ENVIRONMENT

Technological Innovation

ABSTRACT

Electrotechnologies are electric technologies that are used in industrial processes such as heating, drying, heat treatment and smelting to obtain significant improvements in energy use. Electrotechnologies reduce energy use and recycle energy by reclaiming and upgrading heat and by separating and reclaiming materials and water for reuse and recycling. They can therefore help Canadian industry to play an active role in promoting sustainable development and mitigating climate change.

Electrotechnology users include industries, small and medium enterprises, towns, municipalities, governments, communities and individuals.

Electrotechologies are used for applications such as potable water and sewage treatment; liquid and solid waste treatment; bulk transportation; indoor air quality; and electric vehicles.

INNOVATIVE TOOLS AND PROCESSES

ELECTROTECHNOLOGIES TO ENHANCE PRODUCTIVITY AND REDUCE GREENHOUSE GAS EMISSIONS

Photo: Donald Angers / LTE

HIGHLIGHTS

Technology
- Enhanced process control
- Improved productivity
- Enhanced product quality
- Reduced energy consumption
- Enhanced workplace health and safety

Environment
- Improved energy efficiency
- Reduced reliance on fossil fuels
- Reduced greenhouse gas emissions
- No toxic emissions
- Improved potential for recycling of materials

Cost
- Reduced fuel consumption
- Reduced material costs (more opportunities for recycling)
- Improved industry competitiveness by significant energy saving

Canada

Hydro Québec Institut de recherche

PROJECT OBJECTIVES/ PHASES

The object of this fact sheet is to heighten awareness from industry members, consultants, engineers, researchers, managers and political decision-makers across Canada to the many potential applications of electrotechnologies and the opportunities they offer for reducing production costs and enhancing product quality, productivity and environmental protection.

This fact sheet provides more detailed information on the following aspects:

- **The electrotechnologies currently available;**
- **The potential application and benefits of electrotechnologies in industrial sectors;**
- **The link between the use of electrotechnologies and reduced greenhouse gas emissions;**
- **The current use of electrotechnologies in industrial sectors (worldwide).**

This fact sheet has been produced by the Canadian Council on Electrotechnologies (CCE), with the collaboration of Hydro-Quebec's energy technology laboratory (Laboratoire des Technologies de l'énergie, LTE), which is a member of the CCE's Board of Directors. One of the goals of the CCE is to optimize the exchange of knowledge and experience in the field of electrotechnologies in order to contribute to economic progress and the quality of life in Canada and other countries. The CCE represents Canada in the International Union for Electricity Applications (UIE).

TECHNOLOGY

Electrotechnologies are equipment and systems that use electricity to produce and process consumer goods. They are employed in various industrial processes such as heating, drying, heat treatment and smelting.

In the past, fossil fuels supplied the energy needs associated with such processes and electricity was used primarily for motors, lighting and electrolysis. The electrotechnologies that are in use today (see table below), demonstrate that electricity can be used in most industrial processes and that such technologies are efficient, advantageous and easy to adapt. In many cases, electrotechnologies enable manufacturers to reduce their production costs, increase their productivity and improve product quality as well as working conditions and job safety. Electrotechnologies offer many other advantages as well, such as facilitating automation, robotization and computerized supervision of industrial production.

Clean and more environmentally benign than other technologies, easily adapted to a variety of industrial operations as well as to different alternate energy sources.

PRINCIPAL ELECTROTECHNOLOGIES AND CORRESPONDING PRINCIPLE OF OPERATION

Technologies (listed alphabetically)	Principle of operation
Conduction	Conduction (also called direct resistance heating) involves heating a material by passing an electric current through it.
Electric arc	Electric arc heating is a specific kind of plasma heating that uses an electric arc created by the flow of current through ionized gas between two electrodes. Temperatures of up to 4000°C can be reached in furnaces using electric arcs or submerged arcs as radiant heat sources.
Electrical resistance	Indirect resistance heating consists in passing an electric current through a heating element. The heat that is generated is confined in an insulated enclosure such as a furnace. The heat can be used by direct contact or through an intermediate material.
Electrochemical processes	These processes use devices that convert chemical energy into electrical energy (and vice versa) through a chemical reaction induced in an electrochemical cell. They include electrooxidation, metal recovery, electroflotation and electrocoagulation.
Fuel cells and advanced batteries	Fuel cells and advanced batteries are energy storage devices that are used in manufacturing plants and in transportation systems. A fuel cell produces electricity by causing a chemical reaction (as opposed to a combustion reaction) between oxygen and a supply of hydrogen. Advanced batteries encompass various new combinations of chemicals that are used to provide self-contained electricity storage capacity.
Heat pumps	Gases heat up when compressed and cool down when allowed to expand. To provide heating, the fluid (ambient air, a gas or a liquid) used in a heat pump extracts heat from a cold source and transfers it to a hotter reservoir. For cooling, heat is extracted from the area to be cooled and delivered to the warmer reservoir for disposal.
High efficiency motor and variable-speed drives	Indirect resistance heating consists in passing an electric current through a heating element. The heat that is generated is confined in an insulated enclosure such as a furnace. The heat can be used by direct contact or through an intermediate material.
Induction	Induction heating involves placing an electrically conductive object in an electromagnetic field. The induced current causes the object to heat up.
Infrared	Infrared heating uses radiation (short, medium and long wavelengths) emitted by electrical resistors heated to relatively high temperatures.
Laser	A laser is a device that emits an extremely intense and coherent beam of light. Very high power densities can be attained, and the beam can be concentrated within a very small area.
Mechanical vapour recompression	Vapours produced by evaporation are compressed in a condenser to higher temperature and pressure levels, producing heat. This technology requires no coolant and has only one exchanger.
Membranes	These processes, which include reverse osmosis, ultrafiltration, microfiltration and nanofiltration, are used to separate and concentrate various fractions of liquids containing suspended or diluted products. The solution to be processed is compressed by an electric pump.
Microwave	In microwave heating, a non-conductive material is subjected to an ultra-high frequency electric field. The vibrations associated with the electric charges result in homogeneous heating of the material.
Plasma	Plasma is a gas that has been ionized and has become electrically conductive. Plasma generators can heat gases to temperatures as high as 10,000°C
Radio frequency	Same heating mechanism as with microwaves, except that the material to be heated is placed between electrodes in an alternating electric field (10 to 30 MHz) which induces heating.
Ultraviolet radiation	Unlike the other electrical processes, which have a primarily thermal effect on matter, ultraviolet radiation has a radiochemical effect.

MAIN ADVANTAGES AND INDUSTRIAL APPLICATIONS

Processes	Industrial Applications							Electrotechnologies										
	Primary metals	Petroleum refining	Paper and allied products	Chemicals and chemical products	Non-metallic mineral industries	Food industries	Wood manufacturing	Conduction	Electric Arc	Electrochemical Processes	Electrical Resistance	High efficiency motor and Variable-Speed Drives	Fuel Cells and Advanced Batteries	Heat pumps	Induction	Infrared	Laser	Mechanical Vapour Recompression
High temperature processes																		
Fusion	•								✓		✓				✓			
Sintering									✓		✓							
Heat treatment	•				•			✓			✓				✓	✓		
Surface treatment								✓							✓	✓	✓	
Anode fabrication	•										✓				✓			
Heating / Melting	•				•				✓	✓	✓							
Drying											✓					✓		
Casting	•								✓						✓			
Reduction			•							✓								
Reforming				•				✓	✓		✓							
Cracking		•		•					✓									
Firing					•													
Moderate to low temperature processes																		
Dyeing, Coating	•									✓	✓				✓	✓		
Heat recovery														✓				✓
Cooking, baking, sterilization, pasteurizing						•		✓			✓				✓	✓		
Drying			•		•		•				✓	✓		✓		✓		
Separating										✓		✓						✓
Distillation		•																✓
Digesting			•				•											
Pressing							•					✓						
Blanching											✓							
Bleaching			•			•					✓							
Flash tank, multiple evaporator			•									✓		✓				
Vacuum		•																
Other processes																		
Motors and VSD												✓						
Compressors												✓						
Crushing, mixing and grinding	•			•	•	•						✓						
Conveyors	•			•	•							✓	✓					
Cutting, drilling							•					✓					✓	✓
Coating, plating										✓		✓						
Water treatment			•							✓		✓						
Transport			•										✓					
Rolling	•											✓						
Pumping		•		•								✓						
Refrigerating						•						✓		✓				
Separating						•				✓								✓
Planing, Chipping, Trimming							•					✓					✓	

OF ELECTROTECHNOLOGIES

					Main advantages of electrotechnologies														
					Technical						Environmental						Cost		
Membranes	Microwave	Plasma	Radio Frequency	Ultraviolet Radiation	Replacing combustion processes	Processes efficiency	Product quality	Efficient of energy use	Energy recovery	Low energy consumption	Environmental protection	Greenhouse gaz emissions	Water-reuse/recycling	Material losses	Material recycling	Working conditions	Production cost	Productivity	High value products
		✓			X	X		X		X	X	X							
	✓	✓	✓		X	X		X		X	X	X							
		✓			X	X		X		X	X	X							X
		✓			X	X	X	X		X								X	
	✓		✓		X	X	X	X									X		
		✓			X	X		X		X	X	X							
					X	X		X		X								X	
		✓			X	X	X	X		X	X	X							
					X	X					X	X							
		✓				X		X		X									
		✓			X	X	X	X		X									
		✓			X	X		X		X							X		
	✓		✓	✓	X	X	X										X		X
					X	X			X	X									
	✓		✓	✓	X	X	X			X							X	X	
	✓		✓		X	X	X			X							X	X	
✓						X							X		X				
✓						X							X		X				
✓	✓		✓			X							X		X				
						X			X				X		X				
						X	X		X	X	X			X					
					X	X	X			X	X			X				X	
✓						X		X											
						X		X		X									
						X		X					X						
						X		X					X	X					
		✓			X	X		X			X	X							
						X	X	X			X	X							
		✓			X	X	X	X			X	X						X	X
✓				✓	X	X	X	X			X	X	X					X	X
✓				✓	X	X													X
					X						X	X							
					X	X	X	X			X	X	X				X		
						X		X									X		
						X		X		X			X				X		
✓						X		X									X		
					X	X	X	X			X	X							X

RESULTS

Electrotechnologies account for a growing share of Canada's energy and economic base and hold considerable promise for helping to meet Canada's commitments under the Kyoto Protocol. They could permit a 19% reduction in greenhouse gas (GHG) emissions at point of use across principal economic sectors, which represent a reduction of roughly 10% in Canada's total GHG emissions[1].

The tables below provide information on the following aspects:

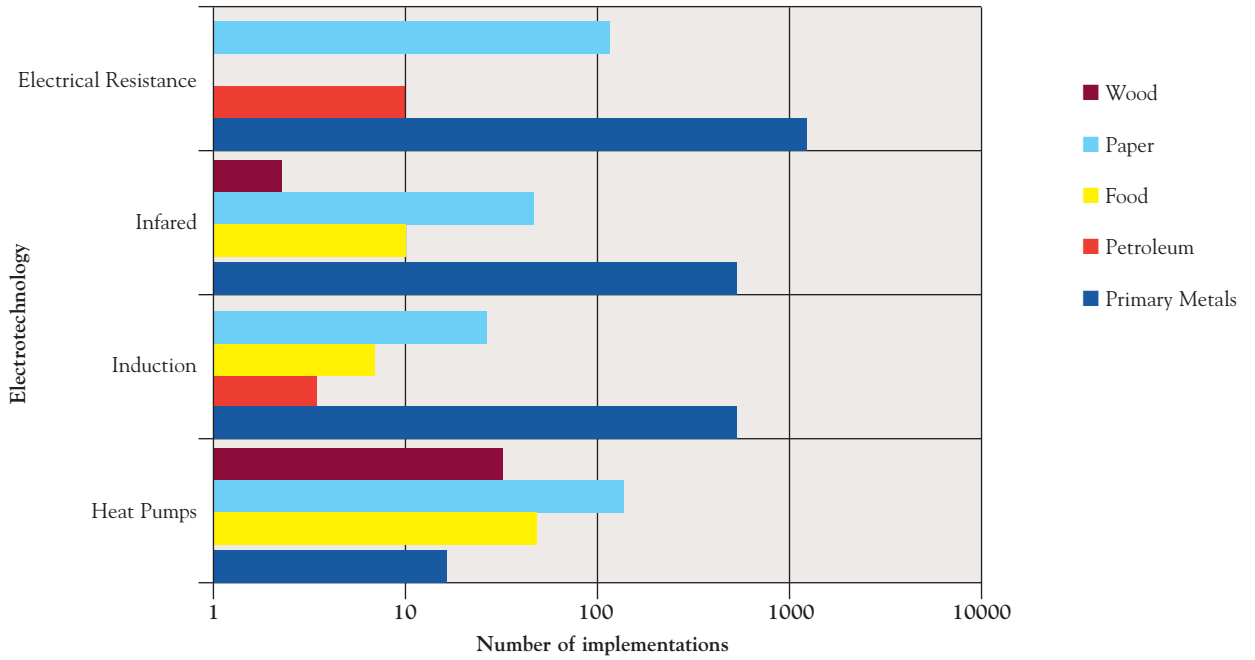
- The main manufacturing sectors that generate the largest energy-related carbon emissions along with the associated emission quantities (in kilotonnes CO_2 equivalent) and the potential for reducing GHG emissions through the appropriate use of electrotechnologies [1, 2].
- The current use of electrotechnologies in industrial sectors (worldwide).

POTENTIAL REDUCTION IN GHG EMISSIONS AT POINT OF USE THROUGH THE APPLICATION OF ELECTROTECHNOLOGIES IN CANADIAN INDUSTRIAL SECTORS (1999)

Canadian SIC Code	Industrial Sector	Emissions in CO_2 equivalent (kt/year)	Potential reduction in GHG emissions (Kt/year)*
29	Primary metals (steel, aluminum, etc.)	19 179	6 500
36	Petroleum products	14 878	9 060
27	Paper and allied products	9 829	7 650
37	Chemicals and chemical products	9 176	3 850
35	Non-metallic minerals	5 627	1 760
10	Food	3 201	1 890
25	Wood	1 741	1 050
	Total for industrial sectors	**63 631**	**31 760**

* Based on potential implementation of 45% to 55% (1996)

ELECTROTECHNOLOGIES MOST WIDELY USED IN INDUSTRIAL SECTORS INTERNATIONALLY



[1] Canadian Council on Electrotechnologies: *The Potential for Electrotechnologies at Point of Energy Use to Meet Canada's Commitment for Greenhouse Gas Reductions*.
[2] The study looks at the technical feasibility, but not the economic aspects, of specific implementations.

POTENTIAL AND LIMITATIONS

Potential

Electrotechnologies, which are used in various industrial processes, can help to enhance productivity, product quality and environmental protection in Canadian industries.

More specifically, the benefits of electrotechnologies are:

- Lower energy use
- Less pollution
- Greater compatibility for automation
- More flexible manufacturing processes
- Greater opportunity for recycling (most of the technologies used in recycling are electrotechnologies)
- Healthier working environment
- Reduction in thermal losses
- Conservation of nonrenewable resources
- Integrated energy supplied

Limitations

- Insufficient awareness among industry and consumers of the potential offered by electrotechnologies
- Lack of familiarity with technology
- Initial capital costs
- Lack of industrial-scale demonstration and evidence of economic benefits

Electrotechnologies also have to compete against old technologies for which the capital cost has been depreciated over time.

INFORMATION

This data sheet is based on a literature review financed by Natural Resources Canada and the expert assistance of the Canadian Council on Electrotechnologies and Hydro-Québec's energy technology laboratory (Laboratoires des technologies de l'énergie, LTE). The project received technical and financial support from Environment Canada.

For more information, please contact:

Laboratoire des technologies de l'énergie
Donald Angers
Tel: (819) 539-1417
E-mail:
angers.donald@lte.ireq.ca
Web Site:
http://www.ireq.ca

Environment Canada Innovation, Monitoring and Industrial Sectors
Jean-René Michaud, Eng, A.M.Sc.
Tel: (514) 283-9207
E-mail:
jean-rene.michaud@ec.gc.ca

Canadian Council on Electrotechnologies
Rick Clayton
Tel: (819) 539-1560
E-mail:
rick.clayton@cce.qc.ca
Web Site:
http://www.cce.qc.ca/

Or

Georges Houlachi
Tel: (819) 539-1400
ext.1307
E-mail:
georges.houlachi@cce.qc.ca

ENVIRONMENT
Technological Innovation

Technological Innovation data sheets, published by Environment Canada, are intended for all companies, industries, organizations and individuals interested in new environmental technologies. Their purpose is to disseminate the results of technology development and demonstration projects carried out in the following sectors: wastewater, atmospheric emissions, contaminated soil, waste management, hazardous waste, agri-environment and innovative tools and processes.

Data Sheets may be obtained from: Environment Canada Innovation, Monitoring and Industrial Sectors Section
105 McGill Street, 4th floor
Montreal, Quebec H2Y 2E7
Tel.: (514) 496-6851
1 (800) 463-4311

Publications available on Environment Canada's Web site in the Publications section:
http://www.qc.ec.gc.ca/dpe

Production:
Julie Leduc

Writers:
Donald Angers
Georges Houlachi

Reviewers:
Jean-René Michaud
Rick Clayton

Graphic Design:
Lacroix O'Connor Lacroix

Printer:
Les impressions IntraMédias

Cat. No: En153-11/58-2005E
ISSN: 1712-0209
ISBN: 0-662-39929-3

November 2005

Cette fiche est également disponible en français sous le titre : Les électrotechnologies pour améliorer la productivité et réduire les émissions de gaz à effet de serre.

Canada