Power Generation Equipment

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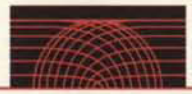

I N D U S T R Y P R O F I L E

1990–1991

POWER GENERATION EQUIPMENT

FOREWORD

In a rapidly changing global trade environment, the international competitiveness of Canadian industry is the key to growth and prosperity. Promoting improved performance by Canadian firms in the global marketplace is a central element of the mandates of Industry, Science and Technology Canada and International Trade Canada. This Industry Profile is one of a series of papers in which Industry, Science and Technology Canada assesses, in a summary form, the current competitiveness of Canada's industrial sectors, taking into account technological, human resource and other critical factors. Industry, Science and Technology Canada and International Trade Canada assess the most recent changes in access to markets, including the implications of the Canada-U.S. Free Trade Agreement. Industry participants were consulted in the preparation of the profiles.

Ensuring that Canada remains prosperous over the next decade and into the next century is a challenge that affects us all. These profiles are intended to be informative and to serve as a basis for discussion of industrial prospects, strategic directions and the need for new approaches. This 1990–1991 series represents an updating and revision of the series published in 1988–1989. The Government will continue to update the series on a regular basis.

Michael H. Wilson
Minister of Industry, Science and Technology
and Minister for International Trade

Introduction

The overall Canadian electrical manufacturing sector includes companies that produce industrial electrical equipment, electrical power generation products, electrical wire and cable products, batteries, major appliances, small appliances, lighting products and miscellaneous electrical products. Each industry differs markedly from the others in technologies, production techniques and markets.

In 1991, shipments of electrical manufactured goods constituted 2.98 percent of total Canadian manufactured goods shipped and 2.02 percent of all manufactured goods exported. Shipments of electrical manufactured goods totalled $8 281.2 million, and the total Canadian market for these products was $10 867.8 million. Exports were valued at $2 139.8 million, and imports of $4 726.4 million satisfied 43.5 percent of the Canadian electrical goods market. The manufacture of electrical goods in Canada provided employment for about 70 000 people.

This profile deals only with power generation equipment that is primarily electric. Other industrial and marine applications included in this industry are not necessarily associated with generating electric power and are not included. Pollution abatement equipment generally associated with this industry is not covered in this profile either. In addition, other profiles have been published on the following industries:

- *Electrical Wire and Cable*
- *Industrial Electrical Equipment*
- *Major Appliances*
- *Small Portable Electrical Appliances*

The demand for power generation equipment is largely a derived demand, dependent upon the demand for electricity and related power. The Organization for Economic Co-operation and Development (OECD) calculates that the final global consumption of energy of all types rose by only 7 percent from 1973 to 1990. This figure includes only the final consumption of electricity, and does not include line losses or the fuels used to produce electricity, both of which are substantial. The electricity subcomponent of this overall consumption rose by 51 percent, indicating that electricity was preferred to other fuels and therefore is replacing other fuels for final usage.

Canada has the fourth-largest power generating capacity in the world — 62 percent is hydro-electric power generation and 38 percent is thermal power generation, including nuclear. This reliance on hydro-electricity is not consistent across the provinces of Canada. For example, about 45.9 percent of Ontario's electricity in 1990 was generated by nuclear reactors (i.e., Canada's Candu reactors). In 1993, with the full operation of the reactor installed at Darlington, Ontario, the share of electricity generated by nuclear reactors in Ontario is expected to approach 60 percent. In contrast, British Columbia and Quebec produced 94.4 percent and 95.6 percent, respectively, of their electricity from hydro.

Canadian energy demand from 1973 to 1990, a period of growth in population and gross domestic product (GDP), grew by 43 percent. Over the same period, Canada's demand for electricity rose by 89 percent, or about one and a half times as fast as the average annual rate of growth of GDP expressed in constant-dollar terms.

Electricity possesses several attributes that have made it a chosen form of energy. It can be transported over long distances with relatively small losses of power, or it can be delivered in large quantities for heavy industrial users, or in minute quantities, such as those required to power microelectronic equipment.

At the point of consumption, electricity is a clean form of energy and is therefore ideally suited for use in urban areas. In the generation of electricity, both utilities and equipment manufacturers are achieving success in reducing pollution. The increased application of scrubber technologies is significantly reducing emissions of oxides of nitrogen, carbon and sulpher (known colloquially as NO_x, CO_x and SO_x) from coal-fired plants. In addition, the increasing use of natural gas rather than coal or oil also reduces the release of these pollutants into the atmosphere. While nuclear power generation does not give off these emissions, other environmental concerns arise from spent nuclear fuel, which may continue to emit significant levels of radiant energy for thousands of years and so requires safe, permanent storage. Nevertheless, research and development (R&D) on this issue has advanced to the point where environmental hearings on a storage system for nuclear wastes are under way.

Structure and Performance

Structure

The production of electricity in quantities suitable for industrial processes or for widespread distribution by utilities is generally achieved by one of five processes. Four of the processes are thermal-based (combustion chamber, nuclear, gas turbines and internal combustion engines, generally diesel) and one is water power-based.

The combustion chamber process burns coal, oil, wood, natural gas or other combustible materials in a combustion chamber, and the heat generated is transferred to water circulating in tubes surrounding the chamber. Additional heat is then applied to convert the hot water into high-pressure steam, which in turn is directed through jets toward the impeller blades of a rotating turbine to provide the power to turn the electrical generator.

Combustion chamber equipment may also be used either on a stand-alone basis to produce hot water and steam for direct use in other industrial, commercial and residential purposes. Combined electricity and heat production, popularly referred to as "cogeneration," captures hot water and steam as waste energy from electricity generation and reuses them productively in order improve overall energy efficiency.

In the nuclear process, the heat generated by nuclear reaction is transferred to the water surrounding the reactor tubes, producing steam. The remainder of the process is similar to the combustion chamber process.

In the gas turbine process, natural gas is burned in a jet engine similar to, and in some cases, the same as, the jet engines used in aircraft. The rotating turbines provide the power to turn the electrical generator. By eliminating the large combustion chambers required for coal burning and the intermediate step of steam generation, the equipment is usually physically small compared with most combustion boilers. The smaller size of gas turbines reduces the time between ordering new infrastructure and bringing it on-line.

For smaller-capacity generators, diesel engines are frequently used to provide the power to turn the generator. Diesel generators are also frequently used as a backup in case of power failures, feeding into hospitals and industrial processes where electrical failures would be dangerous or costly. Generators of this type are included in the industry profile titled *Industrial Electrical Equipment.*

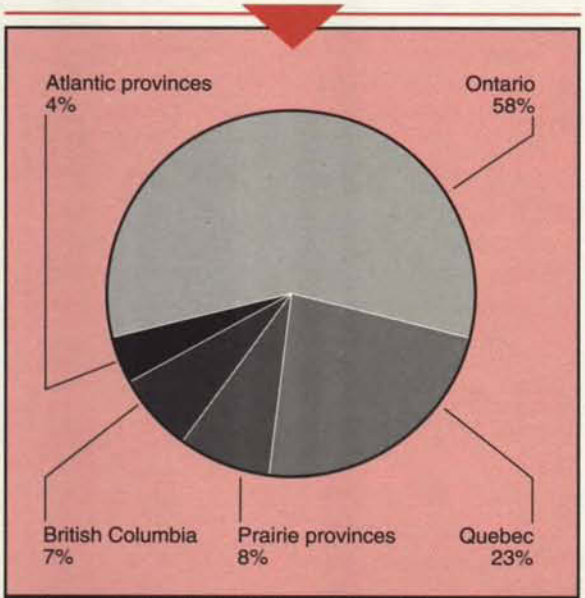

Figure 1 — Regional Distribution of Establishments (average for 1986 to 1988)

Water power-based processes capture the energy contained in water falling under the influence of gravity to turn turbine impellers, which provide the power to turn the electrical generator. This process is often referred to as hydro power or hydraulic power. The greater the vertical drop and volume of water, the greater the potential capacity for generating electricity. Consequently, rainfall, evaporation rates and the ability of a utility to conserve water behind its dams influence actual capacity on a day-to-day basis.

Power generation equipment is purchased by publicly or privately owned utilities. The equipment also has widespread use by non-utility companies, generally by those companies involved in resource processing, for both electrical and heat uses in the manufacturing process.

There were 160 establishments owned by 61 firms in the power generation equipment industry in 1988, the latest year for which such statistics are available. They employed about 9 000 people in the same year. Most establishments are located in Ontario and Quebec (Figure 1).

In 1990, real shipments expressed in terms of constant 1988 dollars peaked at $1 651 million. This represented about 10 percent of total machinery industry shipments that year. The industry had a strong export orientation, with sales abroad of $497 million in 1990, representing 30 percent of its total shipments. Imports worth $842 million captured some 42 percent of the Canadian market.

Products from this industry are largely custom-engineered; therefore, engineering services are crucial to the marketing and designing of high-value power generation equipment. Customization and environmental approval processes can also result in long lead times between the initial design and the shipment of products.

The power generation equipment industry generally consists of three major blocks of equipment used in generating electricity: combustion boilers, pressure vessels and heat exchangers, used in energy conversion; turbines; and generators. Of these, the largest is the first category, with value shipped in 1991 worth $938 million (constant 1988 dollars), compared with $342 million for turbines and $165 million for generators.

Boilers, Pressure Vessels and Heat Exchangers

This subsector is dominated by large, mainly foreign-owned multinational enterprises (MNEs). The major markets for this subsector are public utilities as well as manufacturing and processing industries in Canada and abroad.

For its inputs, this subsector draws on a wide variety of suppliers to provide basic steel castings, refractories, tubings, forgings, fans, pumps, compressors, valves, instrumentation, sophisticated controls and engineering services. Thus, its industrial linkages within the economy are diverse.

Since the mid-1980s, the major companies in this subsector have been undertaking gradual restructuring, mergers and reorganization to become competitive on a global scale. Three large, foreign-owned MNEs have emerged as the dominant suppliers, and all have specific product mandates and/or responsibilities for global markets that are met through subsidiary companies in Canada. The other 40 small and medium-sized boiler and heat exchanger manufacturers tend to sell smaller, more standard units to Canadian and U.S. markets.

In almost all cases, alliances with related or parent companies, including some large engineering firms, ensure that the technology is world-class. The high level of quality in design and manufacture attained by this industry is shown by its ability to manufacture under stringent tolerances for nuclear facilities. Several of these companies continue to sell equipment based on superior technology and performance to developing countries.

Heat exchanger companies tend to supply local markets. Some of these companies are small, owner-operated fabricating shops. Manufacturing firms that make smaller heat exchangers are spread across Canada and tend to supply equipment and service for local industrial processing rather than for electricity generation.

In addition to electric power applications, Canada has particular expertise in recovery boilers for the pulp and paper industry, boilers and pressure vessels for high-temperature/high-pressure applications and fluidized bed boilers for burning a wide variety of fuels. The larger boiler manufacturing

firms are concentrated in southern Ontario and Quebec, with service facilities in most major cities of Canada. There are also a few smaller boiler manufacturing firms located in British Columbia, Alberta and the Atlantic region.

Turbines

The Canadian market for large gas, steam and hydraulic turbines is dominated by the requirements of public utilities, whereas multinational oil, chemical and resource-based industries are usually the largest buyers of smaller steam and gas turbines.

This subsector also has evolved through rationalization into a world-class competitive force in which companies with either foreign ownership or foreign partners provide technology and world marketing networks. Canadian companies are well known throughout the world for their hydraulic turbine designs, and the three manufacturers of large hydraulic turbines tend to be involved in many global hydro developments. Companies manufacturing smaller hydro turbines tend to supply markets located mainly in Canada and the United States.

Only two companies, both multinational, are involved in manufacturing gas and steam turbines. Although both companies are active in world markets, the choice of manufacturing locale for specific products depends on the competitive standing of the Canadian operation within their respective companies.

The industrial linkages of this subsector within the economy are very broad. The subsector buys basic steel castings, forgings, gears, electric motors, pumps, valves and environmental controls.

Generators

Both alternating-current (AC) and direct-current (DC) generators powered by gas, steam and hydraulic turbines are manufactured by two large firms that traditionally produced only hydraulic-driven generators. In the late 1980s, generators, powered by either steam or gas, were generally imported by suppliers of turbines and sold as a package to the utility or resource-based industries as part of a complete power supply. Recently added capacity in Canada will enable one of these firms to manufacture steam- or gas-driven generators producing up to 150 megawatts (MW), and the other to service steam- or gas-driven generators producing up to 600 MW.

Through foreign ownership or foreign partners, both firms provide some of the world's most advanced technology in this field. Because of their excellent reputations, they are in export markets, usually aligning themselves with one of the turbine manufacturers and offering complete units to foreign power producers.

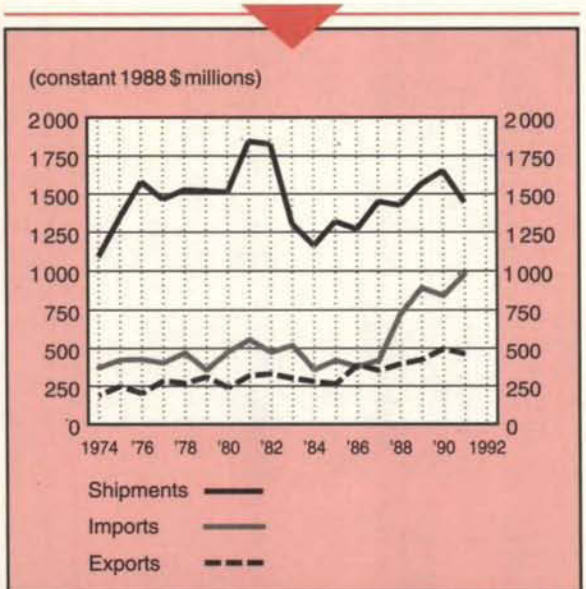

Figure 2 — Total Shipments, Imports and Exports

Performance

Power generation mega-projects such as large hydro or nuclear facilities can take from five to 15 years to complete. Investment decisions are based on projected demand. An unexpected increase in demand can initiate a series of large projects in several different regions simultaneously. Conversely, a downturn in economic activity can initiate the opposite — cancellations and postponements. These types of reactions can lead to abnormally large fluctuations in the business cycle for the power generation equipment industry.

Figure 2 illustrates total shipments, imports and exports in constant 1988 dollars from 1974 to 1991. There was modest growth in shipments of power generation equipment after 1984. Shipments in 1990 worth $1 651 million (constant 1988 dollars) approached those of the boom years for this industry of 1981 and 1982. Despite the subsequent decline in 1991 to $1 445 million, these figures indicate a substantial revitalization of industry shipments from the low in 1984 of $1 164 million.

In most industrialized countries, domestic markets for power generation equipment are overtly or effectively closed to import competition by national procurement policies or the use of other non-tariff barriers (NTBs). The power generation equipment industry in these countries has therefore been able to develop from a captive market base, with the accompanying advantage of some stability in volume and price for a significant percentage of its business. Canada and the United States have remained reasonably open markets. As trade barriers are reduced, MNEs are restructuring

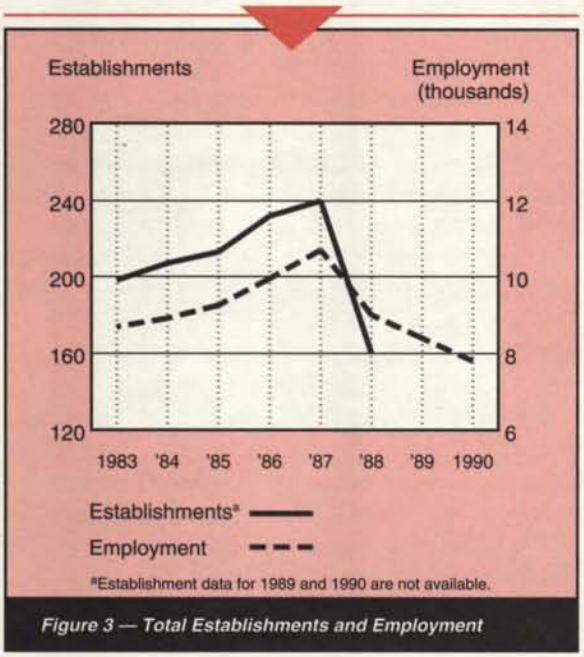

Figure 3 — Total Establishments and Employment

to meet the growing world demand for power generation equipment. Some Canadian suppliers are being awarded world product mandates and are now finding acceptance in previously closed markets through their international alliances. The international alliances of some manufacturers, utilities and Canadian engineering firms have been a great asset in developing sales in less developed countries.

Public utilities are the major purchasers of both hydraulic and steam turbines in Canada. Until the early 1960s, the majority of their requirements were met by domestic suppliers. Ontario and Quebec utilities continue to purchase from Canadian suppliers. Other provinces, however, are now obtaining some of their power generation equipment from abroad.

The Canadian industry work force grew from 8 690 people in 1983 to 10 698 in 1987. In 1988, the closure of some facilities led to a sharp reduction in employment (Figure 3). Shipments continued to increase until 1990, however. These two trends indicate that shipments per employee were increasing, due in part to automation leading to more efficient manufacturing methods.

This industry's work force now contains a large number of employees approaching retirement age and there may be serious shortages of the skilled labour, such as machinists, required for the industry in the next decade. For example, firms and workers need to meet special standards for nuclear technologies and construction sites. Serious consideration is now being given to the question of how and when to develop the skills needed to replace the aging work force.

Boilers, Pressure Vessels and Heat Exchangers

Shipments of boilers, pressure vessels and heat exchangers in 1990 totalled $1 044 million (constant 1988 dollars), with exports accounting for $262 million. Statistics Canada estimates that sector shipments in 1991 fell to $938 million, reflecting roughly proportional declines in exports and domestic shipments. Exports fell from $262 million in 1990 to $214 million in 1991. There has, however, been increasing competition from imports, which rose from $175 million in 1990 to $242 million in 1991.

Despite the fact that the Canadian market is open to imports, domestic manufacturers have received most of the Canadian power boiler orders because of their price-competitiveness, advanced technical ability and excellent after-sales service. Some of the larger Canadian boiler manufacturers have had considerable success selling to other countries. For example, Babcock & Wilcox, the largest manufacturer of boilers in Canada, has complete control of its export marketing from the Canadian operation, which directs the international division of Babcock & Wilcox. This mandate has been a major factor in the success of the company in world markets.

This subsector has undergone less restructuring than the other subsectors. However, Combustion Engineering gained financial strength when it was acquired by the U.S.-owned ABB Combustion Systems, the world's largest electrical company.

Turbines and Generators

Shipments of Canadian turbines and generators in 1990 were $607 million (constant 1988 dollars). This level of shipments was based on domestic sales as well as on the success that Canadian companies experienced in their sales to the United States and developing countries. Statistics Canada estimates that shipments dropped to $507 million (constant 1988 dollars) in 1991. This decline was wholly attributable to losses in domestic sales. Exports increased from $235 million in 1990 to $249 million in 1991, while imports also rose from $667 million to $753 million in those years. Both India and China have been excellent markets for turbine manufacturers.

Hydraulic-driven generators continue to maintain reasonable sales. Both of the major manufacturers in Canada have had world product mandates for several years. One supplier has benefited from its proximity to key projects. The other supplier has been extremely successful in world markets and continues to enjoy an above-average share of export projects.

Competition in the generators subsector comes from major manufacturers in Japan, Italy, the United Kingdom, Switzerland, France, Germany and the Commonwealth

of Independent States (CIS). Each of these countries has three elements necessary for success: unrestricted freedom to export, protection in its domestic market and available financing for exports.

Additional elements essential to a strong, internationally competitive industry are state-of-the-art technology, economies of scale, market mandates, continuous involvement in R&D, a secure domestic market base and the availability of competitive export financing.

Strengths and Weaknesses

Structural Factors

Technologically, Canadian companies in the power generation equipment industry are equal, or in some cases superior to their Japanese or European competition. Constant pressure from large, efficient utilities, such as Hydro-Québec, Ontario Hydro and B.C. Hydro, has encouraged Canadian development of advanced thermal and hydraulic equipment. In many cases, development has resulted from tests and ideas generated by the utilities, three of which operate their own world-class test facilities that they make available to power generation equipment manufacturers. In addition, federal and provincial governments have contributed to development projects involving gas turbines, hydraulic turbines, generators and nuclear energy.

Today, most major manufacturers employ computer-aided design/computer-aided manufacturing (CAD/CAM) systems. In several cases, new forms of management are evolving. Quality has therefore been improving steadily to keep pace with global competition and the needs of the power generation industry.

For products requiring economies of scale, such as smaller heat exchangers and small boilers, the industry has not had the benefit of sufficiently large domestic markets to be internationally competitive. The implementation of the Canada-U.S. Free Trade Agreement (FTA) on 1 January 1989 is, however, increasing access to the U.S. market.

Many of the larger firms are owned by foreign multinationals, which can be either a strength or a weakness, depending on the particular circumstances of the foreign firm and the mandates it negotiates with its Canadian subsidiary. On the one hand, Canadian subsidiaries may have trouble accessing certain export markets because of their ownership structure. On the other hand, foreign ownership has been a strength for many subsidiary companies, particularly those that have world product mandates. Under these circumstances, foreign parent companies have often provided valuable international marketing networks to the Canadian subsidiary, in some cases placing subcontract orders with their Canadian subsidiaries.

In addition to occasionally supplying financing, foreign parent companies often provide subsidiaries with access to their technology and R&D facilities. Conversely, firms such as GE Canada have a long history of R&D in Canada in areas where the Canadian plant has product mandates. For other companies, however, the availability of foreign technology has sometimes resulted in a low level of R&D activity in Canada. Foreign parent companies are often in a better position to finance large projects in developing countries. This can increase the export sales of their Canadian subsidiaries.

As noted earlier, customer relationships and servicing to the major Canadian utilities have also been a source of strength for Canadian manufacturers, particularly for those manufacturers in Ontario and Quebec, which have supplied most of the major power generation equipment.

Previously, some export marketing by the industry has benefited from a full range of standard financing and risk insurance from the Export Development Corporation (EDC). The availability of this financing has encouraged not only individual Canadian exporters, but also national and international consortia when these companies are pursuing large projects. At present, export financing to meet competitive bids is becoming increasingly difficult to obtain. The availability of export financing remains an important issue, however, because foreign competitors are able to secure competitive financing from their governments.

Offers of excellent financing packages by foreign suppliers of hydraulic power generation equipment to Canadian utilities have made it difficult for Canadian suppliers to win bids on some major Canadian hydro projects. In addition, the cost of shipping large hydraulic equipment from Ontario or Quebec to a foreign market, or even to British Columbia, can be a significant factor when competing with Asian suppliers. Thermal plant suppliers have been extremely successful in Canada, and all recent utility purchases of steam boilers have been from a Canadian supplier.

Often, in conjunction with the Canadian International Development Agency (CIDA), Canadian companies have had notable success selling their power boilers and gas and hydraulic turbines in developing countries including India, Indonesia, Nigeria, Pakistan, the People's Republic of China, the Republic of Korea, Taiwan and Thailand. Most international competitors have the technical ability to produce high-quality products at competitive prices. Therefore, attractive and flexible financing packages offered by governments are often the deciding factor in winning contracts.

Power generation equipment companies will need to be resourceful in developing new financial packages for major

export opportunities. Foreign competition is already beginning to secure orders through innovative financing arrangements, such as build-own-operate-transfer (BOOT) projects, combined financing packages through the World Bank and other international financial institutions, and equity participation in projects.

Trade-Related Factors

Historically, the Canadian power generation equipment industry was fostered by the domestic market and by the access that Canadian plants have to British Commonwealth markets through British Commonwealth tariffs. The advantage afforded by the Commonwealth tariff, however, has been eroded with the evolution of regionally based trading blocks and their inherent trade barriers, which generally give stronger preferences to companies within each free trade area.

In general, international markets for power generation equipment are not covered by the General Agreement on Tariffs and Trade (GATT), so many countries are closed to foreign competition. In the 16 to 20 percent of the world's markets that remain open to Canadian manufacturers, international competition is intense. As part of technology transfers, related to earlier contractual arrangements with North American and European firms, companies in India, Brazil and the Republic of Korea have obtained licences to manufacture some machinery and equipment. This evolution has increased the number of well-qualified, international competitors.

Even within markets that are apparently open for competition, several NTBs come into play. Various U.S. state and federal "Buy America" procurement practices create NTBs against imports of Canadian goods. Difficulties in penetrating markets in the European Community (EC) and Japan stem from import competition by their national procurement policies or other NTBs. For example, several countries use the ability to meet national manufacturing testing and safety standards in their bidder selection process in order to ensure that only domestic suppliers can qualify. Both the EC and various U.S. government departments are adopting international standards under the International Organization for Standardization's ISO 9000, with which plants and, often, key suppliers must comply in order to be eligible to bid on contracts. While broad compliance with these standards may facilitate access to markets, it will also involve large-scale competition due to reduced product diffentiation. It may also result in inordinate expenses for small-scale producers in order to adjust their production lines.

In the drive to keep capital costs down for all industries, the Canadian market for power generation equipment has become increasingly open to competition. The relatively high Canadian tariff rates shown in the table above overstate the

Tariffs Assessed by Selected Countries on Power Generation Equipment from Most Favoured Nations, 1992

(percent)

Product	Canada	United States	Japan	European Community
Boilers	12.5	6.5	4.2–5.7	5.5
Engines	9.2	0–5	4.8–4.9	3.2–5.8
Heat exchangers	9.2–10.2	6.5	5.7–7.2	5.5
Machinery (general)	9.2	0–5	4.2–7.2	3.2–5.8
Pressure vessels	9.2–10.2	2.6	5.7–7.2	3.8–4.9
Turbines	15	7.5	4.2–7.2	5–6

Source: ISTC estimates.

protection afforded Canadian power generation equipment manufacturers. The FTA has lowered tariffs on products traded between Canada and the United States. Where rules of origin are met, tariffs under the FTA on some items have been dropped immediately upon implementation and those tariffs on the other items have been falling toward zero in either five or ten equal, annual stages since 1 January 1989. In addition, special end-use tariffs of zero have been extended on other equipment produced by these manufacturers, such as that for fertilizer plants or enhanced oil recovery, thereby reducing the overall level of protection afforded by tariffs.

On 12 August 1992, Canada, Mexico and the United States completed the negotiation of a North American Free Trade Agreement (NAFTA). The Agreement, when ratified by each country, will come into force on 1 January 1994. The NAFTA will phase out tariffs on virtually all Canadian exports to Mexico over 10 years, with a small number being eliminated over 15 years. The NAFTA will also eliminate most Mexican import licensing requirements and open up major government procurement opportunities in Mexico. It will also streamline customs procedures, and make them more certain and less subject to unilateral interpretation. Further, it will liberalize Mexico's investment policies, thus providing opportunities for Canadian investors.

Additional clauses in the NAFTA will liberalize trade in a number of areas including land transportation and other service sectors. The NAFTA is the first trade agreement to contain provisions for the protection of intellectual property rights. The NAFTA also clarifies North American content rules and obliges U.S. and Canadian energy regulators to avoid disruption of contractual arrangements. It improves the

dispute settlement mechanisms contained in the FTA and reduces the scope for using standards as barriers to trade. The NAFTA extends Canada's duty drawback provisions for two years, beyond the elimination provided for in the FTA, to 1996 and then replaces duty drawback with a permanent duty refund system.

At this time, Canadian power generation equipment appears to be competitive with similar Mexican products. The improved performance of the Mexican economy will also stimulate demand for additional generating capacity as NAFTA becomes increasingly effective between 1994 and 2004.

Technological Factors

Canadian technology is at least equal to that of its major international competitors in terms of costs and reliability, particularly in product areas such as hydraulic turbines, gas turbines, hydraulic generators and steam boilers. Candu reactors, for example, have an enviable record of very little downtime for refuelling because shut-down is not required. Canadian manufacturers have developed leading-edge technology in heavy water nuclear systems as well as CAD/CAM applications. In several cases, this technology has been developed through R&D projects that have been partially funded by the federal government. In some cases, the modern facilities used by the industry have also received some government support.

Power generation equipment is generally not a field where technical breakthroughs have provided large gains in thermal efficiency, but rather one of slow evolution, which demands continuous R&D. However, renewed interest and recent developments in combined electricity and heat generation using existing technology are now providing opportunities for a major improvement in excess of 30 percent in overall system efficiency.

Some foreign subsidiaries manufacturing in Canada import their technology, whereas the remainder of the industry is responsible for its own R&D. Under the domestic market conditions, however, it is difficult for smaller Canadian companies to finance the modern manufacturing facilities, ongoing R&D, and engineering and marketing activities necessary to maintain their technical competence and manufacturing competitiveness.

The quest for improved energy efficiency and the need to lower costs are leading to renewed interest in Canada and the United States in the concept of combined production of electricity and heat (cogeneration). This concept has been operational in Europe for some time, where new developments are leading the way. Cogeneration is distinguished from traditional electrical generating facilities where thermal energy is wasted to a degree, because a combined electricity and heat system captures exhaust and engine coolant heat for use in industrial or commercial processes or space heating. It therefore provides the potential to operate at efficiencies above 85 percent. This represents considerable long-term energy savings compared with the process of generating thermal and electrical energy separately, which usually results in a significantly lower combined efficiency of between 50 to 55 percent. Greater overall systems energy efficiencies also reduce CO_2 emissions when utilizing fossil fuels.

To be as effective as possible, combined electricity and heat generation requires a year-round market for the low-temperature exhaust, steam or water. These systems can be custom-designed to optimize the mix of these outputs. Therefore, the early installations in Canada and the United States are located or proposed in close proximity to large institutions or industrial complexes where infrastructure costs are not an insurmountable factor.

In the long run, district heating for residential purposes will be required in order to absorb the large quantities of heat. Finding a market for the excess heat is the controlling component but it is a complex issue. Assembling the heat load can take time and therefore is likely to control the rate of installation.

During the summer when the demand is for air conditioning rather than heat, technology is directed at other uses for the excess heat. Both the absorption and ammonia refrigeration cycles can use heat as the power input for refrigeration. Thus, cogeneration has the potential to become increasingly attractive for year-round use.

With respect to advanced designing, processing and machining technology, some Canadian manufacturers have already undertaken modernization programs through the installation of computer numerically controlled (CNC) machine tools and the use of CAD equipment. For example, the application of these technologies by Atomic Energy of Canada Limited facilitates the modular design and construction of nuclear stations. Their preciseness ensures that the modules will fit together, while other computer software facilitates the three-dimensional modelling of the assembly and construction processes. This fundamentally new approach to constructing nuclear plants builds on methods used for construction of offshore petroleum processing plants. It is designed to cut construction time in half, which will save an estimated one-sixth of the total cost of construction. These total cost savings largely reflect reduced interest costs during the construction period, which historically have made up as much as one-third of total costs. Based on constant interest rates over the life of the project, interest costs would be cut in half.

Evolving Environment

Both global and Canadian developments are crucial to this industry. From 1967 to 1984, economic growth in the Western world was just over 3 percent per year. From 1984 to 1989, this rate grew to 4 percent per year. Subsequent to the recent recession, indications are that once growth is re-established, it is expected to exceed 3 percent per year. Thus, global requirements for new electric power generating capacity every three years will be greater than the present power generating capacity of Canada. The following markets are expected to experience rapid annual growth in the near term: Thailand (15 percent), Indonesia (13–14 percent), Mexico (7 percent) and China (7 percent). China alone is expected to add at least 130 gigawatts (GW), or about a third of the capacity to be built in Asia during this decade; this is 25 percent more than Canada's current total capacity.

Financing is forecast to play a critical role in future years, both in determining the rate of growth and the supplier of the equipment. There is an evolving trend for developing countries to rely on the supplier of power generation equipment to arrange for or provide total funding packages for the project. BOOT projects are becoming popular, particularly in thermal plants where power generating capacity can be provided relatively quickly, with no capital outlay by the country and payback of investment costs from revenues spread over several years. Complex financing arrangements also tend to spread the risk of these projects; for example, a thermal plant in China has been financed by 111 banks for approximately US$550 million. This type of financing arrangement may be the way of the future. Canadian companies, therefore, will need to become extremely knowledgeable about where and how to obtain financing for major projects.

Canada has had recent successes selling Candu reactors to the Republic of Korea's Wolsong nuclear site. One reactor is already in operation, a second is under construction, and the construction of two other reactors has been announced. The last two Candu reactors were sold for approximately $500 million each, and will directly utilize 7 000 person-years in Canada from late 1992 to 1999.

The CIS has established an operation in the United States to serve the non-nuclear elements of the North American market, and some Asian countries have been aggressively marketing in Canada. There are a few major hydro developments under consideration in Canada that could provide a market for hydro turbines and generators. Although the timing is uncertain, the industry's current perception is that, by the late 1990s or turn of the century, only a few of these developments will be launched. In the interim, the export market will offer potential for sales growth.

The elimination of tariffs under the FTA will affect some product areas more than others. In standard products such as heat exchangers, pressure vessels, power boilers and packaged boilers, rationalization of production between U.S. and Canadian plants is taking place, with some Canadian plants obtaining North American manufacturing mandates. Subject to legislative approval and ratification, the NAFTA will encourage trade between Canada, Mexico and the United States.

Canadian manufacturers using advanced technology are competitive for specific applications in Eastern Europe. Further, expertise in environmental control equipment and nuclear technologies will likely provide opportunities for Canadian suppliers of these services and equipment in the emerging market of Eastern Europe.

Given the long lead times required for mega-projects, orders for power generation equipment must be placed on the basis of long-term forecasts of demand for electricity. Total costs can run into the billions of dollars for a nuclear or large hydro plant, and interest charges can accumulate quickly. Considering these two factors, the accuracy of the forecasts then becomes a critical factor for the purchaser, the equipment supplier and the user. Unfortunately, forecasting has recently become much more difficult and, from a financial point of view, more critical.

Historically, forecasting was linked almost exclusively to growth in population, income and GDP. This is no longer the case, and other factors must now be considered. Some factors will tend to increase and some to decrease actual demands relative to those forecasted. Complicating the task is the simultaneity of the factors. Overriding all of the forecasting are society's objectives of decreasing the overall consumption of all types of energy and conserving all types of resources. For example, the reduction in consumer packaging will lead to a reduced demand for electricity.

One factor that will tend to continue to increase the demand for electricity is the substitution of electricity for other types of fuel. An example is the newer types of dual energy systems for home heating. In this case, electricity is utilized during periods when surplus is available or when it is otherwise advantageous to do so. This normally happens in the spring when the hydro catch basins cannot hold all of the run-off. Another substitution may be the use of the electric car, now under development by many auto manufacturers.

Factors tending to decrease the demand for electricity include increased electricity prices, reduced economic activity, conservation programs and shifting of the load away from the periods of peak demand. In addition, utilities are undertaking demand management initiatives to improve efficiency, and

manufacturers of products that consume electricity are making more efficient models. Combined electricity and heat generation by the private sector will reduce demand on utility-generated electricity, but may not reduce the overall consumption of electricity. On the other hand, use of waste heat from combined electricity and heat generation may displace some electricity currently used for residential and industrial heating.

The private sector has always been active in generating electricity, both for private use and for sale to others. In some provinces and municipalities, power continues to be generated by the private sector. Other private sector industries generating electricity include mines, smelters, large industrial plants as well as pulp and paper operations. Combined electricity and heat generation technology is now making it financially attractive, in some cases, for the private sector to generate electricity for sale.

Although most electricity in Canada is produced and distributed by provincial government-owned utilities, there is some electricity produced by companies that are not utilities. Non-utility generating (NUG) output is defined as electrical power generating facilities owned and operated in each province and territory by electrical producers other than the major electrical utilities. As of 31 December 1991, the total installed NUG capacity in service in Canada was estimated to be about 7 477 MW, or about 7.2 percent of Canada's total capacity.

The growing importance of combined electricity and heat generation by NUGs is likely to change the nature of planning and operation in the utilities and community at large. To be successful, these combined generating units require a full systems or community approach and this means that equipment suppliers, fuel suppliers, operators and users are likely to become more involved in all aspects of planning and operation. Some gas companies are already into design and BOOT of facilities for NUGs. Given the efficiencies of operations, market forces will likely come to bear on the utilities to introduce more combined power and heat operations into their systems.

Throughout North America, investors outside the traditional utilities are expected to play a larger role than they have in the past. Both the investors and the utilities will need to work together to facilitate systems integration and maintain quality and reliability. The recently announced intention of a $140 million expansion of Rolls-Royce's facilities in Lachine, Quebec, and future expansion of production lines oriented to producing natural gas turbines specifically for cogeneration is an attempt to position it and its key suppliers to take advantage of global opportunities.

When assessing any forecast for power generation equipment, the reader should be aware that the recent recession has subsequently led many participants in the industry to revise electrical energy demand forecasts downward. In 1992, the utilities announced delays in investment worth $12 billion. In January 1993, Ontario Hydro withdrew its 25-year plan. These events will affect the assessment of the longer-term outlook for energy demand. For example, Energy, Mines and Resources Canada's 1992 forecast will go through significant revisions prior to the release of its updated forecast planned for fall 1993.

Competitiveness Assessment

The Canadian range of manufacturing capability is fairly complete. Canada's particular strengths lie in large hydraulic turbines and generators, gas turbines and a wide range of combustion boilers for electrical power generation and industrial processes. Assuming the manufacturers are afforded access to a global level playing field on financing, it is anticipated that they will remain strong and continue to grow over the next five to ten years in light of the growing need in developing countries for electrical power.

In a similar manner, demand will increase for steam-based thermal generation equipment because world demand for thermal power stations is forecast to increase. Demand for this equipment will also increase because environmental controls such as scrubbers continue to limit the capacity of new and existing plants due to the additional downtime required for cleaning and maintenance.

The concern about nuclear power development has already had a profound effect on the power generating sector. Orders for new nuclear capacity fell during the late 1980s despite growing demand for electricity. Nevertheless, the sale of Candu nuclear reactors to the Republic of Korea will also heighten international awareness of Candu's competitiveness. The Republic of Korea has experience with both the Candu, a heavy water reactor, and light water reactors provided by international competitors. Their recent preference for the Candu reactor is a major endorsement.

For further information concerning the subject matter contained in this profile, contact

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PRINCIPAL STATISTICS[a]

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Establishments	N/A	198	207	213	232	240	160	N/A	N/A	N/A
Employment	N/A	8 690	8 911	9 251	9 947	10 698	9 000	8 400	7 800	N/A
Shipments										
($ millions)	1 288	1 040	964	1 141	1 140	1 372	1 425	1 664	1 804	1 618
(constant 1988 $ millions)	1 825	1 302	1 164	1 319	1 270	1 449	1 425	1 565	1 651	1 445

[a]ISTC estimates.

N/A: not available

TRADE STATISTICS

	1982	1983	1984	1985	1986	1987	1988[d]	1989[d]	1990[d]	1991[d]
Exports[a]										
($ millions)	258	242	237	232	356	336	396	450	542	516
(constant 1988 $ millions)	330	301	280	263	391	353	396	425	497	463
Domestic shipments[b]										
($ millions)	1 030	798	727	909	784	1 036	1 029	1 214	1 262	1 102
(constant 1988 $ millions)	1 495	1 001	884	1 056	879	1 096	1 029	1 140	1 154	982
Imports[c]										
($ millions)	373	424	303	371	344	401	722	939	913	1 102
(constant 1988 $ millions)	474	519	358	420	378	420	722	891	842	995
Canadian market[b]										
($ millions)	1 403	1 222	1 030	1 280	1 128	1 437	1 751	2 153	2 175	2 204
(constant 1988 $ millions)	1 969	1 520	1 242	1 476	1 257	1 516	1 751	2 031	1 996	1 977

[a]See *Exports by Commodity*, Statistics Canada Catalogue No. 65-004, monthly.

[b]ISTC estimates.

[c]See *Imports by Commodity*, Statistics Canada Catalogue No. 65-007, monthly.

[d]It is important to note that data for 1988 and after are based on the Harmonized Commodity Description and Coding System (HS). Prior to 1988, the shipments, exports and imports data were classified using the Industrial Commodity Classification (ICC), the Export Commodity Classification (XCC) and the Canadian International Trade Classification (CITC), respectively. Although the data are shown as a continuous historical series, users are reminded that HS and previous classifications are not fully compatible. Therefore, changes in the levels for 1988 and after reflect not only changes in shipment, export and import trends, but also changes in the classification systems. It is impossible to assess with any degree of precision the respective contribution of each of these two factors to the total reported changes in these levels.

SOURCES OF IMPORTS[a] (% of total value)

	1983	1984	1985	1986	1987	1988[b]	1989[b]	1990[b]	1991[b]
United States	79	77	75	73	67	71	79	74	79
European Community	10	11	11	9	22	19	12	11	10
Asia	8	10	12	15	9	4	4	11	6
Other	3	2	2	3	2	6	5	4	5

[a]See *Imports by Commodity*, Statistics Canada Catalogue No. 65-007, monthly.

[b]Although the data are shown as a continuous historical series, users are reminded that HS and previous classifications are not fully compatible. Therefore, changes in the levels for 1988 and after reflect not only changes in import trends, but also changes in the classification systems.

DESTINATIONS OF EXPORTS[a] (% of total value)

	1983	1984	1985	1986	1987	1988[b]	1989[b]	1990[b]	1991[b]
United States	73	76	74	84	47	57	57	57	66
European Community	9	7	8	5	5	5	5	8	10
Asia	3	4	5	1	23	16	21	24	8
Other	15	13	13	10	25	22	17	11	16

[a]See *Exports by Commodity*, Statistics Canada Catalogue No. 65-004, monthly.

[b]Although the data are shown as a continuous historical series, users are reminded that HS and previous classifications are not fully compatible. Therefore, changes in the levels for 1988 and after reflect not only changes in export trends, but also changes in the classification systems.

REGIONAL DISTRIBUTION[a] (average over the period 1986 to 1988)

	Atlantic	Quebec	Ontario	Prairies	British Columbia
Establishments (% of total)	4	23	58	8	7
Employment (% of total)	1	20	69	5	5
Shipments (% of total)	1	20	69	5	5

[a]ISTC estimates.

MAJOR FIRMS

Name	Country of ownership	Location of major firms
ABB Combustion Systems	United States	Sherbrooke, Quebec Cornwall, Ontario Calgary, Alberta
Babcock & Wilcox Industries Limited	United States	Cambridge, Ontario
Canadian Erectors Limited (TIW Division)	Canada	Toronto, Ontario Calgary, Alberta
Dominion Bridge (United Dominion Industries)	Canada	Montreal, Quebec
Foster Wheeler Limited	United States	Montreal, Quebec St. Catharines, Ontario
GE Canada Inc.	United States	Peterborough, Ontario Trenton, Ontario Lachine, Quebec
Koch Engineering Company Limited	United States	Toronto, Ontario
Westinghouse Canada Inc.	United States	Hamilton, Ontario Renfrew, Ontario

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