exports prevented the emission of nearly 9 million tons of CO₂ by these customers.

Finally, four interconnection projects between Québec and the United States could help increase Québec's power exports:

- The Champlain Hudson Power Express project, by Transmission Developers Inc., a 1,000-MV direct-current line, buried under Lake Champlain and the Hudson River, which would connect Québec to New York; this project received its "presidential permit" in October 2014, one of the conditions for its execution.
- The Northern Pass project, by Northeast Utilities, a 1,200-MW direct-current lines that would connect Québec to New Hampshire.
- The New England Clean Power Link project, by Transmission Developers Inc., a 1,000-MW direct-current line, buried under Lake Champlain, which would connect Québec to Vermont.
- The Highgate Expansion to Vermont project, by Hydro-Québec, with a capacity of 425 MW.

CONTRIBUTION TO ECONOMIC DEVELOPMENT

The energy sector is responsible for thousands of direct and indirect jobs in Québec and constitutes an important economic development lever for many stakeholders, including businesses, municipalities and Aboriginal communities. The development of Québec's hydroelectric potential has generated and continues to generate major economic and financial benefits. Hydro-Québec's activities create huge benefits for the Québec economy. In 2014, Hydro-Québec spent \$3.3 billion on goods and services. Of this, acquisitions from businesses in Québec accounted for \$3.1 billion, more than 94% of total purchases. The number of jobs supported in Québec by these acquisitions is evaluated at 17,700, including 12,300 direct jobs.

Table 6.7

Value of Hydro-Québec goods and services expenditures in 2014

Goods and services	Expenditures (\$M)
Purchase of goods	1251
Rental of goods	29
Work and specialized services	1675
Professional services	364
TOTAL	3301

Source: Hydro-Québec. (2015). *2014 Annual Report*, 118 p.

BOX 13

ROMAINE COMPLEX HYDROELECTRIC PROJECT

The 1,500-MW hydroelectric complex on the Romaine River on the Côte-Nord will be comprised of four hydroelectric installations with an average annual energy generation capacity of 8.0 TWh. The construction began in 2009 and the first power plant (Romaine-2) was commissioned in December 2014. Work continues on the installations for the Romaine-1 and Romaine-3 plants, in preparation for commissioning in 2016 and 2017.

The Romaine project will generate substantial economic benefits, in the order of \$3.5 billion for the whole of Québec, of which \$1.3 billion will be solely for the Côte-Nord. From 2013 to 2016, personnel at peak periods will exceed 2,000 workers.

In 2014, an investment of \$664 million was made and the number of employees reached 1,608 person-years, of which 42% were held by workers from the Côte-Nord and 12% by workers from Innu communities. The contracts granted in the region are worth \$105 million.

Source: Hydro-Québec. (2015). *2014 Annual Report*, 118 p.

Meanwhile, wind power in Québec is being developed by the private sector, which sells Hydro-Québec Distribution the electricity generated by its wind farms. To create economic benefits, calls for offers to purchase pools of wind power required minimal thresholds of economic benefit for Québec as well as manufacturing spinoffs in the Gaspésie–Îles-de-la-Madeleine region and the regional county municipality of La Matanie.

Hydro-Québec Distribution's purchase of wind power established an integrated manufacturing chain, which is augmented by the work of organizations that are active in the field of research and development and worker training.

A study published by SECOR-KPMG in 2013⁷ estimates that this industry is responsible for 5,000 direct and indirect jobs in Québec, including 1,200 in wind power companies in the designated region. The number of jobs related to the wind power industry in the Greater Montréal area is estimated at 1,000. According to this study, the average salary of workers in the wind power industry is \$48,140, 30% higher than the average personal income in Québec.

In terms of economic benefits, the existing wind farms will have led to investments of over \$10 billion in the Québec economy by 2017, not to mention the fiscal and parafiscal benefits associated with them. Municipalities in Québec have also benefited from the construction of wind farms in their territories. The wind farm owners will pay them voluntary contributions of several million dollars while the wind farms are in operation, which will be used to bolster the economy in many Québec municipalities. Finally, for the Gaspésie–Îles-de-la-Madeleine region and the La Matanie regional county municipality, wind power development has led to a noteworthy improvement in the job market, with a drop in the unemployment rate and major gains in the labour force participation rate.

Table 6.8

Changes in job market indicators in the Gaspésie–Îles-de-la-Madeleine region and Québec as a whole, 2005 to 2014

Indicator	Gaspésie–Îles-de-la-Madeleine		Québec as a whole	
	2005	2014 ^P	2005	2014 ^P
Unemployment rate (%)	18.0	16.6	8.3	7.7
Labour force participation rate (%)	50.6	56.4	65.5	64.8

^P Preliminary data.

Source: Institut de la statistique du Québec (viewed January 27, 2015).

The construction of small hydroelectric plants (SHP) and “community” wind farms has led to the first experiments with development for and by local and Aboriginal communities.

To offer local and Aboriginal communities a springboard to take charge of their economic development, the government reactivated the six projects in the SHP purchasing program that had been cancelled in February 2013.

⁷ SECOR/KPMG. (2013). *Retombées économiques de l'industrie éolienne québécoise*.

ELECTRICITY AND INNOVATION

The development of the hydroelectricity sector in Québec, and especially the power complexes located far from consumption centres, required current technologies to be adapted to meet the needs of Québec's particular situation. For this reason, Québec enjoys worldwide recognition for its expertise in hydroelectric power generation and very high voltage electricity transmission.

Hydro-Québec is upholding its commitment to sustainable development and working to integrate wind power into the transmission grid. Its expertise on integrating intermittent energy is also widely recognized. In fact, Québec has become a world expert in the operation of wind farms in northern climates, and many parts and services have been developed or improved in the Québec wind energy industry over the years. The government corporation is also exploring emerging renewable energies such as marine and wave energy. Its research includes the effects of climate change on the corporation's various business sectors.

Recent Hydro-Québec research has led to growing expertise in grid technology (conservation voltage regulation and reactive power control or CATVAR, integration of intermittent energy production sources, integration of new-generation smart meters).

Hydro-Québec's innovation efforts are largely led by the Institut de recherche d'Hydro-Québec (IREQ) which is a major research centre with 500 scientists, technicians, engineers and employees working in a variety of other specialties. The IREQ's activities take place in two centres: the research and testing laboratories in Varennes and the Energy Technologies Laboratory (LTE) in Shawinigan. The IREQ's work supports five priority areas: the smart grid, the aging of materials and the longevity of installations, the efficient use of energy, renewable energies and materials for batteries and power transmission.

For many years, Hydro-Québec has dedicated an average of \$100 million a year to its innovation projects.

Hydro-Québec also supports research chairs that promote the development of knowledge in areas of interest related to its activities, the preparation of competent next-generation workers who can meet the future needs of the government corporation and industrial partnerships that help maximize the corporation's contributions to research activities. In 2014, Hydro-Québec maintained its cooperation with 17 research chairs at universities and technology transfer colleges in Québec.

Funding for electricity research in Québec universities has increased sharply, from \$1.6 million in 2000 to \$9.1 in 2011.⁸ The number of learned publications in the field of electricity has followed the same trend, rising from 16 in 2000 to 61 in 2011.⁹

Finally, Québec has rolled out substantial research capacity in wind energy in recent years. In addition to the IREQ, Québec has two university labs as well as a certain number of research chairs specializing in wind energy. The TechnoCentre éolien is a wind energy research centre

⁸ Système d'information sur la recherche universitaire (SIRU) and the ministère de l'Économie, de l'Innovation et des Exportations.

⁹ Web of Science, Thomson Reuters, the Observatoire des sciences et des technologies (UQAM) and the ministère de l'Économie, de l'Innovation et des Exportations.

with world-class research infrastructure that carries out joint projects abroad. Québec also has a technology transfer college centre (CCTT) that specializes in wind energy.

Our knowledge and expertise in leading-edge technologies are important for positioning Québec in the international market. The development of avant-garde technologies invariably leads to international consulting-engineering contracts and orders for new technological products.

FINDINGS

For industrial self-generators in Québec, the opening of electricity markets in north-eastern North America may represent business opportunities that conflict with their industrial activities.

The environmental qualities of Québec's electricity generation should be promoted, in particular with regard to its low carbon footprint. Recognition of this aspect might be an asset for some industrial sectors whose products could then be sold under a green banner.

Québec's hydroelectricity exports also contribute to the reduction of GHGs in the north-eastern US. Despite this advantage, the environmental virtues of large-scale hydroelectricity are not recognized by our American partners for the requirements of renewable resource portfolios, except by Vermont.

New ways of exporting electricity are slowly coming into play (e.g., hydrogen made using clean electricity). For example, Japan has decided to invest billions of dollars to develop hydrogen power, in particular for transportation. In its process, Japan intends carry out small research and development projects, the location of which may determine the future location of major manufacturing plants (2020 to 2040).

Regional and Aboriginal communities are demonstrating the firm intention to take an active role in the development of their milieu.

Wind energy is one of the sources of clean energy that have undergone the most impressive growth in the last 15 years in Québec. Wind power has become a major new manufacturing sector.

ISSUES

Hydro-Québec's development, long seen as an essential key to Québec's economic development, is facing growing difficulties: tenacious resistance from people who have a negative view of the public nature of the corporation, resistance from neighbouring US power grids to recognize the environmental virtues of energy from Québec, resistance from Aboriginal communities to hydroelectric developments in their territories, resistance born of the conviction that the "clean" energy from hydroelectric developments cannot be obtained without a significant environmental cost, resistance from regional and local entities to the construction of transmission lines and transformer substations in their territories.

Currently, Hydro-Québec is contributing to vital government programs (health, education, etc.). It is important to protect the future of this contribution. The electricity generated in Québec does not enjoy official recognition as renewable energy, which might offer certain industries important value-added for the goods they produce.

Our North American partners do not officially recognize the “low emissions” and “renewable” attributes of Québec’s electricity generation channels. The development of energy projects by regional and local entities, coveted for the income sources they generate, conflicts with the increased rates they entail. The execution of energy projects by Aboriginals entail major challenges.

QUESTIONS

- Should we review the royalty regime for electricity generation? Are the royalties received sufficient? Should they be increased? What should the royalties be used for?
- What are the benefits for Québec of allowing industrial self-generators to continue their self-generation activities?
- Which industrial sectors would benefit from the value-added offered by green energy certification for the sale of their products? How could the certification rules be established?

ELECTRICITY EXPORTS

- Under what conditions could the needs of adjacent markets justify the addition of new electricity generation capacities in Québec?
- Instead of exporting raw electricity, how else could electricity be used to create wealth in Québec? To this end, should we support the development of hydrogen power?
- How can we encourage the recognition of the environmental attributes of our electricity (large scale hydroelectricity, SHP and wind) in the United States?

DEVELOPMENT OF ENERGY SECTORS AND ECONOMIC DEVELOPMENT

- The recent increases in electricity rates associated with some supplies (SHP, wind), which offer considerable local economic benefits, raise the question of financial responsibility for economic development. Should we favour a rate approach or a fiscal approach?
- To reduce the wind power manufacturing industry’s dependence on local supplies, what avenues should be used to support the industry in the development of its expertise and products, in order to increase its exports and diversify its production?
- Is it beneficial for Québec to promote the industrial development of certain energy generation channels?

- During energy development, what mechanisms should be put in place to maximize benefits for the regions?
- What role can Hydro-Québec play in the regional economic development of Québec, particularly in the context of controlled demand?
- Could the electric power transmission and distribution infrastructures be used to transport digital signals by fiber optic to remote communities?
- What role should communities play in Hydro-Québec's new energy projects?
- What business model should be adopted for the off-grid systems and what role should the communities play?

INNOVATION AND EXPERTISE

- What conditions are required to export our expertise? What support could the governments and Hydro-Québec offer?
- What would be the benefits of combining electricity research activities (Institut de recherche d'Hydro-Québec) with those related to natural gas within a single institution or a research consortium?
- Based on the various niches of expertise (major hydraulic, small hydraulic, wind, etc.), which institutions or organizations should be targeted as the R&D and innovation leaders in Québec? Should organizations be given government support to assume these responsibilities?
- Given that 85% of Québec's wind power potential is located in northern Québec, what areas of northern technology research should Québec pursue?
- Under what conditions would wind-diesel-natural gas coupling be a solution for the off-grid systems? What about marine turbines? Offshore wind? Storage methods?

CONCLUSION

In the last 20 years, thanks to technological advances, the electricity markets have undergone fundamental changes dictated by consumers' interests. The governments with the highest electricity costs were the first to implement these reforms.

Changes (decentralized generation, smart grids, electrification of transportation, etc.) will continue to occur in the years ahead and will shape how we do things. For its future energy policy, Québec must be attentive to these changes so that power consumers, households and businesses can benefit from them.

PART B

HEAT SOURCES AND
BIOENERGY

SECTION 1

HEATING

INTRODUCTION

Heat, for space heating, hot water or industrial processes, accounts for a significant portion of Québec's energy needs. In the residential sector, for example, heating (space and water) accounts for 77.5% of total energy consumption, while in the commercial and industrial sector, it accounts for 44.2%.¹ The industrial sector also uses heat in numerous processes.²

If we exclude the hydraulic and wind generating sectors that provide electricity for Hydro-Québec's main grid and have a carbon footprint that is virtually nil,³ the other sources of renewable energy offer tremendous potential for the fight against climate change. In many cases they can replace fuel oil or natural gas, both of which emit GHG, for heat production, and have the added benefit of contributing positively to Québec's balance of trade by reducing its dependency on hydrocarbons.

The heat, geothermics, passive and active solar energy options and waste heat or steam recovery are often ideal energy solutions from both an environmental and economic standpoint. They are also part of the solution to the anticipated power deficit that Hydro-Québec anticipates during cold winter spells.

These renewable energy sources, described as “emerging” due to the fact that they are not yet widely used in Québec, are nevertheless plentiful and technologies exist for their use. Québec already has expertise in active and passive thermal solar energy, geothermics, industrial exhaust heat or thermal discharge from data centres, and heat networks fuelled by waste forest biomass. Although widely available, the renewable sources for these forms of energy are also scattered throughout the territory and the task of converting them into energy is extremely challenging.

¹ GOUVERNEMENT DU QUÉBEC (2015), *Energy Efficiency and Innovation* [Online] [politiqueenergetique.gouv.qc.ca/documentation/] (Consulted on January 30, 2015).

² GOUVERNEMENT DU QUÉBEC (2014), *Profil statistique de l'énergie au Québec* [Online] [politiqueenergetique.gouv.qc.ca/documentation/] (Consulted on January 30, 2015).

³ The electricity sector produces less than 1% of Québec's GHG emissions and meets roughly 43% of its energy needs.

ACTIVE SOLAR THERMAL ENERGY

DESCRIPTION OF THE TECHNOLOGY

Active solar technologies such as solar walls, solar water heaters and solar air conditioning use thermal energy from the sun's rays to preheat the air in buildings and to heat or cool indoor space and water. A solar collector system to preheat air can convert between 50% and 80% of the solar energy it collects into usable heat.⁴ According to Natural Resources Canada, Québec's solar potential is positive. In 2010, the technical and economic potential for the use of solar thermal energy in buildings heated by electricity was estimated at 43 million kWh⁵. For comparison purposes, an average single-family home in Québec uses 26,500 kWh per year.

Solar collector systems have been installed over an estimated surface area of 544,000 m² in Québec since 2007. Most are unglazed plastic solar collectors used to heat swimming pool water (71%) and perforated, unglazed solar collectors used to heat air in commercial buildings (26%), which produce roughly 627,000 GJ in total and release roughly 38,000 tons of CO₂ per year.⁶

Solar walls

Solar walls are generally used to preheat incoming air in mechanical ventilation systems. The technology is used mainly in industrial, institutional, farm and municipal buildings, and in manufacturing company buildings that require space heating and large volumes of outside air for ventilation. All buildings that contain mechanical ventilation systems requiring outdoor air, which have a vertical, unshaded wall and plenty of sunlight, could potentially use solar collector systems.

The problem with this technology lies in the high equipment purchase and installation costs, its unattractive architectural appearance and the long payoff time for investments, given Québec's relatively low energy costs.

Solar water heater

Solar water heaters are fuelled by collector systems in which heat transport fluids circulate. The thermal energy collected is then sent to the storage tank via a heat exchanger that heats the water.

Although less common in some countries, concentrator collectors are also used to achieve higher temperatures and produce steam that can be used to power electricity generating turbines.

⁴ CONTECH BÂTIMENT (2013), *Énergie solaire dans les bâtiments efficaces*, practical training session, training handbook.

⁵ TECHNOSIM (2011), *Potentiel technico-économique de l'énergie au Québec*, technical report presented to Hydro-Québec, 123 p.

⁶ NATURAL RESOURCES CANADA, *SOLAR THERMAL ENERGY* [ONLINE] [rncan.gc.ca/energie/renouvelable-electricite/solaire-thermique/7302] (CONSULTED ON FEBRUARY 23, 2015).

BOX 1

AN EXAMPLE FROM ABROAD

The experimental Drake Landing solar community in England stores energy from solar collectors on 52 homes, using a high temperature geothermal reservoir. The reservoir is composed of 144 vertical wells and attains a temperature of 70°C before the heating season begins. Based on a life cycle of 20 years, the cost of the solar thermal energy generated by the project is estimated at \$0.37/kWh. Phase 2 of the project, aimed at reducing the cost to \$0.21/kWh, is currently under development.⁷ For comparative purposes, electricity delivered to the residential sector in Québec costs roughly \$0.083/kWh.

The Renewable Heat Incentive⁸ purchases solar thermal energy from businesses, individuals and communities in Québec, through 20-year purchase contracts, at a rate of 19.2 pence/kWh, or roughly \$0.344/kWh.

POTENTIAL AND CHALLENGES

In Québec, solar energy is easily available but the cost of active solar thermal energy is between three and four times higher than the cost of electricity and fuel oil. The acquisition cost must therefore be reduced significantly before the technology can be used extensively in Québec.

Given the steadily decreasing cost of solar collectors and the population's growing interest in environmental issues, solar thermal technology has begun to make its mark in the province, thanks mainly to support from the Government, which has helped reduce the investment payoff term, one of the main decision criteria for organizations wishing to adopt green technology.

The low cost of electricity in Québec (and the fact that it is carbon neutral) means that projects using solar thermal energy are of more interest on foreign markets. Nevertheless, some air preheating projects have been undertaken in Québec's industrial sector, with a unit energy cost close to that of traditional energy sources. However, no storage is available for this technology, and it can be difficult to match the availability of heat with the heating needs of the building.

Active solar technologies are in direct competition with heat recovery air exchangers; the purpose of both systems is to preheat new air brought into the building.

⁷ Doug McCLENEHAN (2011), *Drake 2: The New 1,000-Home Solar Thermal Community in Alberta*, presented at the Canadian Solar Industries Association Annual Conference & Exposition, December 5, 2011, Toronto.

⁸ UNITED KINGDOM GOVERNMENT, *Increasing the use of low-carbon technologies- Renewable Heat Incentive* [Online] [gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi] (Consulted on January 30, 2015).

EXPERTISE AND PROJECTS IN QUÉBEC

Concordia University's Industrial Research Chair in Optimized Operation and Energy efficiency: *Towards High Performance Buildings*, has obtained \$2 million in funding from the Natural Sciences and Engineering Research Council of Canada (NSERC), Hydro-Québec, Natural Resources Canada and Regulvar. It carries out research and gives training on commercial and industrial buildings, and in particular on the development and testing of intelligent operations, computerized energy demand forecasting technology and integrated systems such as solar panels and heat storage technologies.⁹

The Natural Gas Technologies Centre (NGTC) has facilities able to test solar thermal equipment. The Industrial research Chair in energy and Energy Efficiency at the École de technologie supérieure du Québec is also interested in solar thermal energy.

Roughly 30 companies in Québec are specialized in the design, distribution or installation of active thermal energy devices. The value of Québec's solar thermal energy market is estimated at around \$9.5 million per year.¹⁰

Hydro-Québec, Gaz Métro and the Ministère de l'Énergie et des Ressources naturelles (MERN) have all had financial support programs for solar wall acquisition since 2005. A number of projects have been carried out as a result, mostly involving solar wall systems and concentrating collector systems used for high-temperature water preheating.

Québec's solar thermal energy industry has also received financial support to help deploy applications such as the Lubi solar collectors and parabolic dish collectors produced by the Québec-based company Rackam, which has two demonstrator projects for its parabolic system, one at the Chagnon dairy in Waterloo (400 m²) and the other at the Cascades mill in Kingsey Falls (4,000 m²). Both projects were funded by the Energy Innovation Program offered by the Bureau de l'efficacité et de l'innovation énergétiques.

The Polyvalente Bélanger in Saint-Martin de Beauce purchased and installed a 43.3 m² solar wall. The investment of roughly \$17,500 has allowed the institution to reduce its annual heating costs by approximately \$1,080. Originally, the break-even period was more than 16 years, but was reduced to just eight years thanks to the financial assistance.

⁹ VOIR VERT, *Nouvelle chaire de recherche en bâtiments verts à Concordia* [Online] [www.voirvert.ca/nouvelles/actualites/nouvelle-chaire-recherche-batiments-verts-concordia] (Consulted on January 30, 2015).

¹⁰ ZINS BEAUCHESNES ET ASSOCIÉS (2011), *Portrait économique du secteur de l'énergie solaire au Québec*, final report, 46 p.

PASSIVE SOLAR DESIGN

DESCRIPTION OF THE TECHNOLOGY

Passive solar techniques do not require mechanical or electrical equipment, but consist instead in design methods that promote direct use of the sun's rays to heat or light a building. Elements to be considered when designing a passive solar building include the exposure of the building and windows, good insulation, and the use of high thermal mass materials and shading devices.

EQuilibrium, a national sustainable home demonstrator initiative led by the Canada Mortgage and Housing Corporation (CMHC), has shown that passive solar design can reduce a home's energy consumption by 20% or more of its normal energy requirements.

EXAMPLES THROUGHOUT THE WORLD

In Germany, the Passive House Institute (PHI) is an independent organization that has developed and promoted the passive solar building concept since 1990. It also develops certification systems and lobbies European jurisdictions to adopt design standards as part of their regulatory base.

The Canadian Passive House Institute (CanPHI) is a non-profit organization authorized to issue certificates based on German PHI standards. In Canada, the first passive homes were built around 1977.¹¹

POTENTIAL AND CHALLENGES

In 2002, the technical and economic potential of passive solar design for commercial and institutional buildings heated by electricity in Québec was estimated at 40 GWh.¹² However, current urban configurations limit the possibilities for development. Passive design should preferably be applied to new constructions in urban developments configured specifically for that purpose.

EXPERTISE IN QUÉBEC

The Société d'habitation du Québec's Northern Housing Laboratory, the NSERC's Net-Zero Energy Buildings Strategic Research Network, the Industrial Research Chair on Energy Technology and Energy Efficiency, Laval University's School of Architecture and other institutions all work in the field of passive solar design or disciplines in which this type of design is used.

¹¹ CANPHI, *First Passive Houses* [Online] [passivehouse.ca/first-passive-houses-2/] (Consulted on January 30, 2015).

¹² TECHNOSIM (2002), *Mise à jour du potentiel technico-économique d'économie d'énergie au Québec — Marchés commercial et institutionnel*, report presented to Hydro-Québec and to the Agence de l'efficacité énergétique, 79 p.

MEASURES TO PROMOTE THE TECHNOLOGY

There are currently very few initiatives in Québec to promote the use of passive solar design. It is mentioned in the Good Practice Guide for land planning and sustainable development, produced by the Ministère des Affaires municipales et de l'Occupation du territoire (MAMOT).¹³ The ÉcoPerformance program also supports projects using solar technologies to reduce greenhouse gas emissions.

QUESTIONS

- What can Québec do to develop its solar energy potential?
- Are financial support programs effective in helping solar energy sectors to develop?
- What is the potential for solar energy supplies in off-grid power systems, especially in the area covered by the Plan Nord?

GEO THERMICS

DESCRIPTION OF THE TECHNOLOGY

The Earth's crust stores nearly half the energy received from the sun, and concepts involving shallow geothermics (up to 1,500 metres) take advantage of this. After the first few metres, underground soil temperatures are no longer influenced by surface weather conditions, and gradually increase by an average of 3°C per 100 metres.¹⁴

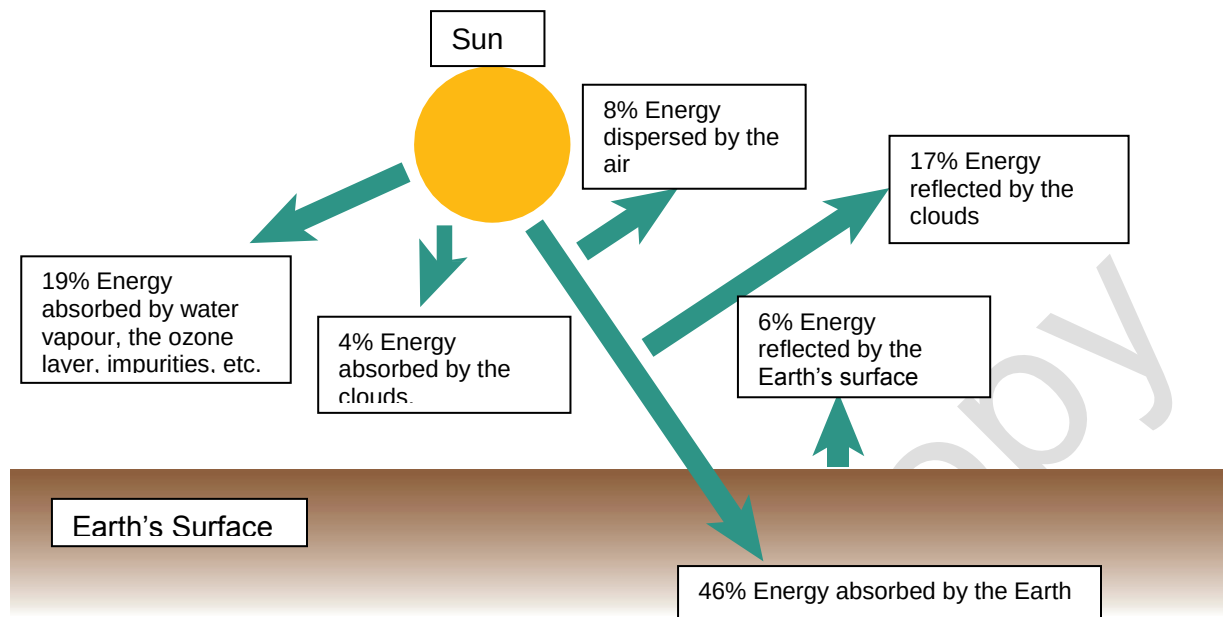
Geothermal systems transfer energy from underground in order to heat or cool buildings. In the vast majority of cases (residential, commercial and institutional buildings), a heat pump is used for maximum efficiency. For each unit of energy (electricity) used to operate it, the pump is able to collect up to 3.5 units of energy through a network of underground ducts, which it then transfers to the building (in the form of hot or cold air, depending on the season). Clearly, the savings in terms of energy and money are significant. However, the installation costs, in particular for the underground ductwork, are much higher than for so-called standard heating technologies.

¹³ Isabelle BOUCHER, Pierre BLAIS and VIVRE EN VILLE (2010), *Le bâtiment durable, Guide de bonnes pratiques sur la planification territoriale et le développement durable*, Ministère des Affaires municipales, des Régions et de l'Occupation du territoire, coll. "Planification territoriale et développement durable", 89 p. [mamrot.gouv.qc.ca].

¹⁴ HYDRO-QUÉBEC (2007), *La géothermie*, Varennes, 34 p.

Figure 1.1

Distribution of solar rays received by the Earth



Source: HYDRO-QUÉBEC (2007), *La géothermie*, Varennes, 34 p.

BOX 2

DEEP GEOTHERMICS

Deep geothermics differ from surface geothermics in that they require much deeper underground ductwork, sometimes to a depth of several thousand metres, compared to several hundred metres for surface geothermics. The purpose of deep geothermics is to extract thermal energy from a depth of several kilometres (usually between 3 and 6 kilometres) and to use it either as heat (thermal energy) or to produce electricity. There are two main types of geothermal resources that can be used to produce electricity, the first associated with hydrothermal reservoirs and the second with reservoirs produced by hydraulic fracturing. All the projects currently under consideration in Québec are of the second type.

In Québec, no electricity or heat is currently produced using deep geothermal systems. The technology requires very large investments, and is far from being economically viable. Nevertheless, it has attracted interest from researchers in Québec, who regard it as an emerging means of producing electricity or heat. The Institut national de la recherche scientifique (INRS) and the Institut de recherche d'Hydro-Québec (IREQ) are currently carrying out preliminary analyses of potential deep geothermic reservoirs in Québec. The INRS is also studying the Québec population's perceptions and knowledge of this technology, and its social acceptability.

EXAMPLES THROUGHOUT THE WORLD

Worldwide, 94.5% of all electricity derived from geothermal systems is produced by just ten countries.¹⁵ Most of the generating stations are located in volcanic areas providing high-energy hydrothermal geothermics.

A handful of pilot projects, including one in Soultz-sous-Forêts, in the Rhine Rift Valley on the France-Germany border, use deep geothermics with stimulation outside volcanic areas. France is a leader in this field in Europe, with an electricity production capacity of 17 MW (mostly of volcanic origin) and a heat production capacity of 2,300 MW.¹⁶

In Canada, the greatest potential for deep geothermics is located in sparsely populated regions in the West (British Columbia and the Northwest Territories). However, the technology is only being considered for experimental demonstrator purposes at this time.¹⁷

In the document entitled *The State of the Canadian Geothermal Heat Pump Industry 2011*,¹⁸ published by the Canadian GeoExchange Coalition (CGEC), Québec ranked seventh among the Canadian provinces for the number of new installations per capita in 2010, with a rate of two units per 10,000 inhabitants. Ontario ranked first with a rate of 5.5. In all, more than 10,000 new installations were identified in Canada in 2010 in the residential, commercial and institutional sectors, bringing the total number of installations to more than 80,000.

In Québec, sales of geothermal heat pumps declined in 2009 and 2010, despite the strength of the construction market during that period (an increase of 15% in housing starts).¹⁹ Elsewhere, the geothermal market remains small. In both France and the United States, financial assistance is available to support the use of the technology, since its installation costs are high compared to traditional options.

¹⁵ OBSERV'ER (2013), *La production d'électricité d'origine renouvelable dans le monde : collection chiffres et statistiques* [Online] [energies-renouvelables.org/observ-er/html/inventaire/pdf/15e-inventaire-Chap02.pdf] (Consulted on January 30, 2015).

¹⁶ ASSOCIATION FRANÇAISE DES PROFESSIONNELS DE LA GÉOTHERMIE (2013), *Étude de marché de la géothermie en France mise à jour 2013*, 22 p. [Online] [afpg.asso.fr/resources/Nos-actions/Travaux/AFPG-Etude-Marche_maj2013_V072014.pdf] (Consulted on January 28, 2015).

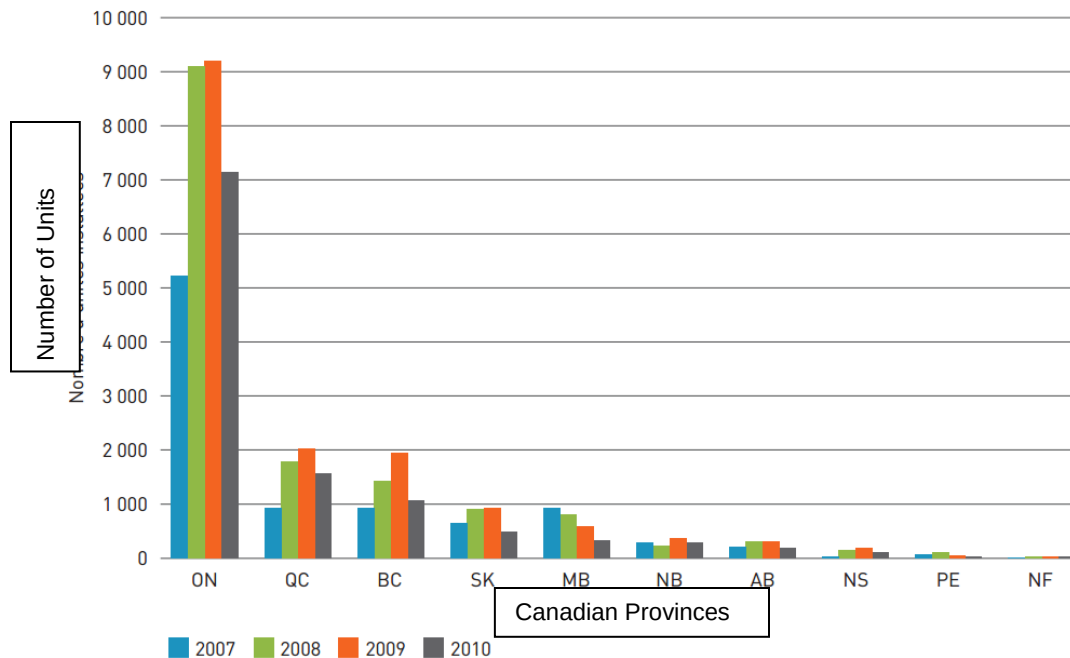
¹⁷ NATURAL RESOURCES CANADA (2012), *Geothermal Energy Resource Potential of Canada*. 301 p.

¹⁸ CANADIAN GEOEXCHANGE COALITION (2012), *The State of the Canadian Geothermal Heat Pump Industry 2011*, 40 p. [Online] [geo-exchange.ca/fr/UserAttachments/article82_Final%20Stats%20Report%202011%20-%20February%206,%202012_F.pdf] (Consulted on January 28, 2015).

¹⁹ STATISTICS CANADA, *Tableau 027-0008, Canada Mortgage and Housing Corporation, Housing starts, completions and absorptions, all regions, quarterly (units)* [Online] [statcan.gc.ca/tables-tableaux/sum-som/l02/cst01/manuf05-fra.htm] (Consulted on January 28, 2015).

Figure 1.2

Number of geothermal units installed every year, by province



Source: Canadian GeoExchange Coalition (2012). *The State of the Canadian Geothermal Heat Pump Industry 2011*, 40 p.

POTENTIEL AND CHALLENGES

From a technological standpoint, the interest of surface geothermics is clear, and its performance has improved over the years, especially in the commercial and institutional sectors. Until recently, standard applications required the use of low-temperature heating systems (air or water). Today, however, geothermics are often incorporated into existing buildings where the systems transport heating water at higher temperatures. This makes it possible to replace more greenhouse-gas producing heat generating systems while limiting the repercussions on power demand in winter.

The concept is more effective in existing buildings (homes or others) and even in new buildings when combined with energy efficiency measures (controls, heat recovery, insulation and sealing of the building envelope) and an auxiliary boiler (electric or oil) for very cold days. This approach reduces the need for extensive underground ductwork.

Building owners, especially in the commercial and institutional sectors, also save money on their energy bills by avoiding higher demand in peak periods, when tariffs are higher.

In Québec, the potential for use of this technology in the new housing sector is hampered by the tendency to install baseboard heaters (two-thirds of the market in certified Novoclimat homes in 2011), a practise that complicates future conversion possibilities. The same applies to a lesser extent in the commercial sector.

The technological challenges facing the geothermics market are more to do with reducing the initial investment required to install a geothermal system, as well as improving heat pump performance and improving both duct configurations and land use. Although current heat pump performance is sufficiently interesting to attract clients, progress is still both possible and desirable. Prices are similar to those of oil heating systems, but the cost of installing underground ductwork needs to be reduced, especially in Québec. In 2010, the average cost of duct installations was roughly 5% higher in Québec than in the rest of Canada, and 23% higher than in Manitoba,²⁰ where costs are lowest. According to the Canadian GeoExchange Coalition, these differences are due mainly to drilling practices.

EXPERTISE AND PROJECTS IN QUÉBEC

The geothermics industry has been established in Canada since the middle of the last decade, and has improved market dynamics. Québec is well-positioned in this respect, hosting the offices of the Canadian GeoExchange Coalition, which has played an important role in all this. The organization oversees a competency accreditation process for companies and designers in the field, as well as a certification process for geothermal installations. In the case of the residential sector, more than 300 designers have been accredited by the Coalition, and 24% are authorized to work in Québec. In the case of the commercial and institutional sector, however, there are only ten at most (2014 figures).

The installation and design of geothermal installations is now governed by standards introduced by the Canadian Standards Association.

As for all relatively new and complex technologies, standardization was considered necessary by both the industry and its clients, as revealed by a consultation of geothermics industry players during a SOM survey in 2011.²¹

Of the projects identified in Québec, the institutional building sector has by far the most, with more than 75 geothermal systems. The sector is also likely to become even more favourable to geothermics, given the targets and State exemplarity measures set out in the 2013-2020 Plan of Action on Climate Change.

A good example is the Murdochville industrial estate, where all ten buildings are heated and cooled by geothermal systems. Heat from the flooded galleries of a copper mine closed in 1999 is recovered and meets 60% of the buildings' energy needs.

MEASURES TO PROMOTE THE TECHNOLOGY

The Rénoclimat program, introduced in 2006, provides financial assistance for installation of geothermal systems during home renovations. Such systems also qualify for subsidies under the MERN's Green Heat program.

Hydro-Québec also gave financial support for the installation of geothermal systems in new and existing buildings through an incentive program that ran from 2007 to 2013. However, the

²⁰ CANADIAN GEOEXCHANGE COALITION (2012), *The State of the Canadian Geothermal Heat Pump Industry 2011*, 40 p. [Online] [geo-exchange.ca/fr/UserAttachments/article82_Final%20Stats%20Report%202011%20-%20February%202012_F.pdf] (Consulted on January 28, 2015).

²¹ *Idem*

program was changed in 2013 and now applies only to new homes. Hydro-Québec has also subsidized feasibility studies for geothermal systems supplying groups of homes, through its PISTE program (a component of its energy efficiency plan). As for the industrial and business sector, Hydro-Québec has offered support programs since 2003.

Geothermal systems also qualify for support from a host of financial assistance programs offered since 2007 by the MERN's Bureau de l'efficacité et de l'innovation énergétiques (BEIE) for the commercial and industrial sector. Examples include the Program to reduce the use of heavy fuel oils and the Program to support effective measures in buildings, both of which now form part of the ÉcoPerformance Program. In all cases, financial support is given for installation of geothermal systems. The BEIE's assistance is in addition to that available from energy distributors.

In 2008, the Agence de l'efficacité énergétique, in conjunction with the Société immobilière du Québec (SIQ), published a list of analysis and selection criteria for geothermal systems. The document is intended for building managers in the public and parapublic sectors, and provides guidelines for consideration of geothermics when renovating heating systems in existing buildings or designing new buildings.

In recent years, the MERN has given financial assistance for three major geothermal projects requiring total investments of \$19.5 million. As a result, 9,892 tonnes of CO₂ equivalent are no longer released into the atmosphere.

QUESTIONS

- Like Québec, several American authorities have also introduced financial incentive measures in the last ten years. To what extent should we continue or increase the financial assistance available to consumers in order to develop the sector in Québec?
- What form of support should the State give for installation of geothermal heat networks to serve existing buildings or new urban developments?
- Should the industry intensify and promote quality control through accreditation of service providers, inspections, maintenance and standards?
- To set an example, would it be appropriate for the State to give preference to this type of energy (as it does for biomass) as the principal source of heat in its new buildings and existing buildings using fuel oil?
- What can be done to encourage the industry in Québec to continue to develop technology that will improve heat pump performance, underground duct design and land use?

HEAT WASTE

In Québec, industrial heat waste is usually regarded as a contaminant and simply discharged into the environment. The cost for potential users is therefore zero, meaning that it is of substantial interest as an energy source, especially if it is sustainable. This type of energy is available at certain cogenerating sites, usually at low temperatures, to heat greenhouses or buildings. Thermal electric power stations, incinerators and large data centres also offer significant potential for heat waste recovery.

DESCRIPTION OF THE TECHNOLOGY

Urban heating networks are composed of piping that transports heat transfer fluids, usually water or steam. The fluid is heated by boilers or heat waste, and provides heat for buildings. Because of heat loss, heating networks help save energy by recycling heat waste from electricity generating activities (cogeneration) or processes (industrial processes, incinerators, cooling, etc.).

EXEMPLES THROUGHOUT THE WORLD

In 1981, France passed a substantial set of legislation²² making it compulsory to report major heat waste, and to disseminate this information and provide free access to the resource, so that it can become a lever for regional development.

In Stockholm (Sweden), Fortum, a Finnish company, operates an “open” community heating network that allows connected customers to buy or sell surplus heat. The system has been in operation since 2013 and is commercially viable.

POTENTIAL AND CHALLENGES

According to 2008 data,²³ Québec has a potential of 76.6 TWh from waste industrial heat and heat waste from thermal electric power stations. For comparison purposes, the total annual amount of electricity that will be produced by the four La Romaine facilities is 8 TWh.²⁴

The main challenge in developing heat waste is to pair available waste with suitable heat users. Yet, heat waste is distributed fairly evenly throughout Québec’s regions, as shown by Table 1.1.

²² INNOVAGRO CONSULTANTS (2011), Potentiel énergétique des rejets thermiques industriel au Québec, 32 p.

²³ *Idem*

²⁴ HYDRO-QUÉBEC, Projets de production d’électricité : Complexe de la Romaine [En ligne] [hydroquebec.com/projets/romaine.html] (Consulté le 30 janvier 2015).

Table 1.1

Energy potential from heat waste in Québec, in 2008

Region	Name	Hot Liquid Effluent (GJ/yr)	Hot Gases T °C < 177 °C (GJ/yr)	Hot Gases T °C > 177 °C (GJ/yr)	Grand Total in GJ/yr	Regional % in Québec
01	Bas-Saint-Laurent	909 882	6 319 449	1 246 216	8 745 546	3.11 %
02	Saguenay–Lac-Saint-Jean	7 558 890	18 630 007	6 005 031	32 193 928	11.82 %
03	Capitale-Nationale	3 058 139	10 755 899	2 225 966	16 040 003	5.89 %
04	Mauricie	6 720 122	12 576 674	1 971 166	21 267 963	7.81 %
05	Estrie	1 930 668	9 524 549	1 749 536	13 204 754	4.85 %
06	Montréal	0	19 916 241	17 848 855	37 765 096	13.87 %
07	Outaouais	3 593 008	6 717 668	1 097 234	11 407 910	4.19 %
08	Abitibi-Témiscamingue	4 960 275	8 840 631	4 124 990	17 925 896	6.58 %
09	Côte-Nord	2 388 827	11 994 360	1 139 114	15 522 300	5.70 %
10	Nord-du-Québec	1 270 152	121	2 116 800	3 387 073	1.24 %
11	Gaspésie–Îles-de-la-Madeleine	213	361	0	574	0.00 %
12	Chaudière-Appalaches	18 902	12 867 534	13 236 664	23 123 100	9.59 %
13	Laval	0	0	0	0	0.00 %
14	Lanaudière	284 943	2 908 042	1 020 650	4 123 634	1.55 %
15	Laurentides	61 243	1 275 262	304 667	1 641 171	0.60 %
16	Montérégie	1 602 782	13 225 464	5 473 364	20 331 610	7.47 %
17	Centre-du-Québec	34 509 616	7 246 836	1 092 925	42 849 377	15.73 %
TOTAL		68 867 662	142 799 098	60 653 178	269 529 935	100 %

Source : INNOVAGRO CONSULTANTS (2011), Potentiel énergétique des rejets thermiques industriel au Québec, 32 p.

BOX 3

HEAT DEPOSITS AVAILABLE IN QUEBEC

Data centres

Computer servers generate large quantities of heat that must be evacuated to keep the hardware at a constant temperature. Data centres with more than one server are therefore good potential sources of heat.

The first phase of the Telus data centre in Rimouski was completed in the fall of 2012 and releases 26.3 GWh of heat per year. Five other phases are planned, for a total of 131.5 GWh.

The first phase of what will become “the largest data hosting centre in the world” according to French owner OVH, was opened in Beauharnois in January 2013.

These two companies offer server hosting services for Canadian and international companies at a site that has a reliable and renewable supply of electricity. In addition, because of Québec’s climate, the data centres are cooled by outside air almost year-round, thereby reducing their operating costs. It would be possible to improve profitability even further by selling waste heat to their neighbours.

Other projects could also be set up in large urban centres where the energy released by data storage units could be reused to heat new air. One example is Montreal’s underground city, where it would be possible to install this type of centre.

Incinerators

Waste incinerators are often situated in urban areas, and there is significant potential for heat waste to be used in urban heating networks. For example, Québec City’s incinerator sells 810,000 tonnes of steam per year,²⁵ or roughly 560 GWh of heat, to a neighbouring paper mill.

One of the problems of creating an urban heating network is the fact that so many parties are involved. The process can be hindered by the physical and technical possibilities, as well as by the willingness of the parties to become involved. In addition, there are very few organizations and companies in Québec with the expertise to manage the different aspects of urban heating networks.

EXPERTISE AND PROJECTS IN QUÉBEC

In the Saguenay region, Serres Sagami joined forces with Elkem Métal in an urban heating network project. Heat pumps extract heat from the cooling water used in Elkem Metal’s blast furnaces, which is then used to heat water for the greenhouse heating system. A heat recovery system for gas burned by the natural gas boiler is also used, jointly with a CO₂ generator. Savings on heating costs amount to roughly \$178,000 per year, for a total investment of \$420,000.

The proposed residual biomass urban heating network in Saint-Jean-de-Dieu brings together several potential customers in a typical rural village. The network includes an elementary school, a secondary school, a church and an inn. The final costs are roughly \$889,000 and savings of \$38,000 per year are expected. The Bureau de l’efficacité et de l’innovation énergétiques has given financial support of \$347,945, and the annual reduction of GHG emissions is estimated at 169 tonnes.

²⁵ VILLE DE QUÉBEC, *Ordures ménagères — Incinérateur* [Online] (ville.quebec.qc.ca/citoyens/matieresresiduelles/ordures_menageres/incinerateur.aspx) (Consulted on January 30, 2015).

MESURES TO PROMOTE THE TECHNOLOGY

Until 2014, the Bureau de l'efficacité et de l'innovation énergétiques offered financial assistance to promote urban heating networks. Heat waste development project promoters were therefore able to obtain financial support through the ÉcoPerformance Program, provided the project would reduce fuel oil use.

CONTRIBUTION TO THE DEVELOPMENT OF QUÉBEC

Waste heat recovery could become a powerful tool for regional development and a major factor in improving the productivity of companies in Québec, within the context of globalization.

In Québec, there are currently very few data centres that release large enough volumes of heat to sell. On the other hand, Québec could attract major international data centres by adding the purchase of heat waste to its many other advantages, including its very reliable, renewable electricity grid and a climate conducive to air conditioning systems using outside air. For Québec, these data centres are stable consumers of electricity whose peak demand is in the summer, and a major source of employment in a field of the future.

According to the average electricity generating profile in the United States, a single 100 GWh transfer from an American data centre located in Québec would generate an annual reduction in GHG emissions of 69,000 CO₂ equivalent tonnes. This calculation does not take into account the reduction in energy consumption achieved by recovering heat released by the data centre.

QUESTIONS

- What can the Government do to promote heat waste development projects?
- How could Québec be inspired by France, which introduced legislation making it compulsory for companies to declare heat waste and allow access to it by all potential users, as a lever for regional development?
- Should Québec encourage the creation of data centres paired with existing or new district heating systems, as eco-neighbourhood projects?

SECTION 2

BIOENERGY

Bioenergy accounts for 10% of the world's primary energy. It provides environmentally, socially and economically sustainable solutions to current energy challenges in the areas of electricity generating, heat production and transportation. It offers alternative solutions to all forms of fossil energy (natural gas, petroleum and coal).

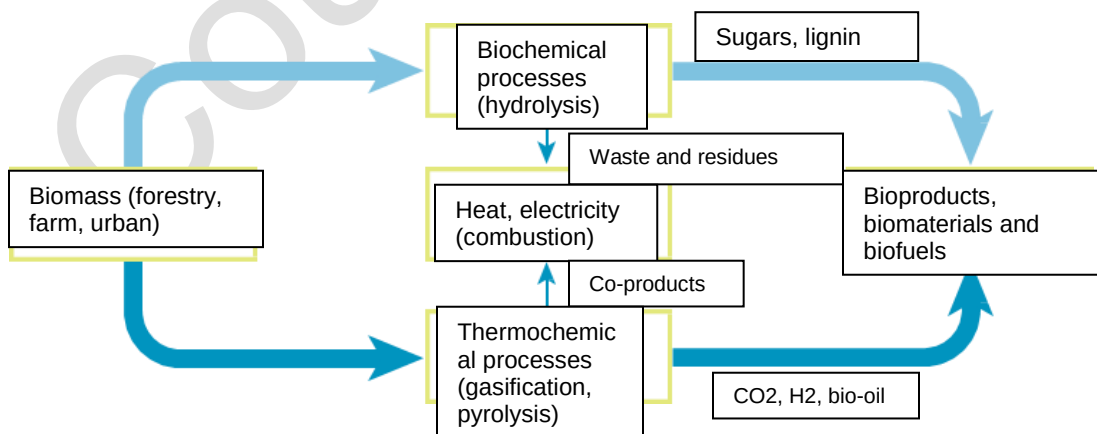
WHAT IS BIOENERGY?

Bioenergy is energy produced by burning or chemically processing different types of biomass, i.e. the organic portion of urban, forestry or farm waste, or crop waste (e.g. cereals, fast-growth crops, micro-organisms, etc.). In reality, bioenergy is solar energy stored by plants through photosynthesis, in the form of biomass from which a variety of energy products can be made for different uses in modern society.

Like the petroleum industry that provides energy and raw materials for the chemical industry, biomass can be a source of materials and basic chemical products. This is the principle of biorefining, which works in the same way as oil refining. The economic success of the bioenergy sector may depend on biorefining, which extracts high added-value molecules from biomass.

Figure 2.1

Some ways of converting biomass into energy or energy products



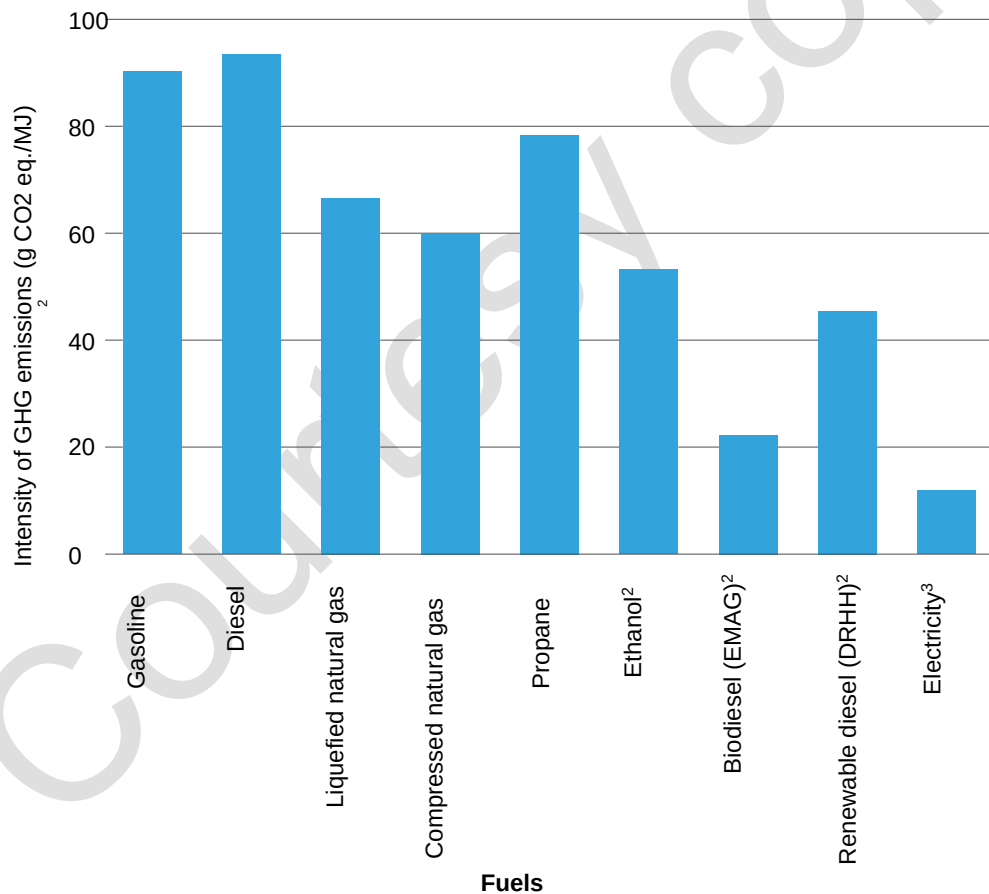
Inspired by: NATIONAL RENEWABLE ENERGY LABORATORY, *What is a Biorefinery?* [Online] [nrel.gov/biomass/biorefinery.html] (Consulted on January 27, 2015).

The environmental benefit of producing bioenergy is that its carbon footprint is usually smaller than that of traditional fossil energies, because its carbon derives from the atmosphere and is returned to the atmosphere when the energy is used. In addition, biofuels used instead of fossil fuels to produce heat can significantly reduce sodium oxide (NO_x) and sulphuric oxide (SO_x) emissions.

Variable quantities of fossil energy are used to produce, refine and transport bioenergy. The carbon footprint will therefore vary from one energy product to another, depending on the amount of fossil energy required to produce each unit of bioenergy. The GHG reductions from fossil fuel replacement will therefore vary, depending on how efficient the bioenergy production process is

Figure 2.2

Comparison based on a carbon intensity life cycle approach: fuels used for transportation in British Columbia (2012)



Notes:

1 Emissions are cumulative for the entire life cycle of the fuel.

2 The figures will vary, depending on the raw materials used.

3 Electricity is generated using 90 % renewable energy

Sources: British Columbia Ministry of Energy and Mines (2014).

Renewable and Low Carbon Fuel Requirements Regulation, Summary for 2012.

GASEOUS BIOFUELS FOR HEATING

Biogas is obtained from the breakdown of organic matter in the absence of oxygen. This is the principle of anaerobic digestion. Biogas can be captured from landfill sites or by biomethanization of organic farm, municipal, industrial, commercial or institutional waste and residues. Biogas mostly contains methane (from 45% to 75 % CH₄) and carbon dioxide (CO₂).²⁶ Methane molecules account for 95%²⁷ of natural gas. Renewable natural gas that meets the quality standards of natural gas distributors can be obtained by purifying biogas.

Biogas has been used in Québec for the last 30 years. Most biogas producers also use the gas to satisfy part of their own heating needs. This is the case of certain industries and municipalities that treat their liquid effluent by anaerobic digestion. Landfill site owners have also entered into biogas supply contracts with customers (e.g. greenhouses, pulp and paper mills) that use the gas to satisfy some of their heating needs. Others purify biogas to form renewable natural gas (biomethane), which can then be distributed throughout the North American grid. Once biogas has been purified to form biomethane, it is also used in the transportation sector in compressed (CNG) or liquefied (LNG) form, to replace diesel fuel.

Gasification (syngas) and pyrolysis are other methods of producing biogas fuels.

LIQUID BIOFUELS FOR HEATING

As their name suggests, biofuels can be used to replace gasoline, diesel fuel, fuel oil or kerosene (aviation fuel). They are produced by converting different types of raw materials, including forestry or farm biomass, municipal waste, industrial residues, etc. Biofuels obtained from farm products usually grown as food (corn, wheat, canola, soya, etc.) are regarded as first-generation fuels, and the methods used to produce them have reached maturity. Second-generation biofuels (sometimes called advanced or cellulosic biofuels) use raw materials (residual biomass) that do not form part of the food chain.

The best-known biofuel is ethanol, which can be made by fermenting the sugars extracted from corn, wheat, sugar cane and sugar beet. There is also cellulosic ethanol, obtained through a variety of processes using waste converted by enzymatic hydrolysis, fermentation, thermochemistry, catalysis and so on.

²⁶ ASSOCIATION QUÉBÉCOISE DE LA PRODUCTION D'ÉNERGIE RENOUEVELABLE, *Le biogaz* [Online] [www.aqper.com/fr/le-biogaz] (Consulted on January 30, 2015).

²⁷ GAZ MÉTRO, *Fiche signalétique gaz naturel (état gazeux)* [Online] [www.corporatif.gazmetro.com/data/media/fiche_signalétique.pdf?culture=fr-ca] (Consulted on January 30, 2015).

Renewable diesel fuel can be used instead of traditional diesel fuel. Like ethanol, it can be first-generation, produced by converting oleaginous cereals (soya, canola, etc.), or second generation, produced by means of pyrolytic, thermochemical, catalytic and other processes from waste and residual materials. Methanol and butanol can also be used as biofuels.

Research has produced some promising findings in recent years, and as a result numerous advanced biofuel production processes and biosourced green chemical coproducts associated with biorefining, such as gasification, pyrolysis and enzymatic hydrolysis, have been developed or marketed in Québec.

SOLID BIOFUELS FOR HEATING

Wood and its by-products have been used to produce energy since the dawn of time. They produce heat and electricity, usually via combustion. Wood is developed in raw form (logs, logging waste, processing waste), in the form of chemical extracts from the pulp and paper process (liquors), in compacted form (pellets and logs) and in carbonized form (biochar). Farm, municipal and industrial biomass can also serve as solid biofuels.

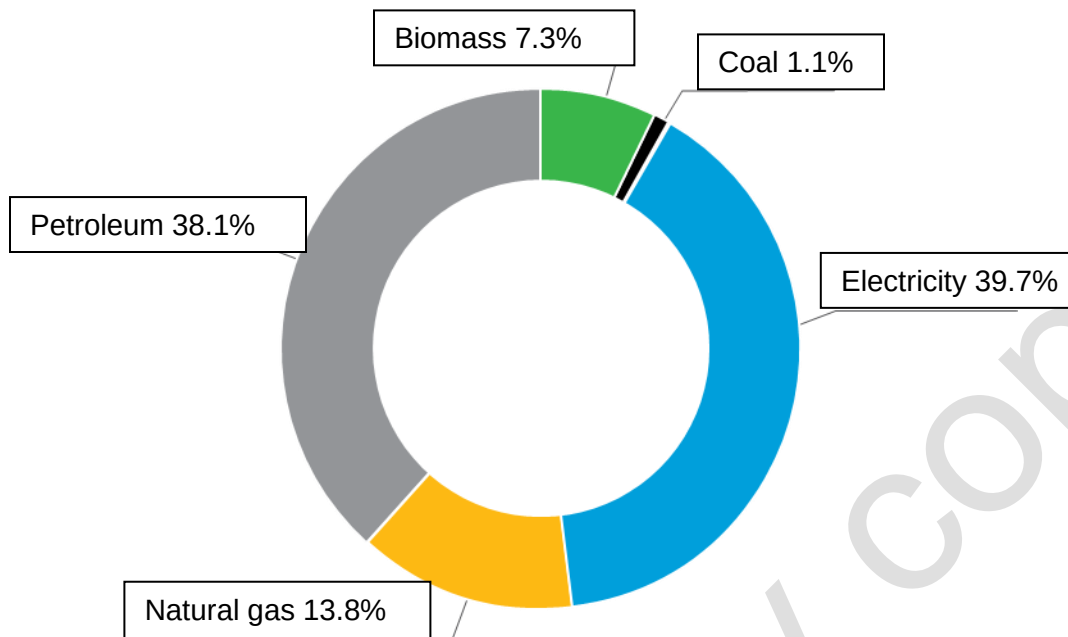
The main wood fibre biofuels used in Québec are coproducts of wood processing mills (barks, chips, shavings and sawdust). Marginally, forest biomass, poor quality roundwood, buried bark and deconstruction wood can also be used. On the other hand, a substantial quantity of firewood is consumed every year in Québec, in addition to products from the compressed wood industry (pellets, densified wood fire logs).

CURRENT PROFILE AND POTENTIAL MARKETS FOR BIOENERGY

Every year, the energy sector is responsible for roughly 5% of Québec's GDP. In 2012, Québec's trade deficit for fossil energies (crude oil, petroleum products, natural gas and coal) was \$13.6 billion. The bioenergy market is therefore huge.

Figure 2.3

Percentage of end energy consumption by energy form (2011)



Sources: Ministère de l'Énergie et des Ressources naturelles and Statistics Canada.

Table 2.1

Variation in petroleum product consumption in Québec, from 1990 to 2011

Year	Diesel (ML)	Gasoline (ML)	Aviation Fuel (ML)	Light Fuel Oil (ML)	Heavy Fuel Oil (ML)
1990	3 136	7 887	1 053	2 307	2 188
2011	5 345	9 774	1 130	918	965
Variation	70 %	24 %	7 %	-60 %	-56 %

Source: Ministère de l'Énergie et des Ressources naturelles.

The transportation sector uses 99% of petroleum products. There was a significant increase in gasoline consumption (24%) between 1990 and 2011, and an even more marked increase in diesel fuel consumption (70%), associated mainly with goods transportation and off-road work. As for fuel oil consumption, it fell by 58% as heating systems were converted to electricity or natural gas (see Table 2.1).

SHARE OF BIOENERGY IN QUÉBEC'S ENERGY PROFILE

According to MERN statistics, bioenergy accounts for 7.3% of all energy consumed in Québec. It is used mainly in solid form, burned to produce heat and electricity (6 Mtma/yr). On the other hand, this statistic, which dates back to 2011, underestimates the contribution of biofuels and biogases, whose use has increased in recent years.

The gasoline market alone is huge. The fact that importers and refiners are obliged by law to include 5% of renewable content in all gasoline sold in Canada creates a real market of nearly 500 million litres of renewable content, which is satisfied by first-generation ethanol.

Since 2013, importers and Québec's petroleum producers are also required to comply with Environment Canada's requirement of including 2% of renewable content in diesel fuel. This creates a market of 100 million litres per year.

Domestic consumption of energy pellets is roughly 60,000 metric tonnes per year.

WORLD MARKETS

The Asian market (South Korea, China, Japan) could become a major consumer of bioenergy in the next decade. According to RISI (Resource Information Systems Inc.),²⁸ world wood pellet consumption could increase from 23 million metric tonnes in 2014 to more than 50 million in 2024 (an annual growth rate of 8.2%).

Most of Québec's production goes for export (United States, residential market, North-East region). Some producers also export to Europe.

²⁸ GROUPE DDM / ÉCORESSOURCES (2012). *Inventaire régionalisé des biomasses exploitables pour la production de bioénergies au Québec*. 137 p.

RAW MATERIAL ACCUMULATIONS

MERN estimates suggest an accumulation of raw materials of more than 30 million metric tonnes per year in Québec.²⁹ Obviously, for all kinds of technical and economic reasons, only part of these accumulations can be used to produce bioenergy. Some are already used for other, more lucrative purposes, for example in particleboard and animal litter.

Residual forest biomass is the most homogenous type of biomass and has high energy value. However, the most easily-converted part of this biomass, waste from the primary processing sector (shavings, sawdust and bark), is already being used. A certain quantity of pulp hardwood is also available for bioenergy: a theoretical volume of more than 1 million metric tonnes per year from the public forest, and roughly 0.5 million metric tonnes per year from the private forest.

The theoretical availability of residual forest biomass is around 2 million metric tonnes per year from the public forest and around 0.8 million metric tonnes per year from the private forest. However, most of this material is currently left in the forests after thinning or logging work, and must be transported over long distances, which considerably increases the supply cost.

Because the material is so scarce, bioenergy producers can also use other raw material sources. Farm biomass, for example, is also relatively homogenous and has significant energy content. Some of these materials (straw, manure) are also in high demand in the farm and horticultural sectors, while others, such as crop waste unfit for human consumption and liquid manure, are often available. Accumulations and demand vary from one region to the next, and this affects prices.

Although more modest, accumulations of urban biomass (table waste, grass cuttings, leaves, etc.) are also available in reasonable quantities. Its best quality derives from the fact that its costs are very low; bioenergy producers may even receive tipping fees. However, the low price comes with a major limitation, namely that the material is extremely varied and needs a significant amount of pre-processing prior to development.

Organic materials in sludge or liquid form are preferred for biomethane production. These materials, whether buried or processed, naturally produce biogases composed of methane (a powerful greenhouse gas), CO₂ and various other components. Municipal and industrial sludge from water treatment plants, residual organic materials (green waste, brown bin), farm waste and agro-food processing waste can all be processed using anaerobic digestion.

²⁹ S. WALKER et coll. (2014), *Global Pellet Demand Outlook – Special Market Analysis Study*, RISI, 79 p.

SOLID BIOFUEL OPTIONS

WOOD FIBRE USAGE STATISTICS

The Ministère des Forêts, de la Faune et des Parcs (MFFP) keeps forestry registers containing annual data on the receipts and production of the various wood primary processing mills. These data include consumption of energy product mills (pellets and densified wood fire logs, cogenerating, wood charcoal) and consumption for energy purposes of other wood processing mills (heating, wood drying, etc.). These data are presented below in Table 2.2 by type of mill and in table 2.3 by type of fibre

Table 2.2

Use of wood fibre for solid biofuel and energy production, by mill type

Mill Type	Quantity Received (thousands of mt/yr)				
	2009	2010	2011	2012	2013
Pellet and densified wood fire log mills	292	235	185	296	377
Cogenerating plants	1 481	1 288	1 149	975	1 291
Wood charcoal mills	11	11	13	14	12
Other wood processing mills	900	994	1 126	1 197	1 116
Total	2 684	2 528	2 472	2 482	2 796

Source: Ministère des Forêts, de la Faune et des Parcs (2015). Forest Register.

In 2013, Québec had 10 active wood pellet mills producing a total of 304,000 metric tonnes of pellets. This amount was equal to only 50% of the mills' total capacity.

Table 2.3

Use of wood fibre for solid biofuel and energy consumption, by fibre type

Fibre Type	Quantity Used (thousands of mt/yr)				
	2009	2010	2011	2012	2013
Roundwood	11	11	13	17	16
Forest biomass	0	0	0	24	30
Bark	2 020	1 986	2 035	1 874	2 064
Chips	5	9	2	47	55
Sawdust	235	213	171	225	246
Shavings	111	75	55	97	118
Wood residue and demolition wood	302	234	197	198	268
Total	2 684	2 528	2 472	2 482	2 796

Source: Ministère des Forêts, de la Faune et des Parcs (2015). Forest Register.

Tables 2.2 and 2.3 show that Québec's wood processing mills consumed nearly 2.8 million anhydrous metric tonnes of wood fibre to produce solid biofuels and energy in 2013. Of this amount, nearly 1.3 million anhydrous metric tonnes were processed by cogenerating mills. In addition, most of the fibre used (more than 2 million anhydrous metric tonnes) was in the form of bark. Additional quantities of wood fibre may also have been used for energy purposes by mills without wood processing plant operating permits.

In addition, the data do not include firewood consumption in Québec. Although it is difficult to set an exact value for this, MFFP data suggest that a total of roughly 1.1 million anhydrous metric tonnes of firewood were cut from Québec's public and private forests in 2013.

Use for energy purposes is likely to increase in the coming years, in particular as a result of new electricity sale contracts through Hydro-Québec Distribution's program to purchase electricity produced by cogeneration using residual forest biomass (PAE2011-01).

SUPPLIES

Local supplies are used to produce bioenergy from solid fuels. A radius of 100 km around the wood fibre processing mill is usually considered an acceptable limit in order to maintain a satisfactory profitability threshold. Wood fibre supply costs account for a significant portion of the cost of producing pellets in Québec.

Most of the fibre used to produce energy pellets is composed of sawdust (56 %), followed by shavings (27 %). This type of raw material is much sought-after by pellet producers, since its size, cleanliness and low moisture levels (30 %) are very close to those required for the fibre pelleting stage. In addition, sawdust and shaving costs are fairly low (\$60/anhydrous metric tonne, shipped) compared to other types of raw materials. However, given these benefits and the presence of other major buyers (the board industry and baggers), these materials are available in limited quantities in Québec, which hinders the development of new projects by producers wishing to use this type of fibre. The cost of the fibre itself is high, at roughly \$100/anhydrous metric tonne shipped over an average distance of 130 km in Québec. Moreover, this type of raw material is often shipped in the form of chips, which have a higher moisture content (50%). Another consideration is that processing costs are higher when roundwood is used to produce pellets, due to the need for debarking, fractionation and drying.

Another type of raw material that can be used by pellet producers is residual forest biomass left behind by commercial logging. Its cost is estimated at \$100/anhydrous metric tonne, shipped over a maximum distance of 100 km. Its moisture content is generally 30%. Given that residual forest biomass harvesting is a fairly new process for many firms in Québec, production quality tends to vary in terms of volume, cleanliness and moisture. On the other hand, the material is widely available in Québec.

The use of wood chips is marginal in Québec, but could become more widespread as the demand for newsprint – for which chips are the main source of fibre – continues to decline. Their cost (roughly \$100/anhydrous metric tonne, shipped) could also decline as a result. As for bark, it is being considered for use in manufacturing industrial grade pellets and would, among other things, allow for greater tolerance of ash content. The purchase cost of bark (roughly \$30/anhydrous metric tonne, shipped) is very low, compared to other types of raw materials available in Québec.

LIQUID BIOFUEL OPTIONS

BIODIESEL

Biodiesel composed of fatty acid methyl ester (FAME) produced in Québec is obtained by means of transesterification of animal-origin fatty acids and vegetable oils salvaged from restaurants. It accounts for less than 10% of total renewable diesel fuel consumption in Québec.³⁰ The major oil companies have chosen to import another type of renewable diesel fuel from abroad, in the form of hydrogenation-derived renewable diesel (HDRD). Local producers must therefore either export or reduce their production. HDRD is more expensive, but meets diesel fuel quality standards (ASTM D-975 or CAN/CGSB-3,517-2013) and passes the cloud point test³¹ more easily in winter conditions.

Virgin vegetable oils (soya, canola) are virtually absent from domestic biodiesel production.

BOX 4

ROTHSAY BIODIESEL INC.

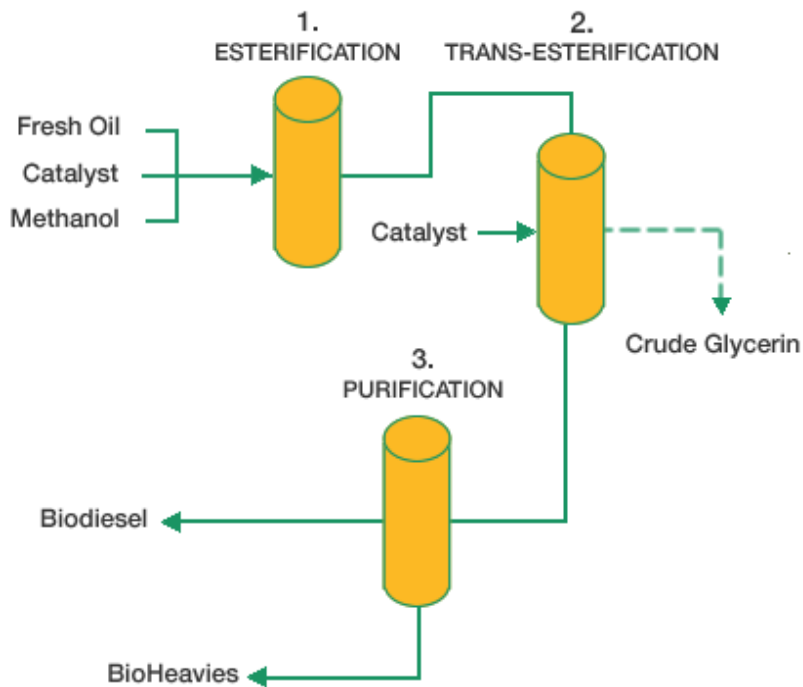
Rothsay Biodiesel, a rendering company in Ontario, first began producing biodiesel in 2001, at a pilot plant. After playing an active role in the BioBus and BioMer demonstrator biodiesel projects in 2003, Rothsay inaugurated the first-ever commercial biodiesel plant in Canada, at Sainte-Catherine in Montérégie. The plant has a capacity of 45 million litres per year. Rothsay biodiesel is produced from rendering waste from its own plants.

³⁰ ECO RESSOURCES CONSULTANTS (2012), Compte rendu sur l'infrastructure du diesel renouvelable au Canada. Final Report to Natural Resources Canada, 39 p.

³¹ When the temperature falls, opacity appears even before the fluid solidifies, due to paraffin crystallization.

Figure 2.4

Transesterification process used by Rothsay Biodiesel



Source: ROTHSAY BIODIESEL, *Our Biodiesel* [online] [rothsaybiodiesel.ca/francais/notre_biodiesel.html] (Consulted on January 30, 2015).

Raw material costs account for roughly 80% of total production costs.

In Québec, according to the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, it would be possible to produce roughly 100 million litres per year of renewable diesel fuel from residual biomass such as animal fats or recycled frying oils.³²

Forest biomass can also be used to produce renewable diesel fuels using technologies that are still at the development stage, either technically or economically. Some fairly large plants are beginning to appear.

³² MAPAQ (2008), Rapport final intégral sur les bioproduits – 18 juin 2008.

Table 2.4

Biofuel production process using forest residue

Tall Oil	Pretreatment	Hydrotreatment	Fractionation	Renewable Diesel Fuel
Tall oil is a chemical pulping process residue containing natural extractive components of wood.	Tall oil is purified: salts, impurities, solid particles and water are removed.	The chemical structure of the purified tall oil is modified by feeding it into a reactor with hydrogen.	Uncondensable gases and hydrogen sulphide (H ₂ S) are removed.	Renewal diesel fuel is obtained after distillation.

Source : UMP BIOFUELS, *Advanced biofuel production* [Online] [upmbiofuels.com/biofuel-production/advanced-biofuel-production/Pages/Default.aspx] (Consulted on January 14, 2015).

ETHANOL

Québec produces roughly 175 million litres of first generation fuel ethanol per year from surplus grain corn production. Canadian regulations require a 5% ethanol content in all gasoline, and because domestic production is insufficient to meet this requirement, Québec must import roughly 300 million litres of ethanol per year, also produced from cereals or sugar cane. There are no plans to build other plants of this type, first because the raw material is not available locally, and second because of questions regarding the use of food products in biofuel production.

Bioethanol producers receive financial assistance of up to \$0.18/litre when the oil price per barrel falls below US\$65.

Like the rest of the industrialized world, Québec has made a substantial financial effort to help Québec's private sector develop the cellulosic ethanol (or second generation ethanol) industry. Demonstrator pilot units have been set up since the early 2000s, with technologically encouraging results. Commercial plants are now being built in Québec and in Canada as a result.

The first commercial Canadian plants in Québec (Varennnes) and in Alberta (Edmonton) will manufacture cellulosic biofuels from urban and industrial waste. The choice was based on the economic benefits and positive environmental impacts; it allows waste to be converted into bioenergy in line with the principles of sustainable development.

From the economic standpoint, the acquisition cost of the material is negative, i.e. a biofuel manufacturer could be paid to take municipal waste, which is expensive to manage (collection, transportation, construction and management of landfill or incineration sites, etc.).

Using this waste to produce cellulosic ethanol fuel would help reduce the volume of waste for elimination and generate substantial savings as a result. It would also substantially reduce the volume of biogas produced by landfill sites.

As for residual forest biomass, recent statistics suggest that reserves are plentiful. However, given the high factory-delivered price of \$60 to \$100 per tonne, experts in Québec and abroad have focused on biorefining technologies that can produce both biofuels and value-added bioproducts.

BIOMETHANE OPTIONS

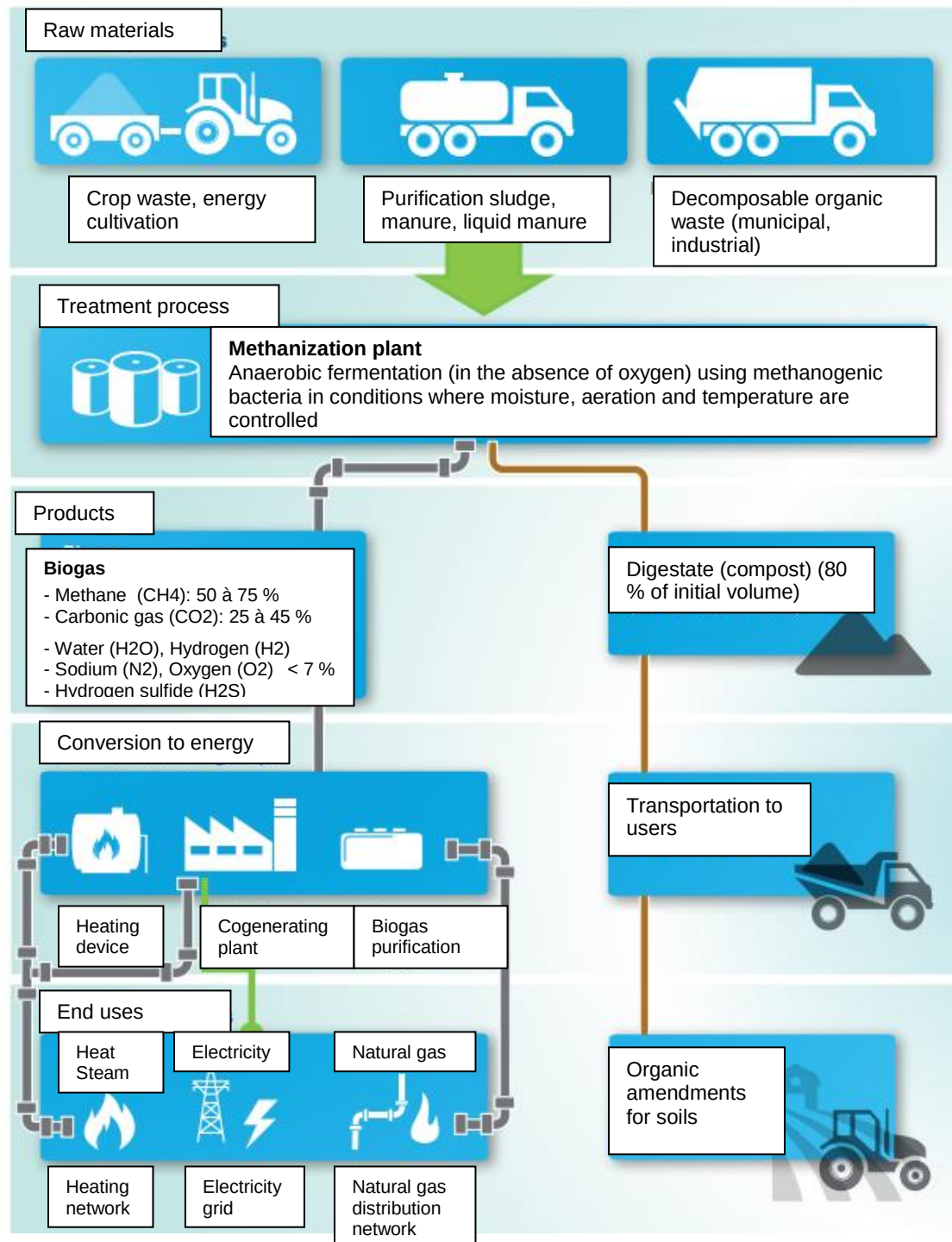
Gas biofuels consumed here in Québec are produced locally through decomposition of buried waste in engineered landfill sites. They can also be made by fermenting sludge and liquid effluents with high organic content, such as those from pulp and paper mills and agro-food factories. Biogases produced in water treatment plants are often salvaged to produce heat on site.

Courtesy copy

Figure 2.5

Biomethane production and development process

Methanization process



Source: Ministère de l'Énergie et des Ressources naturelles (2015)

The Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques has introduced a Program to treat organic waste by biomethanization and composting, known by its French acronym PTMOBC, to address the environmental issues of managing municipal waste and the fight against climate change.^{33, 34} If all the biomethanization projects being considered under this program were to go ahead, Québec would have to fund investments totalling more than \$1 billion in the coming years. In most cases foreign technologies and techniques would be used. However, firms from Québec have set up partnerships with these foreign firms, to ensure acquisition of knowledge and expertise, and some have even managed biomethanization projects outside Québec.

The natural gas distributor Gaz Métro estimates that between 25 and 30 million m³ of renewable natural gas could be injected into its grid every year via municipal development projects. The remainder could be developed without recourse to the grid.

Table 2.5

Municipal projects funded by the Program to treat organic waste by biomethanization and composting

Organization	Region	City or Town	Supply (tonnes/ayr)	Capacity (m ³ /ayr)
Société d'économie mixte en énergie renouvelable (SEMER, Rivière-du-Loup)	Bas-Saint-Laurent	Cacouna	27 200	1 500 000
Ville de Québec	Capitale-Nationale	Québec	182 600	7 600 000
Ville de Laval	Laval	Laval	115 000	7 000 000
Régie d'assainissement des eaux de la Vallée-du-Richelieu	Montréal	Mont-Saint-Hilaire	7 600	360 000
Régie d'assainissement des eaux du bassin de La Prairie	Montréal	La Prairie	32 000	800 000
Régie intermunicipale de valorisation des matières organiques de Beauharnois-Salaberry et de Roussillon	Montréal	Beauharnois	33 900	1 500 000
Société d'économie mixte de l'est de la Couronne Sud (SEMECS)	Montréal	Varenes	46 000	2 400 000
Ville de Longueuil	Montréal	Longueuil	70 000	6 084 000
Ville de Saint-Hyacinthe, phases 1 and 2	Montréal	Saint-Hyacinthe	215 200	13 000 000
Ville de Montréal — Biometh 1	Montréal	Montréal	230 000	3 300 000
TOTAL			959 500	43 544 000

Source: Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, internal communication.

³³ MINISTÈRE DU DÉVELOPPEMENT DURABLE, DE L'ENVIRONNEMENT ET DE LA LUTTE CONTRE LES CHANGEMENTS CLIMATIQUES (2011), *Plan d'action 2011-2015 de la Politique québécoise de gestion des matières résiduelles*. 34 p.

³⁴ MINISTÈRE DU DÉVELOPPEMENT DURABLE, DE L'ENVIRONNEMENT ET DE LA LUTTE CONTRE LES CHANGEMENTS CLIMATIQUES (2012), *Cadre normatif du Programme de traitement des matières organiques par biométhanisation et compostage (phase II)*. 23 p.

BIOENERGY TRANSPORTATION AND DISTRIBUTION

SOLID FUELS

In Québec, significant volumes of solid fuels are produced at some distance from markets and from the port infrastructures used for exporting. Given the relatively low energy density of these products, this is somewhat challenging from an economic standpoint. On the other hand, Québec is geographically well-situated with respect to European markets. It also has a good rail network and port infrastructures suited to exports of pellets (deepwater ports on the St. Lawrence River, imminent start-up of Arrimage Québec's pellet storage and shipping terminal in Québec City).

LIQUID BIOFUELS

Now that Canadian fuel distributors are required to mix a certain volume of renewable content into their products, bioethanol and renewable diesel fuel are usually transported using the same traditional networks as their fossil counterparts. On the other hand, given that domestic oil companies have refused to use the FAME-type biodiesel produced in Québec, the Québec manufacturer has set up an independent distribution network to ship its product directly to companies operating diesel-fuelled vehicle fleets.

GASEOUS FUELS

Biogas is usually converted into heat, via cogeneration, or into replacement fuel (CNG or CNB), at or close to the production site, meaning that a distribution network is not needed. The natural gas distribution grid can distribute renewable natural gas made from biogas, provided the product complies with certain standards and does not lower the overall quality of the gas provided by the distributor to its clients. It can also be exported. The Act respecting the Régie de l'Énergie was amended in 2006 to allow producers to ship biogas to clients without using the natural gas distribution grid.

INNOVATION

Bioenergy is energy from renewable neutral carbon. It is generated by converting biomass, produced by photosynthesis, into electricity or heat and into biofuels such as bioethanol, biodiesel, biohydrocarbons, biohydrogen and so on.

If a bioenergy development strategy is to be effective, it requires:

- a supply of biomass suitable for use in bioenergy production with no ecological impact;
- reliable and effective conversion technologies;
- a range of products that can be sold competitively on the energy, fuel, coproduct and fibre markets for different end uses;
- non-risk-averse funding methods.

Structured interventions to generate innovation are needed to meet these conditions. Careful attention must be paid to the maturity of the various sectors.

Table 2.6

Ranking of sectors by technical and economic fossil fuel replacement potential

Sectors with high short-term potential 2014-2020	Sectors with medium-term potential 2020-2025	Sectors with longer-term potential 2025-2030
Ground material Forest waste	Biogas Municipal sludge	Cellulosic ethanol Forest waste
Wood powder Forest waste	Biodiesel Animal processing waste	Biodiesel Animal processing waste
Pellets Forest waste	Pyrolysis oil Forest waste	Cellulosic ethanol Lignocellulosic crops
Synthetic gas Forest waste	Synthetic diesel fuel Forest waste	Biomethane Municipal sludge
Chips Forest waste	Biogas Food waste and biosolids	Biogas Municipal waste and animal processing waste
Densified wood logs Forest waste	Liquefied natural gas Institutional, commercial and industrial waste and sludge	Biomethane Food waste and biosolids

Source: ECONOLER (2013), *Étude sur le potentiel technico-économique des filières de bioénergie au Québec*. 129 p.

In recent years, several advanced biofuel production processes and biosourced green chemistry coproducts such as gasification, pyrolysis, biorafining and so on, have been developed or marketed in Québec. The best-known example is Enerkem Inc.'s gasification-based cellulosic ethanol production process. The company now has plants in Québec and in Alberta.

According to bioenergy experts and companies, the most profitable activities in these fields involve the development of technologies to improve processing yields and reduce costs.

With regard to the development of technologies to produce energy from biomass, recent progress has been made in methanization, pyrolysis and second-generation ethanol production using thermo-chemical gasification and pyrolysis or biological processes. In the medium term, these advances should lead to substantial improvements in performance and more flexible use of fuels derived from biomass.

In spite of this progress, however, further development of new bioenergy technologies will be required in the coming years, before they can be marketed, to ensure that the bioproducts can be manufactured at competitive prices without State subsidies.

The federal government also offers a number of programs to which companies and research centres from Québec should be encouraged to apply.

GASEOUS FUELS

Technologies have reached maturity but are still not well-known in Québec, especially those relating to biomethanization. Work has taken place in recent years to perfect a process that operates at temperatures of around 10°C, which would be of interest for winter conditions.

LIQUID FUELS

First-generation biofuels (cereal ethanol and biodiesel (fatty acid methyl ester)) are usually produced from the starch in corn, wheat or vegetable oils derived from canola, soya or sunflower plants.

Second-generation biofuel production using lignocellulosic materials has an advantage over other biofuel production techniques in that it is applicable to vast quantities of renewable raw material resources that are not in competition with food resources.

Lignocellulosic crops are also preferable for development of the new generation of biofuels because they offer a better energy, water and carbon budget. Another benefit of the lignocellulosic approach is that it promotes the conversion of marginal land into plantations for energy and fibre production. In Québec alone, the biomass production potential of marginal lands is estimated at between 2 and 3 million anhydrous metric tonnes per year.

This offers Québec an excellent opportunity to:

- meet its bioenergy goals;
- develop wealth in the regions, based on the principles of sustainable development;

- develop a resource use model that complies with the principles of sustainable development and can be exported throughout the world;
- make profitable use of land that is not currently used because of its low yields for classic agriculture.

Québec is a pioneer province in the development of cellulosic ethanol.

- Technological development and innovation should focus mainly on second-generation biofuels (cellulosic ethanol and different types of biodiesel containing esters and ethers [such as dimethyl ether or DME]) derived from agricultural waste, urban waste, wood, fibrous biomass crops (willow, miscanthus) or lipid-producing microalgae and other microorganisms. The list of second-generation biofuels should also include new biofuels (levulinic acid esters, aromatic compounds, etc.) produced from non-food sugars and lignin. Chemical products can also be extracted from these raw materials.
- Third-generation biofuels could be considered in the longer term. They will be produced by synthesis via select or genetically modified organisms and catalytic conversions using CO₂ as input.
- The priority for technological innovation is to demonstrate the sector's technical and economic viability with a view to implementing demonstrator plants in five to ten years' time.

SOLID FUELS

The technology needed for heating and cogenerating with forest biomass (burners, boilers, heat exchangers, turbines, alternators) is fairly mature. On the other hand, the task of burning farm biomass in compliance with environmental standards is somewhat challenging.

New equipment must also be developed to harvest residual forest biomass and break down wood fibre. New technology is also required for torrefaction and pyrolysis of wood fibre, farm biomass and urban waste.

BOX 5

EXAMPLES OF FUTURE BIOENERGY SOLUTIONS

Forest waste, farm waste (straw) and biomass from energy plantations (e.g. willow and switchgrass) can be developed provided certain conditions are met:

- Technologies are developed to obtain intermediaries that can easily be processed organically or thermochemically, or by a combination of the two.
- Satellite plants are built in the regions to fracture the materials into intermediaries that can then be shipped to large-capacity finishing plants.
- CO₂, a by-product of all forms of organic or thermochemical biodevelopment, is used as a neutral carbon source able to be converted into additional biofuels or biocommodities.
- Hydro-electricity and electrotechnologies are included in development strategies, in collaboration with Hydro-Québec.

To interest investors in these solutions, pilot facilities able to operate for several hundred hours must be set up to help identify the technological and financial risks.

INITIATIVES TO PROMOTE BIOENERGY USE

According to the American Web-based journal *Biofuel Digest*, 13 American countries, 12 Asia-Pacific countries, 11 African countries, the European Union countries and two other European countries have all adopted regulations requiring the use of biofuels. World demand will be dominated by Europe, the United States, China and Brazil.³⁵

The European Union's goal is for 20% of its total energy consumption should come from renewable sources by 2020, including 10% in the transportation sector.³⁶ The current target is for all fossil fuels sold to contain 5.75% of biofuel. In 2013, it was proposed that the portion of biofuels used as raw materials in food resources should be limited to 6%.

European Union member countries also have their own "domestic" requirements for biofuel use. One country – Italy – is aiming to require the use of 0.6% of second-generation fuels by 2018.

Stimulated by these targets, the industrial pellet markets in the United Kingdom, Belgium, the Netherlands and Germany are currently undergoing strong growth.

In the United States, the Clean Power Plan (2014) is designed to reduce GHG in the electricity generating process. This could have repercussions for the bioenergy market. Already, most American states (30) have a regulated target for electricity generated from renewable resources (the Renewable Portfolio Standard) and seven others have voluntary targets. Wind energy, solar energy, geothermics, biomass, biogas and municipal waste are all qualified as renewable sources.

The United States has also adopted the Renewable Fuel Standard (RFS), which sets requirements for mixing of different types of biofuels in the country's transportation fuels. The ultimate goal of the RFS is for 36 billion gallons (136 billion litres) of biofuels to be used by 2022. Until then, if technology development matures, 16 billion litres should be available from cellulosic sources. Corn ethanol will be limited to 15 billion litres annually.

Eleven American states have chosen instead to adopt biofuel use requirements for their own territories,³⁷ and some have used the Low Carbon Fuel Standard (LCFS) mechanism.

In Canada, Environment Canada has introduced a regulation requiring importers and producers of automobile fuel to include 5% and 2% of renewable content respectively in gasoline and diesel fuel.

In recent years, all the provinces to the west of Québec, from Ontario to British Columbia, have adopted requirements for the use of renewable content in gasoline and diesel fuel sold within their territories.³⁸

³⁵ LANE, Jim (2013), *Biofuels Digest*, *Biofuels mandates around the world: 2014*. [Online] biofuelsdigest.com/bdigest/2013/12/31/biofuels-mandates-around-the-world-2014/ (Consulted on January 15, 2015).

³⁶ EUROPEAN COMMISSION, [Online] [Csis.org/](http://ec.europa.eu/energy/policy/bioenergy/) (Consulted on January 15, 2015).

³⁷ CENTER FOR CLIMATE AND ENERGY SOLUTIONS, *Biofuels: Incentives and Mandates*. [Online] <http://www.c2es.org/us-states-regions/policy-maps/biofuels> (Consulted on January 16, 2015).

³⁸ CANADIAN RENEWABLE FUELS ASSOCIATION (undated), *Evolution & Growth – From biofuels to bioeconomy*.

BOX 6

SCANDINAVIAN INITIATIVES

In Sweden, bioenergy accounts for nearly 30% of the energy portfolio, and 85% is derived from the forests. Since fossil fuels have virtually been eliminated from electricity and heat generating processes, transportation is Sweden's biggest challenge in terms of greenhouse gas reduction. In 2009, the country, with 9.5 million inhabitants, set itself the goal of ensuring that 10% of all energy used for transportation in 2020 would come from renewable sources. It achieved its goal in 2012. Sweden aims to have a vehicle fleet that is completely independent of fossil fuels by 2030, and to be a carbon neutral country by 2050. Biogas accounts for a significant percentage of the renewable energies used for transportation in recent years.

The government has taken several steps to support bioenergy supply and demand:

- Renewable fuels are exempt from tax, and the renewable fuel mixture requirements have been compulsory since 2014.
- Service stations selling more than 1 million litres must offer replacement fuels.
- The most important signal sent by Sweden is undoubtedly its Carbon Tax, which has been applicable since 1991. In 2012, it was 118 €/tonne!

The high cost and shortage of biofuel supplies is forcing Sweden to invest in research and development. Economic development is one of its strategic goals.

As for Norway, which has 5 million inhabitants, its aim is to reduce its greenhouse gas emissions by 30% from their 1990 levels by 2020, and to become carbon neutral by 2050, if its example is followed by other countries. Norway's energy profile is similar to that of Québec. Roughly 99% of its electricity is generated hydraulically, and this renewable energy is used massively in buildings. Fossil energy is prohibited in residential buildings. As is the case for Québec, transportation in Norway still uses mostly fossil fuels.

A transportation agency has been set up in Norway to reduce GHG emissions from the transportation sector. A 5% renewable content has been mandatory in all fuel since 2009, and may be increased to 10% in the future.

As is the case in Québec, biomass accounts for 10% of the country's total energy use. Norway is seeking to increase the portion of renewable energy in its total energy consumption to 67.5% by 2020 (up from 60% in 2005), despite the fact that it is the world's third-largest exporter of petroleum.

Norway also relies extensively on research and development to achieve its ambitious goals. Second-generation fuels and biogas from farms and the municipal sector may be good solutions.

Sources :

GOVERNMENT OF SWEDEN (2014), *Energy Use in Sweden*. [En ligne] [sweden.se/society/energy-use-in-sweden] (Consulted on January 30, 2015).

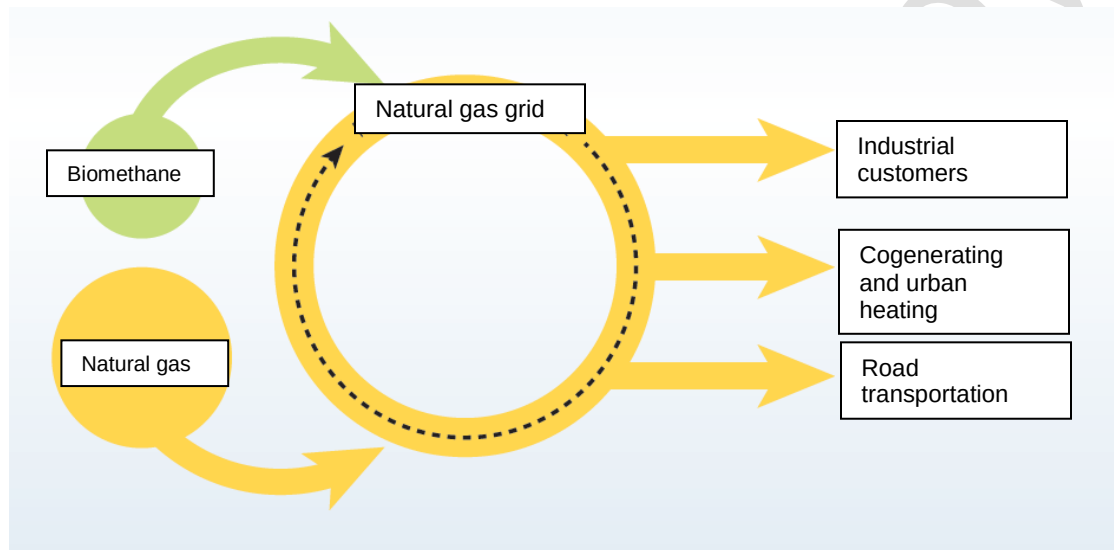
INTERNATIONAL ENERGY AGENCY (2013), *Energy Policy of IEA Countries – Sweden* - 2013 Review. 182 p.

INTERNATIONAL ENERGY AGENCY (2011), *Energy Policy of IEA Countries – Norway* - 2011 Review. 146 p.

BOX 7

THE EXAMPLE OF GÖTEBORG ENERGI IN SWEDEN

Göteborg Energi is a public municipal company in the energy field. Its project, GoBiGas, produces renewable natural gas on a commercial scale. Residual forest biomass is gasified and the syngas obtained as a result is methanized catalytically. The renewable natural gas is distributed via Sweden's natural gas distribution grid. In Phase 2, the factory will produce electricity and the residual heat will be used to fuel an urban heating network. Göteborg Energi aims to produce enough renewable gas to power 100,000 vehicles in 2020. The city has 50 of the country's 100 natural gas stations. The country as a whole has 40,000 gas-powered vehicles.



Source: GOBIGAS – GÖTEBORG ENERGI, Biogas production with good performance [Online] [gobigas.goteborgenergi.se/En/Biogas_through_gasification] (Consulted on January 15, 2015).

The MERN's Biomass Heating Support Program has supported roughly 40 biomass conversion projects in Bas-Saint-Laurent, Gaspésie-Îles-de-la-Madeleine and Saguenay-Lac-Saint-Jean, replacing approximately 2 million litres of fuel oil per year.

Until quite recently, projects to convert from fossil fuels to residual forest biomass could also obtain financial assistance under a MERN residual forest biomass energy conversion program.

CONTRIBUTION OF BIOENERGIES TO DEVELOPMENT

Bioenergy can generate significant economic impacts, first by reducing the energy costs of final users, and second because the harvesting, preparation and conversion of biomass into bioenergy create value-added jobs in engineering, agronomics and construction. Specialists will also be required to operate the plants in the future.

Table 2.7

Main impacts from bioenergy in Québec

Sectors	Jobs	Other Impacts
Biodiesel	70	Conversion of non-recyclable waste
Corn ethanol	60	Market for grain corn
Cellulosic ethanol	200	\$40 million in equipment sold for the Edmonton plant
Pellets	270	10 plants Revenues of \$45 million in 2012 including \$20 million from exports
Cogeneration from biomass	200	10 plants situated in Québec's regions

Sources: Ministère de l'Énergie et des Ressources naturelles and Ministère des Forêts, de la Faune et des Parcs.

The ten wood pellet plants currently active in Québec are located in different regions and provide roughly 270 direct jobs. In 2012, shipments were valued at \$45 million, including roughly \$20 million from exports (99,000 mt).

A number of Québec firms and researchers in CEGEPs and universities are working to develop new bioenergy production processes, creating hundreds of high-calibre jobs.

Raw materials traditionally regarded as waste either become valuable or no longer cost money to eliminate. Raw materials formerly destined solely for export can find more lucrative local markets.

Domestic production and use of bioenergy helps reduce the constantly increasing imports of fossil energies and creates jobs locally in biomass harvesting and production.

One day, biorefining will be used to extract high added-value products and hence make bioenergy production activities more profitable.

Socially, the third pillar of sustainable development, a bioenergy value chain would help maintain regional economies, which are so important for territorial occupation.

SECTION 3

ISSUES AND QUESTIONS

A fraction of Québec's GHG emission reduction target can be achieved by using biofuels to produce heat and electricity, and for transportation. However, these choices raise some economic questions because, for the time being, the cost of bioenergy is higher than the cost of the fossil energies it will replace.

Québec has extensive biomass resources that could be converted into a variety of energy products. However, raw material supply costs (harvesting, transportation) constitute a major obstacle for the industry. The supply chain is one of the principal issues for the development of the bioeconomy.

GENERAL QUESTIONS

- What consequences might the massive use of farm biomass to produce gas, liquid and solid biofuels have for regional economies and Québec's farming sector?
- What advantages does Québec have for successful development of a major bioenergy industry? What obstacles would it have to overcome?
- What role could energy crops play in supplying the bioenergy sector with biomass?
- What impact could tighter public finances and falling oil prices have on policies to promote renewable energies?
- What changes should be made to legislation and regulations to promote the development of bioenergies in Québec?

BIOMETHANE

ISSUES

- Because of regulatory requirements aimed at reducing GHG emissions in the United States, the American market is currently good for biomethane, and some of Québec's production is exported there.
- The production cost of biomethane, including purification to bring it into line with the natural gas grid's quality requirements, means that profitability for renewable natural gas production projects is by no means certain. Current low energy costs, combined with electricity surpluses, are additional obstacles.
- The natural gas distributors are regulated by the Act respecting the Régie de l'Énergie. They cannot buy supplies at just any price, which limits their ability to market biomethane produced in Québec.
- Municipal waste is extremely varied in nature and less suited to methanization than the farm waste and sludge used elsewhere in the world to produce biomethane. In Québec, the Program to treat organic matter by biomethanization and composting limits the use of organic waste from the farm sector to 10%, and requires biomethane produced from municipal waste to replace fossil hydrocarbons.
- The biomethanization technologies used by Québec's municipalities to treat their waste are probably from abroad. Accordingly, it is extremely difficult for Québec firms to win a share of the technology market and maximize the spin-offs in Québec from the major investments required for large-scale biomethanization.

QUESTIONS

- What should the Government do to promote biomethane distribution by natural gas distributors and stimulate the renewable natural gas market among consumers wishing to act economically in a positive way for the fight against climate change?
- Is cogeneration of electricity and heat from biogas an economically viable option in Québec, as an eco-responsible way of managing gas emissions from waste burial sites?
- What impacts will the post-2020 ban on burial of biodegradable organic waste have for biogas production at landfill sites?
- What manure and liquid manure management practices should be encouraged to promote the development of biomethanization in Québec's regions?
- In the current North American context, what other avenues could be explored if the Program to treat organic materials through biomethanization and composting is found to be incompatible with the current state of Québec's public finances?

LIQUID BIOFUELS

ISSUES

- The international market for both biofuels and production technologies is extensive. In the United States alone, investments of more than \$600 billion could be needed in infrastructures to produce the 16 billion gallons of second-generation biofuels required by the Renewable Fuel Standard (RFS).
- In Canada, the fuel replacement market is supported by federal regulations requiring distributors to include the equivalent of 2% of renewable diesel and 5% of ethanol in fuels sold in Canada, but leaves distributors free to choose the regional markets on which they sell their products. The market is currently satisfied by biofuel imports valued at roughly \$350 million per year.
- The higher production cost of biodiesel is a serious handicap on the market. The recent decline in oil prices will not help this situation.
- The public authorities do not offer any measures to encourage consumers to choose biodiesel, which costs a few cents per litre more than its fossil equivalent for the same energy quality.
- The cloud point of biodiesel (the temperature at which solid particles appear in fuel) is higher than that of fossil diesel. This constitutes a major limitation on its marketability in winter.
- For the biofuel sector, regional viability depends on the organization and cost of salvaging raw materials in the field and transporting them to the biorefineries.
- Second-generation fuel production processes and technologies will soon reach the commercial demonstrator phase here and elsewhere in the world. Québec's industries must find opportunities to display their know-how commercially, in order to become world leaders.
- The Canadian government's biofuel production support program (EcoEnergie) will terminate on March 31, 2017.
- Although plants have been built with very few means, the limited financial capacity of some domestic producers affects the innovative ability of the FAME-type biodiesel fuel sector.
- The negative supply price for residual biomass (waste and sludge) provides interesting opportunities for profitability of investments aimed at producing biofuels and value-added coproducts, by helping them be financially competitive with fossil energies.
- Biofuels could become a good outlet for Québec's farmers and forest producers and provide them with additional revenue.

QUESTIONS

- What else is needed for Québec's biofuel producers to gain a significant share of the vehicle fuel market, even beyond the minimum requirements imposed by the federal government?
- What can be done to overcome the biodiesel (FAME) quality problems in winter? Are these problems technical or perceptual?
- Like other North American states that produce renewable fuels from oil crops, what impact would the use of farm biomass to produce biofuel have on Québec's farm sector?
- What can the Government do to help the forest and farming industries make the shift towards bioenergy and biofining to extract high value-added products?
- What must be done to reduce the biorefineries' biomass supply costs and make biofuels and bioproducts more competitive, especially now, when oil prices are so low?
- What are the main innovation needs of Québec's biofuel sector?

SOLID BIOFUELS

ISSUES

- The growth prospects for pellets on the residential and industrial markets are modest, due to the structural (low electricity and natural gas costs) and cyclical (falling oil prices) energy context.
- Potential exists for replacing oil-based fuels (fuel oil, diesel fuel) with solid biofuels. However, long-term supply stability (availability and price) and competition from natural gas are major obstacles to the adoption of solid biofuels by customers.
- The production cost and amortization period for the investments needed to convert oil heating systems to solid biofuels have a major impact on the sector's development.
- International markets are expanding rapidly and provide a strategic opportunity for Québec's biomass. On the other hand, Québec's plants are operating at only 50% of their installed capacity, due to the shortage of accessible, reasonably-priced raw materials.
- The energy density of forest biomass is much lower than that of fossil fuels, and the distance over which the raw material must be transported to reach the market is a significant obstacle to the development of the biomass pellet sector.

QUESTIONS

- What steps could the Government suggest to stimulate the domestic forest-sourced energy product market in general, and the institutional market in particular?
- Should Québec follow Ontario's example by providing more funding for forest roads and reducing the amount of forest dues payable by companies using wood fibre to produce solid biofuels?
- What can the forest-sourced biofuel industry do to reduce its dependency on primary wood processing companies for their raw material supplies?
- Given the challenges of accessing good quality, reasonably price raw materials in a context where fossil energy prices are low, is solid fuel production viable without the existence of biorefineries extracting high value-added products to ensure their profitability?
- What can be done to minimize transportation costs for raw materials and finished products, so as to make it more profitable to produce pellets from non-traditional sources such as roundwood and forest biomass? Are existing transportation and transshipment facilities adequate?
- What can be done to improve residual forest biomass harvesting systems to minimize supply costs for all wood fibre purchasers?
- Given the production costs, current markets and demand, is it economically justifiable to produce new-generation solid biofuels (biochar, torrefied pellets)?

CONCLUSION

In a context where Québec is seeking to reduce its GHG emissions, encourage the creation of quality jobs and occupy its immense territory, many solutions are available in the bioenergy sector.

Québec has plentiful resources that can be used to produce cleaner energy. It also has high-quality actors that are working to develop and implement the technologies needed to convert these resources.

The potential markets for these new energy sources are vast, and are not limited to Québec. Québec's resources, technologies and expertise can be exported, and will generate substantial economic spin-offs in many regions.

While renewable resources are already used and create economic activity, there are still obstacles along the road to optimal use of all our biomass resources, beginning with the relatively low cost of traditional energies compared to the impacts they have on the environment. Technological progress is still needed before certain resources can be converted. Markets may sometimes be timid and even unsympathetic to the adoption of new solutions.

The financial capacity of governments everywhere is increasingly limited, and new approaches are therefore needed to overcome these obstacles. What path should the renewable energy producers take to ensure that their products occupy a more important place in Québec's energy portfolio and facilitate sustainable development, both here and elsewhere?

APPENDIX 1 – CONVERSION TABLES AND MEASUREMENT UNITS

Energy equivalent to one ton oil equivalent (TOE)	
Gigajoule (GJ)	41.85
Kilowatt-hour (kWh)	11 630

GHG emissions equivalent to those from one TOE (tonne of CO ₂ equivalent/TOE)	
Natural gas	2.10
Propane	2.53
Gasoline	2.86
Light fuel oil	2.95
Diesel	3.02
Petroleum	3.10
Heavy fuel oil	3.10

Volume equivalent to one ton of oil equivalent (TOE)	
Petroleum	1.1161 m ³ 7.3 barrels
Natural gas	1 100 m ³
Gasoline	1.20 m ³
Diesel	1.09 m ³
Light fuel oil	1.09 m ³
Heavy fuel oil	1,03 m ³
Propane	1.66 m ³

Prefixes of decimal multiples		
Peta (P)	10 ¹⁵	Quadrillion
Tera (T)	10 ¹²	Trillion
Giga (G)	10 ⁹	Billion
Mega (M)	10 ⁶	Million
Kilo (k)	10 ³	Thousand

Measurement Units	
GJ	Gigajoule
GWh	Gigawatt-hour
KTOE	Kilotonne of oil equivalent
Km	Kilometre
kWh	Kilowatt-hour
CO ₂ eq. kt	Kilotonne of CO ₂ equivalent
l	Litre
m ²	Square metre
ML	Million litres
Mm ³	Million cubic metres
MTOE	Million tonnes of oil equivalent
CO ₂ eq. mt.	Million tonnes of CO ₂ equivalent
Mmt	Million metric tonnes
Mamt	Million anhydrous metric tonnes
PJ	Petajoule
t	Tonne
TOE	Tonne of oil equivalent
t CO ₂ eq.	Tonne of CO ₂ equivalent
amt	Anhydrous metric tonne
tWh	Terawatt-hour

APPENDIX 2 – ELECTRICITY REGULATIONS IN CANADA

	Québec	Newfoundland and Labrador	Prince Edward Island	Nova Scotia	New Brunswick
Regulatory approach – Tariffs – Supply component	Price set by law for heritage pool electricity and prices set by calls for bids and purchase programs for post-heritage electricity	Base price ¹ set by a provincial board	Base price set by a provincial board	Base price set by a provincial board	Base price set by a provincial board
Regulatory approach – Tariffs – Transportation component	Base price set by the provincial board	Base price set by the board	Base price set by the board	Base price set by the board	Base price set by the board
Regulatory approach – Tariffs – Distribution component	Base price set by the board	Base price set by the board	Base price set by the board	Base price set by the board	Base price set by the board
Opening of retail market	No, possibility of a pilot project	No	No	Opening limited to renewable energy	No, except for large consumers
Opening of wholesale market	Yes, 9 municipal grids and 1 coop	No	Yes, 1 municipal grid	Yes, 6 municipal grids	No
Main entities involved in supplies	Hydro-Québec Production (PC)	Newfoundland & Labrador Hydro (PC)	PEI Energy Corp (PC) and Purchases (New Brunswick Power)	Nova Scotia Power (PCo)	New Brunswick Power (PC)
Main entities involved in transportation	Hydro-Québec TransÉnergie (PC)	Newfoundland & Labrador Hydro (PC)	Maritime Electric (PCo)	Nova Scotia Power (PCo)	New Brunswick Power (PC)
Main entities involved in distribution	Hydro-Québec Distribution (PC), 9 municipal grids and 1 coop.	Newfoundland Power (PCo) and Newfoundland & Labrador Hydro (PC)	Maritime Electric (PCo), Summerside Electric Utility (MC)	Nova Scotia Power (PCo), 6 municipal grids	New Brunswick Power (PC), 3 municipal grids

PC = Public corporation; PCo = Private company; MC = Municipal corporation

Source: MERN compilation.

¹ This refers tariffs based on cost plus rate of return or base price.

	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia
Regulatory approach — Tariffs — Supply component	Base price set by a provincial board for heritage pool electricity, daily competitive price for post-heritage electricity	Base price set by a provincial board	Recommendation by a review panel (base price), government decision	Daily competitive price	Indexed price, established once (base price) by a provincial board for heritage pool electricity and competitive price for post-heritage electricity
Regulatory approach — Tariffs — Transportation component	Base price set by the board	Base price set by the board	Recommendation by a review panel (base price), government decision	Base price set by the provincial board	Base price set by the board
Regulatory approach — Tariffs — Distribution component	Incentive regulation by the board	Base price set by the board	Recommendation by a review panel (base price), government decision	Base price set by the board	Base price set by the board
Opening of retail market	Yes	No	No	Yes	No, except for large consumers
Opening of wholesale market	Yes, less than 100 municipal or private grids	Yes, but only Manitoba Hydro	Yes, 2 municipal grids	Yes, several municipal, private and rural coop grids	Yes, 11 municipal and private grids
Main entities involved in supplies	Ontario Power Generation (PC), Bruce Power (PCo)	Manitoba Hydro (PC)	SaskPower (PC)	ATCO Electric (PCo), TransAlta Corp. (PCo), Capital Power (PCo), TransCanada Energy (PCo)	BC Hydro (PC)
Main entities involved in transportation	Hydro One (PC)	Manitoba Hydro (PC)	SaskPower (PC)	Altalink (PCo), ATCO Electric (PCo)	BC Hydro (PC)
Main entities involved in distribution	Hydro-One (PC) and less than 100 municipal or private grids	Manitoba Hydro (PC)	SaskPower (PC), Saskatoon Light & Power (MC) et City of Swift Current Light & Power (MC)	Enmax (MC), EPCOR (MC), ATCO Electric (PCo), Fortis Alberta (PCo), City of Red Deer Electric Light & Power (MC), City of Medicine Hat Electric (MC) and several rural coops	BC Hydro (PC), Fortis BC (PCo), 4 other private services, 6 municipal grids



Québec 