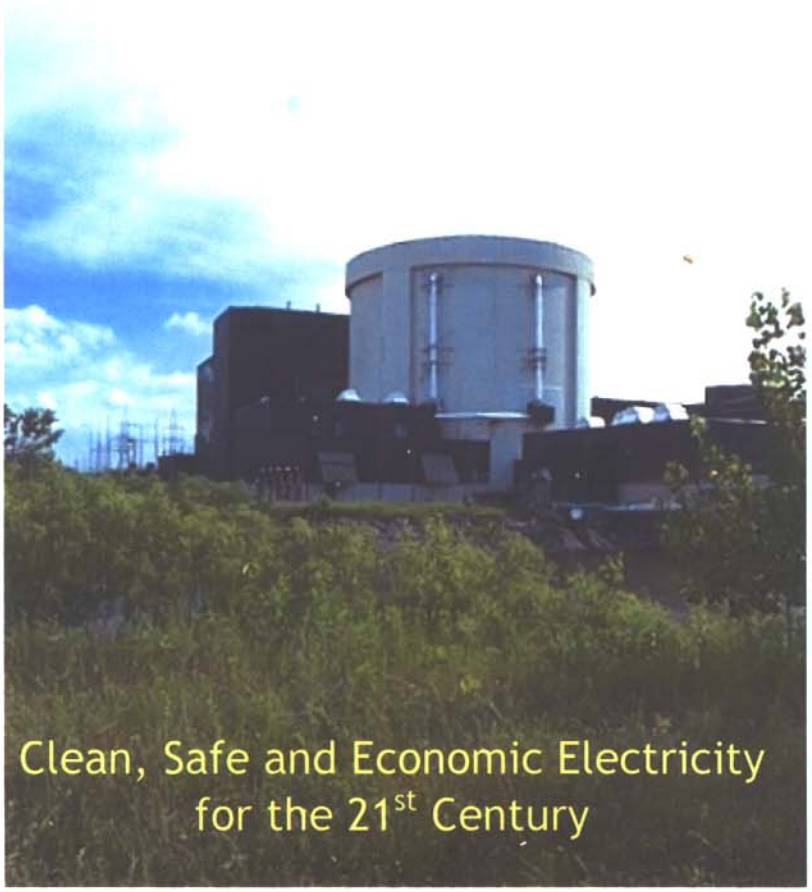
The Atomic Energy of Canada Limited's Submission to the bureau d'audiences publiques sur l'environnement in Support of Gentilly–2 Refurbishment Project



EACL
Énergie atomique
du Canada limitée

1. INTRODUCTION

Hydro-Québec produces clean, renewable and safe energy through its generation of electricity from hydro and nuclear power sources. In keeping with its strategic plan, the company intends to continue developing Québec's hydroelectric potential and consider refurbishing the powerhouse at the province's only nuclear power generation station, Gentilly-2.

The Gentilly-2 CANDU 6® pressurized heavy water reactor is owned and operated by Hydro-Québec and designed by Atomic Energy of Canada Limited (AECL), with a gross output of 675 MWe. Gentilly-2 was one of the first 700 MWe class CANDU 6 plants to be built worldwide. Gentilly-2 started commercial operation in 1983. Nuclear energy generated by Gentilly-2 provides approximately 3% of Québec's base-load, continuous and stable supply of electricity. The plant has a key role in the generating fleet, mainly because of its excellent performance, profitability and contribution to system stability and reliability. Gentilly-2 is also an important engine of the regional economy.

In addition to having one of the first CANDU 6 nuclear power plants, Hydro-Québec was the first utility to adopt AECL's MACSTOR® technology for its Gentilly-2 station. MACSTOR (Modular Air-Cooled STORage) provides above ground dry storage for spent nuclear fuel produced from Gentilly-2 reactor. Hydro-Québec 's first MACSTOR was installed in 1995. There are now five units installed and two additional under construction at the same site.

The Gentilly-2 refurbishment project would include modifying the radioactive waste storage facilities and overhauling the nuclear plant systems. Preliminary studies indicate that refurbishment of Gentilly-2 to extend its operation until 2035 is the most economical and best solution for Québec to continue having a diverse and base-load electricity supply.

As the designer of Gentilly-2 nuclear power plant and MACSTOR waste storage system and also a major participant in this refurbishment project, this submission by Atomic Energy of Canada Limited (AECL) provides support to the public hearings by the Bureau d'audiences publiques sur l'environnement (BAPE).

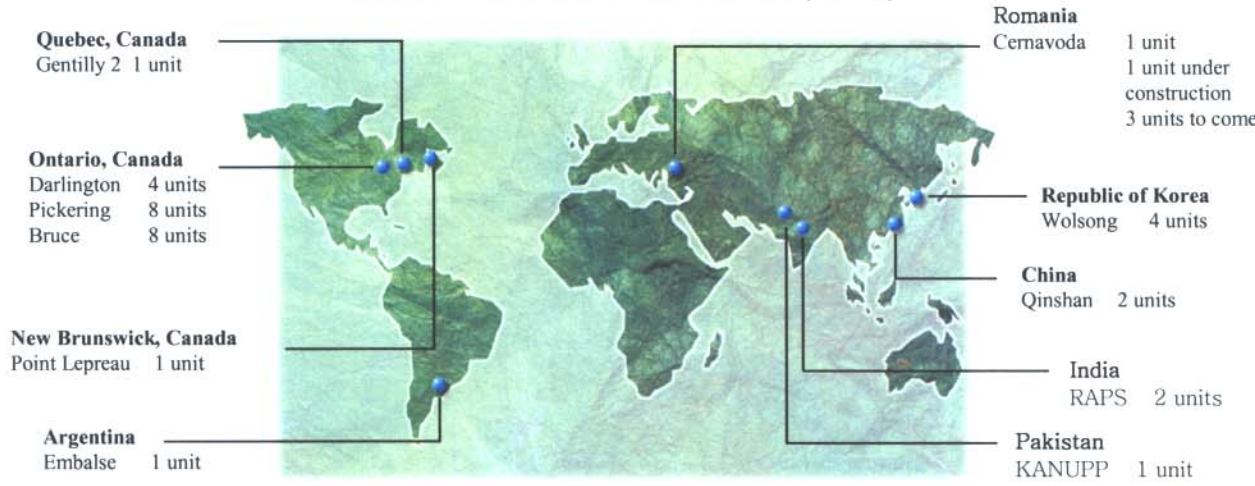
AECL strongly believes that its technologies and experiences offer a competitive, economic, safe, environmentally-friendly and diverse provision of electricity and safe and stable waste storage facility, which can continue to meet Québec's future energy requirements and commitments in the post-Kyoto world.

AECL: A Government-Owned Company

AECL is a global nuclear technology company that designs, develops, markets and services CANDU nuclear power reactors. AECL was established in 1952 and employs approximately 3600 staff around the world. It is headquartered in Mississauga, Ontario and has offices around the world, including a regional office in Montreal, Québec.

The scope of AECL's nuclear technology includes design, engineering, construction, project management, outage management and life extension management, to decommissioning and nuclear waste storage management. CANDU nuclear reactors are AECL' flagship product and a recognized international success, having provided about 40 years of safe, economical and reliable electricity production. There are 33 CANDU reactors around the world, including Gentilly-2 in Québec, and one more unit is under construction in Romania. Ten utilities operate CANDU units across the world safely and economically.

CANDU Reactors Worldwide (2004)



AECL's Proven Experience in Nuclear Technology and Project Management

AECL has recent new-build and life extension experience. Since 1990, AECL has developed and overseen major reactor building and refurbishment projects in Romania, South Korea and China. These projects have demonstrated AECL's ability to manage a broad range of implementation models in a variety of cultures and climates.

AECL is proud of its record of delivering the completed projects on schedule and on budget, or better. AECL can help with assessments, strategies and execution of the Gentilly-2 refurbishment project, which in turns, helps Hydro-Québec to enhance its management of Gentilly-2 efficiently, economically and most importantly, safely.

AECL's Building Records

In-Service Date	Plant	Status
1996	Cernavoda Unit 1, Romania	On budget, on schedule
1997, 1998 and 1999	Wolsong Units 2, 3 and 4, S. Korea	On budget, on schedule
2002 and 2003	Qinshan Phase III, Units 1 and 2, China	Under budget, and 4 months ahead of schedule
2007	Cernavoda, Unit 2, Romania	70% completed, on budget, on time

AECL's Experience in Waste Management

AECL and CANDU utilities around the world have extensive experience in managing used nuclear fuel. Safe and cost-effective interim storage for spent fuel has been developed and implemented successfully throughout the world. The current methods for managing used fuel are initial cooling in wet storage bays at the nuclear power stations for up to 10 years and then transferring to above ground dry storage facilities such as the MACSTOR units at Gentilly-2 for a minimum of 50 years.

In 1977, an expert group was established by the federal government to carry out a study on the safe and permanent storage of radioactive waste from nuclear power stations. This led to AECL undertaking the research on nuclear waste disposal in deep underground repository and that it would be a safe, secure and desirable method. After extensive research and international collaborations for over 20 years, the concept of safely dispose of waste in a deep geological facility has been accepted and well understood with advances made toward implementing disposal in the US, Finland, Canada and Sweden.

Since 1998, the Nuclear Waste Management Organization (NWMO) – a federal organization independent from the nuclear industry, has been reviewing AECL's concept of deep geological disposal and will make recommendations on the long-term management of nuclear fuel waste in Canada by November 2005.

Expanding the waste facility at the Gentilly-2 site can be planned and achieved successfully by taking full advantage of AECL and Hydro- Québec's extensive experiences gained from their waste management development programs and projects.

2. NUCLEAR POWER: PROVIDING AN ENVIRONMENTALLY-FRIENDLY SOLUTION

The environmental impact of greenhouse-gas (GHG) emissions has become a major concern for policy-makers and societies all over the world. Central to this debate is the role of energy production in producing GHG emissions. A major challenge for the world today is finding the balance between meeting the demand for electricity and mitigating the environmental impacts of meeting that demand.

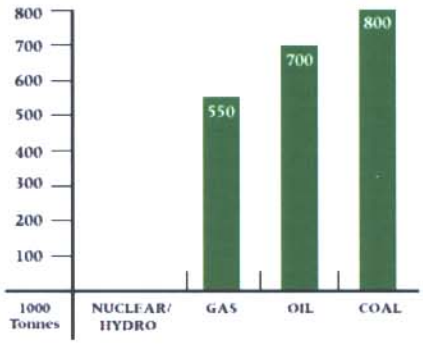
The impacts of the Earth's climate change vary from one place to another. However, it is accepted that climate change will affect ecosystems, water regimes, human health and safety, human and industrial activities, etc. as well as impacts on the general economy. Québec is not immune against such impacts and has recognized that crucial actions must be planned and implemented to stabilize and reduce its GHG levels.

Since 1992, Québec has made the commitment to counter the climate change phenomenon to implement its policies and strategies to meet the objectives of stabilizing and reducing GHG emissions. It has adopted the Canada's Kyoto GHG-reduction objectives and set its own climate change undertakings and commitments.

Québec has been and still remains the province producing the least GHG emission per capita, in Canada. This has been mainly attributed to electricity being the leading form of energy used in Québec and that more than 95% of electricity generation comes from low-carbon sources such as hydro, winds and nuclear.

Nuclear power plants emit no CO_2 or other noxious gases. By using nuclear energy, Canada has avoided emitting about 12% of Canada's total GHG emission and an additional 10% of smog and acid rain producing gases. In addition, if nuclear power plants were replaced by modern fossil-fuelled power plants, CO_2 emissions from energy sector would rise from its current levels.

Tonnes of CO_2 produced per unit of electricity per TWh (terawatt hour = million megawatt hours)



Source: Atomic Energy of Canada Limited (AECL), World Nuclear Association (WNA), National Energy Institute (NEI).

In addition to nuclear energy being the large-scale energy source capable to providing environmentally clean base-load electricity, nuclear can supply the world's energy needs for thousands of years and generates only a small volume of waste. This small volume of used fuel produced by Canadian nuclear power plants to generate huge amounts of electricity is controlled and stored in carefully managed facilities in ways that protect human health and the environment – now and in the future.

About 85,000 fuel bundles are generated each year in Canada. By December 2001, nuclear reactors in Canada have produced almost 1.6 million used fuel bundles. Tightly stacked, this small volume of waste would fill a soccer field to a height of 1.3 metres.

3. NUCLEAR ENERGY – PROVEN, RELIABLE AND RENEWED

Contrary to misperceptions, nuclear power is still growing worldwide with new plants, which are on order or under construction. Today, one of the keys to advancing civilization and protecting the health of our planet and our people is nuclear energy. It is a reliable technology that offers stable electricity and provides 16% of the world's demand, outranking all other sources as a clean, efficient, economic and large-scale primary source.

More particularly, the CANDU nuclear power plants were originally designed and built in the 1960s and 1970s as part of the solution to meet growing electricity demands in Ontario. Over the years, the continually improving CANDU nuclear power plant has earned an international reputation for its exceptional safety, performance and economic features.

Today, a total of 34 CANDU nuclear power plants are either in operation, under construction or undergoing life extension worldwide. The safety records and performance levels of the CANDU fleet have made it a reliable source of energy for decades.

World's Perspective on Nuclear Power

World-wide nuclear	440 reactors in operation in 31 countries 16% of the world's electricity demand; 13% of Canada's, 3% of Québec 365 GWe installed capacity (about 85% located in OECD countries)
Generation in 2003	Generation of 2,525 TWh
Reactors committed (planned with funding in place, ground work may have commenced)	34 reactors, about 36 GWe
Reactors under construction	25 reactors under construction amounting to about 25 GWe

Source: Uranium Information Centre, March 2004

CANDU 6: A Proven and Reliable Technology

The CANDU 6 is AECL's 700 MWe class nuclear power reactor. Designed in the 1970s, Gentilly-2 was one of the world's first CANDU 6 unit to be built and went into service in 1983. Over the last two decades, AECL has continued to build CANDU 6 plants around the world and has continuously made improvements to the design.

CANDU operating performance has been world-class with average lifetime capacity factor of 88%. Three top-ten cumulative lifetime performance

CANDU 6 Lifetime Capacity Factor

Unit	In-Service Date	Lifetime Capacity Factor
Pt. Lepreau	1 February 1983	83%
Gentilly 2	1 October 1983	79%
Wolsong 1	22 April 1983	86%
Embalse	20 January 1984	85%
Cernavoda 1	2 December 1996	87%
Wolsong 2	1 July 1997	93%
Wolsong 3	1 July 1998	94%
Wolsong 4	1 October 1999	97%
Qinshan 1	31 December 2002	93%
Qinshan 2	20 July 2003	86%
CANDU 6 Average		**88%**

Source: COG Q1 March 2004

At the end of 2003, there were three CANDU 6 plants ranked second, third and sixth in the world with their lifetime capacity factor being over 90% (see World's Top-Ten Lifetime Capacity Factor). In the same reporting period, capacity factor for the top-performing CANDU 6 for the year 2003 was by Wolsong 4 at 98.2%. In 21 years, Gentilly-2 has maintained a capacity factor that compares favourably with that of other nuclear plants in the world.

Given the strong growth in nuclear power worldwide, there is still the perceived issue of waste disposal. Long-term nuclear waste disposal technologies have been fully developed, with current advances towards implementation in the US, Finland, Sweden and Canada. Meanwhile, interim storage technology is mature, proven and available. Modern storage technology such as the AECL's proprietary MACSTOR system at Gentilly-2 is fully capable of addressing storage needs safely and economically for many decades to come. Hydro-Québec plans to refurbish the nuclear power plant at Gentilly-2 to extend its operation until 2035 as well as to modify the on-site existing radioactive waste storage facilities to house future waste.

In over 40 years of utilizing nuclear technology in Canada, no member of the public has been harmed as a result of a radiation exposure from a nuclear power plant or waste storage facility.

Resurgence Interests in Nuclear Power

In recent years, there has been a renewed interest in nuclear power, more specifically in nuclear power as an environmentally-friendly power generation. This has brought forth a sense of revival in the nuclear industry worldwide. New plants have continued being planned and built in Asia and Europe and refurbishment projects have emerged in the US and Canada. There have

been considerable advances in new nuclear reactor technologies and life extension of existing nuclear plants and Atomic Energy of Canada Limited (AECL) is at the forefront of these new developments.

Although nuclear power industry around the world has been striving, the industry in North America has existed under intense public opposition in the last two decades – resulting in a halt in the expansion of the industry. There has not been a new nuclear plant ordered or built in Canada or the US in more than 20 years. It has been widely assumed that the existing nuclear power plants would operate until the end of their initial life expectancy and then be shut down.

However, utilities in North America have planned and executed successful life extension programs for their existing plants in recent years. In addition, there is now a positive enthusiasm in deploying new nuclear power capacity in North America. The environment for nuclear capacity continues to improve. Governments are recognizing the benefits of nuclear power and are supporting refurbishing projects, as well as new build capacity as a part of the energy mix. This is based mainly on continued growth in electrical demand, excellent performance by the existing nuclear fleet, a new focus on reliability, security and diversity of supply and a clear recognition of the environmental benefits of nuclear power.

In addition, the North American power blackout on 14 August 2003 served as a catalyst to push the debate on energy and nuclear power to the forefront. The blackout was the largest power outage in the history of North America, affecting an area with close to 62 GWe and an estimated 50 million people in much of the Midwest and Northeast United States and Ontario, Canada.

It is now a commonly held belief that maintaining existing generation and building new generation will be required and that security of supply will be a critical issue. As a result, governments continue to move forward with policies (with considerations paid to public opinions) supporting and guiding nuclear programs.

CANDU utilities in Ontario, New Brunswick and Québec are either considering, planning or undertaking reactor life extension for two units at the Bruce A generating site, 3 units at Pickering A, Point Lepreau and Gentilly-2.

Increasing Positive Public Awareness and Acceptance of Nuclear Power

Public opinions have not always been traditionally supportive of nuclear power due to various reasons. However, the recent survey – by Ipsos-Reid for the Canadian Nuclear Association in 2004, indicted that public awareness and acceptance of nuclear power in Canada is now more favourable.

There is a broad sense from those surveyed that nuclear power would continue to be a part of Canada's future energy mix in light of the growth in demand over the next 25 years. In addition, respondents nationwide supported upgrading and refurbishing existing nuclear power plants (57%), while a smaller portion of those surveyed supported building new nuclear plants (37%).

4. COMMERCIAL ASPECTS IN REFURBISHING GENTILLY-2 NUCLEAR GENERATION STATION

Overall Reasons for Refurbishing Gentilly-2 Plant

Gentilly-2 is the only nuclear power plant in the province and is a base-load plant that provides a continuous, stable supply of electricity all year long. The plant is located near the large load centres in the St. Lawrence Valley and makes a substantial contribution to the stability and reliability of Hydro-Québec's transmission system. Gentilly-2 supplies 3% of the electricity generated by Hydro-Québec.

The refurbishment project will enable Québec to maintain a high degree of nuclear expertise that is well recognized in the world and applied everyday by almost 700 staff at the plants.

Studies have indicated that it makes sense to optimize the existing facilities before building new ones, especially when the cost is lower and the environmental impacts are mitigated.

Confidence in a Successful Refurbishing Project

The refurbishment of a nuclear generation station is a significant project in any utilities capital program. Before such an important project is authorized, it is essential that a reasonable level of confidence be established to ensure delivery on time and budget.

Hydro-Québec and AECL have put considerable efforts, through the pre-project phase, for developing a thorough assessment of the station condition as well of its main components. In addition, a great attention was paid to establish a pre-approved licensing basis. These efforts lead to clearly define the scope for refurbishing the station with its associated costs and schedule.

AECL in its role as *design agency* will ensure that all engineering (design, procurement and field) activities undertaken by the Gentilly-2 project are carried out in a manner that produces the required design outputs in accordance with defined regulations, standards, manuals, and applicable procedural documents. As design agency AECL will also ensure the implementation of the AECL quality assurance program, approved by Hydro-Quebec, for all engineering activities.

AECL is an ISO 9001 qualified company and utilizes is well-tested project management and engineering change control processes for the project. Recent success of Qinshan project in China was based on the same work and QA processes. Work process management approach used in PARS was based on outage practices while AECL will use practices better suited for large scope projects such as Gentilly-2 refurbishment.

A major task of the Gentilly-2 project is the replacement of 380 of each of the feeders (on each side of the reactor), fuel channels, and calandria tubes. These activities are repetitive and require efficient work processes. Extensive computer simulations and full-scale mock-ups are already prepared by AECL. These will be useful to train the personnel and maximize the efficiency of

the work in these areas. As another example, special tools are developed for the breaking and compacting of the removed fuel channels at the face of the reactor, which eliminates the need for time consuming manoeuvring and handling of these large active components.

A similar level of preparedness has been put in the preparation of other important tasks, which should contribute to risk reduction during the project execution.

AECL has demonstrated its capabilities in managing large projects by successful completion of six CANDU 6 units in Romania, Korea, and China over the past 10 years. The two-unit project in China was completed in 2003, on budget and four months ahead of schedule.

On a separate note, AECL is preparing a cluster of engineering companies as well as its technology partner companies such as SNC, NNC, Hitachi, and B&W to assist in the delivery of product and services to Gentilly-2 and other refurbishment projects. An initiative, with the involvement of CANDU Owners Group, is also addressing the issue of availability of resources for the refurbishment projects in Canada and abroad.

AECL is confident that the level of preparedness for this project by Hydro-Quebec and its partners provides a good basis to ensure a commercial success for the refurbishment of Gentilly-2.

5. ECO-SOCIAL IMPACTS OF GENTILLY-2 NUCLEAR GENERATION STATION

Gentilly-2 is a 680-MW class CANDU 6 reactor and the one of the first CANDU 6 nuclear reactor built and licensed for operation in the world. The station has been operating since 1983 and is part of the base load generation capacity. Since its start-up, Gentilly-2 has been a source of clean and economic electricity for over 20 years.

Province of Quebec has a good record of low carbon emitting generation mix and Gentilly-2 has been a contributor.

Nuclear power remains a major electricity generation option many in jurisdictions around the world including Ontario. Gentilly-2 has introduced nuclear technology in the province and its refurbishment and continued operation will keep this important strategic option open to the province.

Nuclear Generation Cost

Fuel generation cost is lower and is much less volatile compared to those such as oil or natural gas. Gentilly-2 is fuelled by natural uranium, which is housed in CANDU fuel bundles. Each fuel bundle costs between $2000 to 3000 and, unlike fossil fuels, has not increased significantly in cost since the start-up of Gentilly-2. The energy content of a single fuel bundle can produce enough electricity for the average home for 100 years. An equivalent to roughly 1000 tons of coal or 1500 barrels of oil would be needed to produce the same amount of energy.

Uranium is from Canada - one of the world's largest producers. It is plentiful and provides diverse and secure fuel source whose market price fluctuations have little effect on nuclear plant economics unlike fossil fuel prices that significantly impact fossil generation costs.

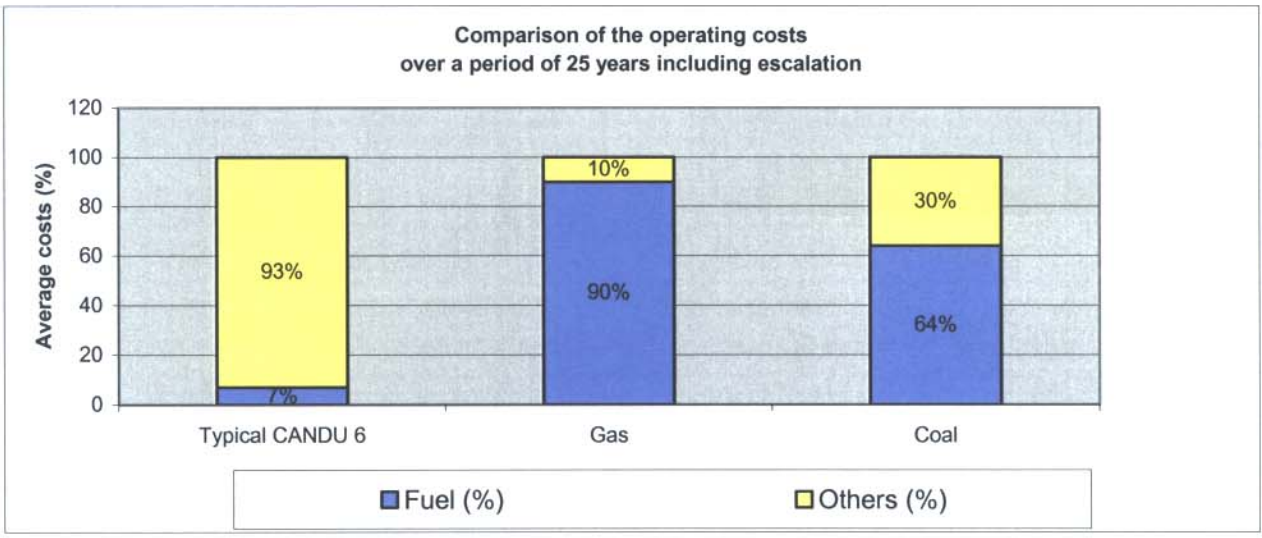
Province of Quebec has an electricity intensive industrial production structure. Thus, maintaining various options for a secure and competitive supply of electricity is of special importance to the economic well-being of the province.

Income for the Region

Gentilly-2 employs directly about 600 to 700 highly skilled staff resulting in up to $70 million (in today's dollar) annually in direct income stream in the region from the operation of the plant. The income multiplier effect could result in about 1500 direct, indirect and induced jobs for the region.

During the 25 years of extended life approximately $140M (in today's dollar) will be spent yearly on the operation and maintenance of the G2 station. Over 90% of this expenditure is for services, which can be sourced in the province of Quebec and less than 10% for purchase of fuel from out of province. On the other hand, a similar capacity natural gas plant will spend close to $200M (in today's dollar) each year during 25 years of operation and maintenance. Of this

amount more than 85% will be spent on out of province fuel purchases. This is more demonstration of the economic benefits of the refurbishment to the province of Quebec.



6. CONCLUSION

Nuclear energy is a proven and reliable source of energy. Gentilly-2 performance compares well with other utilities producing power from this source of energy. Public acceptance of nuclear as a source of energy has increased in the recent past. It is seen as a more environmentally-friendly solution than alternate fossil sources of energy

Recent experiences demonstrated that nuclear stations can be built on time and budget. Refurbishment of Gentilly-2 where the scope is well defined and planned can also be delivered on time and budget. Such a project is in line with the trend seen in the world and more particularly in Canada and USA. It makes economic sense to maintain these stations. It provides power to Hydro-Quebec's customers at a very competitive price.

The operations of Gentilly-2 over the last 21 years have been a source of economic wealth in the region of Trois-Rivières and will continue to do so as most of the operating costs are redistributed amongst the local workers and industries supporting the station.

AECL supports the refurbishment project as proposed by Hydro-Quebec

References

- Québec Action Plan on Climate Change 2002-2002, Ministère de l'Environnement du Québec, Nov. 2004, http://www.menv.gouv.qc.ca/changements/plan_action/index-en.htm.
- Inventory of Greenhouse Gases in Québec 1990-2000, Ministère de l'Environnement du Québec, Nov 2004, http://www.menv.gouv.qc.ca/changements/ges-en/ghg-emission.
- Nuclear Power in the World Today, Nuclear Issues Briefing Paper 7, Uranium Information Centre Inc., Fall 2004.
- International Atomic Energy Agency website, Oct 2004, http://www.iaea.org/programmes/a2/index.html.
- "New Nuclear – Delivering on the Promise", M. Caplan, J. Hopwood, J. Polcyn, K. Hedges, AECL, Pacific Basin Nuclear Conference 2004, Hawaii, US, March 2004.
- "Modification of Radioactive Waste Storage Facilities and Refurbishment of Gentilly-2 Nuclear Power Plant", Information Bulletin No. 1, Hydro-Québec, March 2003.
- International Energy Outlook 2004, Energy Information Administration, April 2004, http://www.eia.doe.gov/oiaf/ieo/index.html.
- "Nuclear Energy 2004, Clean Electricity is Important to All of Us", Canadian Nuclear Association, http://www.cna.ca/.