

PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT (PERD)
Business Report 2002



Natural Resources
Canada

Ressources naturelles
Canada

Canada

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Message from the Minister

Natural Resources Canada (NRCan) is a major contributor to the Government of Canada's science and technology (S&T). Through its knowledge, policies and programs, NRCan promotes the responsible use of Canada's natural resources — meeting our needs today while ensuring that future generations can meet theirs.

I am proud of the role NRCan plays in managing the Program of Energy Research and Development (PERD). We provide the structure within which government departments and agencies can develop the science and technologies related to climate change, air quality and energy efficiency.

According to the third report of the Council of Science and Technology Advisors, *Science and Technology Excellence in the Public Service (STEPS)*, “Excellent federal S&T provides an essential contribution to the knowledge and innovation needed for a progressive and supportive society, and a competitive economy.” Through sharing knowledge, resources and expertise, PERD is strengthening federal S&T and contributing to our country's capacity for innovation.

PERD is also an excellent example of collaboration with the private sector and other research organizations. Our S&T strategies, programs and priorities benefit greatly from industry participation on NRCan's advisory boards.

I invite you to read about our recent achievements in the *PERD Business Report 2002*. The technologies developed through PERD are helping the Government of Canada achieve its goals of quality of life in our communities, a healthy environment and continued economic prosperity. We are also making our country a world leader in innovation — for the Canada we want, for ourselves and for future generations.



The Honourable Herb Dhaliwal
Minister of Natural Resources Canada

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PERD Overview

The Program of Energy Research and Development (PERD) embodies the Government of Canada's three main principles for federally-performed science and technology (S&T) – alignment, linkages and excellence. Collaboration is one of PERD's strengths. Operating horizontally across the federal government structure and linking with stakeholders and clients, the program ensures that federal energy research and development (R&D) activities use and disseminate knowledge and resources in collaboration with other important areas such as the environment, transportation, health and agriculture. Energy R&D is focused on technology development. It supports federal energy policy and regulatory needs. Results-based management means good value for our energy R&D investments.

Natural Resources Canada (NRCan) manages PERD and operates the program through 12 participating federal departments and agencies. Energy R&D activities are mainly focused in the following areas: diversified oil and gas production; cleaner transportation; energy-efficient buildings and communities; energy-efficient industry; reducing the environmental impacts of Canada's electricity infrastructure; and climate change. PERD's annual budget is approximately \$57.9 million.

PERD Partnerships

PERD provides funds directly to its partner departments and agencies. This is critical to ensure maximum benefits and impacts from the Government of Canada's energy R&D. To a varying degree, most conduct this research in federal laboratories located across Canada, as illustrated on the following map.

PERD'S PARTNER DEPARTMENTS AND AGENCIES ARE:

- Agriculture and Agri-Food Canada
- Canada Mortgage and Housing Corporation
- Environment Canada
- Fisheries and Oceans Canada
- Health Canada
- Indian and Northern Affairs Canada
- Industry Canada
- National Defence
- National Research Council of Canada
- Natural Resources Canada
- Public Works and Government Services Canada
- Transport Canada



Appendix A provides a listing of federal laboratories which undertake projects with PERD funding. They supplement the money they receive from PERD with funding from their own organizations. PERD leverages additional funds from industry and industry associations, the provinces, universities, and other funding programs such as the Natural Sciences and Engineering Research Council (NSERC), the Industrial Research Assistance Program (IRAP) and Technology Early Action Measures (TEAM) (see Figure 1).

Each department and agency appoints a representative to the Panel on Energy Research and Development (see Appendix B) which meets twice a year to provide important input and advice to PERD's strategic planning and priority-setting processes. Representatives from the Department of Foreign Affairs and International Trade, the Department of Finance Canada and the Treasury Board of Canada Secretariat also participate in the Panel meetings.

Figure 1 — PERD and Complementary Energy R&D Funding Sources, 2000-2001

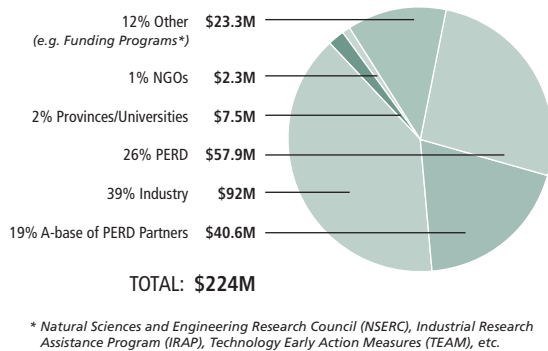


Figure 2 — Contribution of R&D Funding to Climate Change 2001-2002

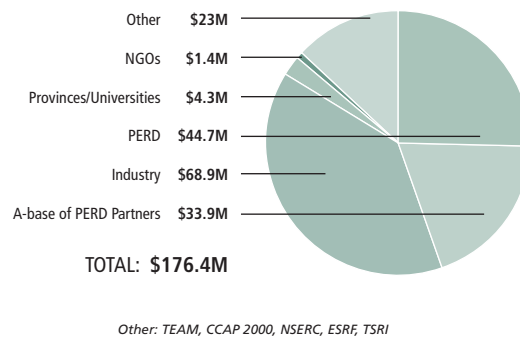


Figure 3 — Current Federal Energy Innovation Mechanisms

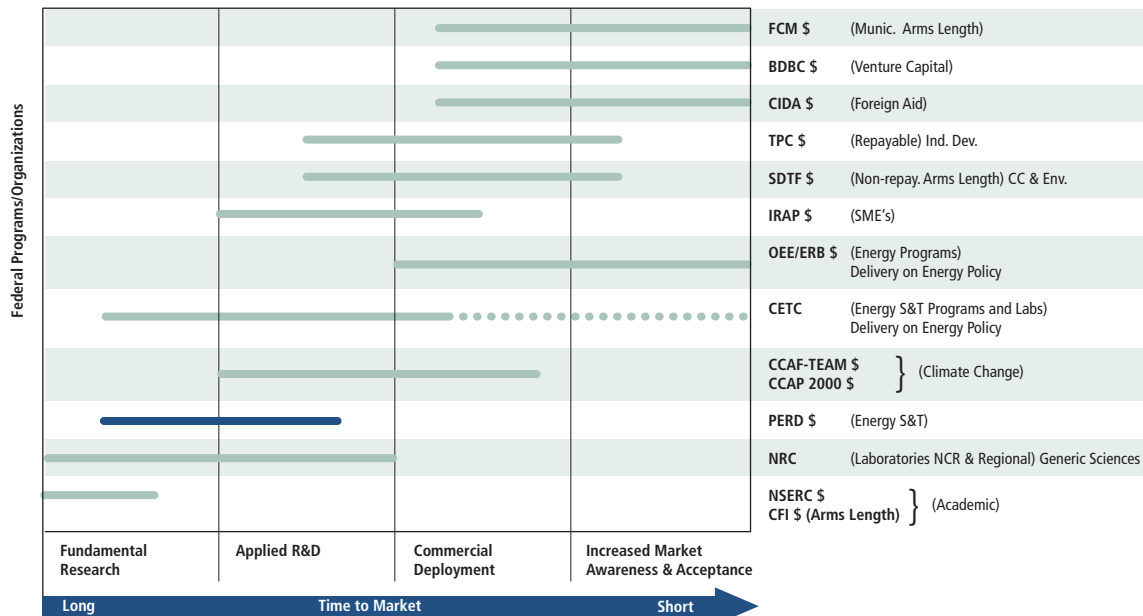


FIGURE 2:
TEAM — Technology Early Action Measures
CCAP 2000 — Climate Change Action Plan 2000
NSERC — Natural Sciences and Engineering Research Council
ESRF — Environmental Studies Research Funds
TSRI — Toxic Substances Research Initiative

FIGURE 3:
FCM — Federation of Canadian Municipalities
BDIBC — Business Development Bank of Canada
CIDA — Canadian International Development Agency
TPC — Technology Partnerships Canada
SDTC — Sustainable Development Technology Canada
IRAP — Industrial Research Assistance Program
OEE — Office of Energy Efficiency
ERB — Energy Resources Branch

CETC — CANMET Energy Technology Centre
CCAF — Climate Change Action Fund
CCAP 2000 — Climate Change Action Plan 2000
PERD — Program of Energy Research and Development
NRC — National Research Council
NSERC — Natural Sciences and Engineering Research Council
CFI — Canada Foundation for Innovation

What does PERD do?

PERD supports energy R&D to ensure a sustainable energy future for Canada in the best interests of both our economy and our environment. Through strategically targeted funding, PERD promotes the development and use of Canada's energy resources in a clean and safe manner, and the development of energy-efficient, renewable and alternative energy sources and technologies. On the international front, it facilitates the exchange of energy R&D information, expertise and technology and influences the international energy R&D agenda. Seventy-seven percent of PERD's current programs contribute to finding technology solutions to help Canada address its climate change challenges (see Figure 2).

PERD supports fundamental and applied energy R&D. However, its close ties to other federal programs that focus on technology deployment and commercialization mean that energy R&D is an important part of the Government of Canada's innovation agenda (see Figure 3). For example:

- Technology Early Action Measures (TEAM) brings together partners in the public and private sectors and funds projects to demonstrate in the marketplace new technological products and processes that reduce greenhouse gas emissions; and
- the Industrial Research Assistance Program (IRAP) provides small- and medium-sized enterprises (SMEs) with technology assistance and financial services to help them build their innovation capacity.

Results-based Management of PERD

MEASURING FOR PERFORMANCE AND RESULTS

Since 1999, NRCan has used a results-based management system to manage PERD's investments. Such a system incorporates performance measurement and reporting of the work conducted with PERD funds. It also uses impact evaluation to assess performance in meeting objectives and inform decisions about resource allocation, including third-party advice and review, to ensure that such decisions are unbiased and reflect energy R&D and policy needs.

The NRCan Advisory Board on Energy Science and Technology (NABEST) meets twice a year to give industry's input regarding energy S&T strategies, programs and priorities.

RESPONSES TO PROGRAM EVALUATIONS

Evaluation of PERD programs provides invaluable information on PERD's achievements. To date, half of the 37 Programs at the Objective Level (POLs) have been evaluated. The remainder will be completed by fall 2003. NRCan also uses evaluations to:

- manage PERD R&D investments
- encourage a "continuous improvement" environment
- help scientists to focus on their research priorities
- promote PERD's achievements
- assess future opportunities for PERD-funded programs

Recent Highlights

PERD programs today are working to find solutions to tomorrow's energy challenges. Although this takes a while to achieve, milestones are reported annually. The following descriptions provide recent highlights of selected PERD programs and illustrate the scope of energy R&D conducted by the Government of Canada. For a complete list of all PERD programs and program leaders, please refer to Appendix C.

SUSTAINABLE OIL AND GAS PRODUCTION

Oil and natural gas account for most of the energy consumed in Canada. While the Government of Canada is committed to developing alternative fuels and renewable energy, it also wants to ensure the sustainable development of our important oil and gas reserves. PERD programs focus on:

- offshore and northern oil and gas
- oilsands and heavy oil
- environmental and safety issues

For example:



FLARING

Alberta's oil and gas industry currently conserves 92 per cent of the solution gas it produces. The rest is treated as a waste product and disposed of by burning or "flaring". Current volumes are 1.8 billion cubic meters per year, an amount

which contributes significantly to greenhouse gas emissions. The public also has concerns about potential environmental and health impacts.

PERD R&D is supported by industry as well as federal and provincial governments. It aims to stimulate technological advances to help reduce flaring and the release into the atmosphere of potentially harmful products of incomplete combustion.

Current activities also support better regulation and best practices. Furthermore, the International Energy Agency is investigating the use of PERD-developed tools and models regarding flare performance to establish worldwide baseline measures of greenhouse gas emissions against which improvements can be measured.

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PIPELINES

Pipelines deliver most of our oil and gas (valued at \$40 billion per year) and would cost \$100 billion to replace. PERD R&D supports:

- assessment of natural hazards for new and existing pipelines
- testing and assessment of the performance of pipeline materials
- regulation, operation and maintenance of pipelines

The ASTM Standard Guide for Evaluating and Qualifying Oilfield and Refinery Corrosion Inhibitors in the Laboratory was published in 2001. Developed with the help of PERD-funded R&D, the Guide will assist oil and gas companies in reducing the number of pipeline accidents in Canada and the release of pollutants, including greenhouse gases.

Another project has contributed to the development of a new material and technology by a major Canadian company which may prove particularly useful for pipeline applications in the North.

The results of PERD R&D on pressure stabilization in pipelines helped a major oil company in Canada eliminate pipeline failures caused by stress corrosion cracking. This has extended the service life of the company's pipelines and reduced its costs.

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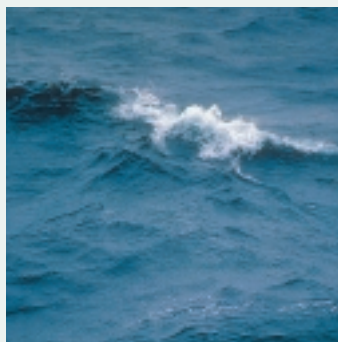
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OFFSHORE DRILLING AND PRODUCTION ACTIVITIES

There are numerous hazards and risks associated with drilling for oil and gas in Canada's offshore regions. The future promises increased levels of offshore drilling for as long as Canada continues to rely on fossil fuels for its heating, industrial and transportation needs. R&D is necessary to develop better environmental impact assessment procedures, operational standards, and regulations to improve safety, reduce costs and address environmental concerns. This program addresses the following issues:

- fish and fish habitat contamination from production water returned to surrounding ocean waters
- ocean contamination from drilling wastes
- treatment of accidental spills



RECENT HIGHLIGHTS INCLUDE:

- studies of sediments around the Hibernia offshore oil site in Newfoundland show that sediment toxicity cannot be directly linked to drilling contaminants and helped federal officials resolve environmental and regulatory concerns
- studies to provide early warning of potential offshore drilling effects on fish health and quality in major fishing grounds:
 - helped the Canada Newfoundland Petroleum Board develop monitoring guidelines for the Grand Banks; and
 - set a benchmark for developers on the Grand Banks which now include studies on fish health as a precautionary measure in their monitoring programs
- data to revise the 1996 Offshore Waste Treatment Guidelines that describe minimum Canadian standards for the treatment and/or disposal of wastes associated with routine offshore oil and gas drilling and production operations
- data collection and analysis, and three-dimensional models that delineate the 'zone of influence' of discharged drilling wastes
- the development and use of innovative oil spill countermeasure techniques (e.g. bioremediation, surf-washing)
- incorporation of the bioremediation and surf-washing technology into the International Maritime Organization's (IMO) Operational Guidelines

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GROUNDWATER AND SOIL REMEDIATION

The remediation of contaminated soil and groundwater from the oil and gas sector can be very costly and environmentally intrusive. The remediation R&D activities funded by PERD will help reduce the environmental impact of oil and gas production on groundwater and soils through:

- enhancement of our knowledge base
- development of mitigation techniques and remediation technologies
- contribution to the generation of standards for hydrocarbons in aquatic and terrestrial ecosystems (i.e., development of testing methodologies)

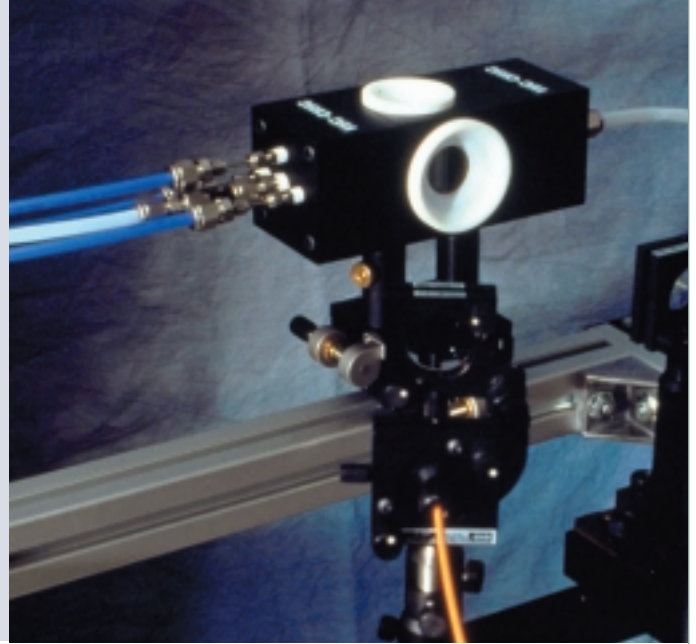
The overall objective of the Environmentally Acceptable Endpoints Project was to generate data that could be used to derive soil quality standards for total petroleum hydrocarbons which contaminate agricultural soils. The environmental toxicology data generated helped determine what level of residual hydrocarbons could safely be left in agricultural soils and helped ensure that numeric values in the Canada-Wide Standards for "Hydrocarbon in Soil" were scientifically defensible and environmentally relevant. This work, conducted in three phases, was of vital interest to the petroleum industry.

- Phase 1 focused on fraction-specific toxicity testing of fresh crude oil with a standardized battery of terrestrial toxicity tests (i.e. earthworms, plants, and soil invertebrates). Results were used extensively by the Canadian Council of Ministers of the Environment (CCME) to develop the Canada-Wide Standards for petroleum hydrocarbons in soil that were released in April 2001.
- Phase 2 evaluated the toxicity of crude oil to plants, soil fauna, soil microbial activity and decomposition/nutrient cycling processes in coarse and fine-grained soil in the field. The goal was to validate the results of R&D conducted in Phase 1 and to address possible changes in hydrocarbon toxicity in weathered soils.
- Phase 3 includes additional field monitoring for 2002 to quantify changes in indigenous organism populations due to the hydrocarbon contamination.

The results of the laboratory and field studies have been summarized in two reports that have undergone a technical review by external experts. CCME and Alberta Environment are expected to review the results of all three phases as part of the planned re-evaluation of the new CCME Canada-Wide Standards for petroleum hydrocarbons in soil in 2003.



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CLEANER TRANSPORTATION

In 1997 vehicles accounted for 25 percent of Canadian greenhouse gas emissions. By 2010, this figure is projected to increase to 32 percent. Vehicles also contribute in a big way to the smog in our large cities.

The Government of Canada wants to reduce the projected growth in greenhouse gas emissions from the transportation sector without harming trade, our economy, the industry's competitiveness, or restricting the mobility of Canadians. Improved urban air quality is also a priority. PERD programs focus on:

- development of fuel cells, their associated hydrogen technologies and infrastructures, and hybrid-electric vehicle components
- alternative gaseous and liquid fuels
- fuels from renewable sources (ethanol and biodiesel)
- measurement and control of the emission of particulate matter and nitrous oxide
- development of advanced lightweight materials for vehicle components
- design of intelligent transportation systems

The following projects provide good examples:

PARTICULATE EMISSIONS

We're all familiar with smog – that hazy layer that covers our cities, particularly during the hottest days of summer. One of the main components in that smog, or air pollution, is particulate matter. These are not just dust particles, which are quite large

by comparison. These fine particles are actually by-products of various combustion processes used to power our vehicles.

Particulate matter consists of tiny particles with a diameter of less than ten microns – less than one-tenth the thickness of a human hair. These particles are so small that they can find their way into our lungs and bronchial passages, resulting in inflammation and respiratory distress.

To address this issue, this PERD program brings together researchers from each step of the process, from engine combustion products to health effects studies, to identify potential strategies to reduce particulate matter. For example, a field study completed in 2001 in the Lower Fraser Valley, B.C. provides data from vehicle emissions and other pollution sources. Researchers will use this comprehensive data to analyze various factors which may affect smog levels and air quality in Canada's urban centres.

PERD-funded R&D is also developing new technology to study, measure and control the production of particulate matter formed in combustion processes. The *Laser-Induced Incandescence* technique to measure particulate matter has recently been patented. The aim is to transfer this promising technology to the private sector as an effective tool for testing vehicle emissions.

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ADVANCED FUELS AND TRANSPORTATION EMISSIONS REDUCTION (AFTER)

The AFTER program supports the development of new transportation technologies in the following areas:

- gaseous and alternative fuels
- light-duty passenger cars
- commercial vehicles powered by diesel fuel

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RECENT HIGHLIGHTS INCLUDE:

- licensing of a new regulator for natural gas vehicles which will improve efficiency and safety, and reduce operating costs
- demonstration of a light-weight refuelling unit for transporting compressed gaseous fuels
- a U.S. patent awarded to Westport Innovations of Vancouver, B.C. for its stratified charge system for low emissions heavy-duty natural gas engines



CANADIAN LIGHT WEIGHT MATERIALS RESEARCH INITIATIVE (CLIMRI)

The Canadian Light Weight Materials Research Initiative (CLiMRI) is a coordinated, interdisciplinary research initiative to develop and implement light-weight and high-strength materials in

transportation applications. The aim is to reduce greenhouse gas emissions through improved vehicle efficiency and to improve the competitive performance of Canadian primary metals, automotive, truck, rail car and aircraft manufacturing industries and their associated parts suppliers.

CLiMRI delivers its program through national and international partnerships and collaboration. It works closely with influential programs such as the U.S. Automotive Materials Partnership (USAMP), the AUTO21 Network of Centres of Excellence and the Centre for Automotive Materials and Manufacturing (CAMM).

Key CLiMRI activities include:

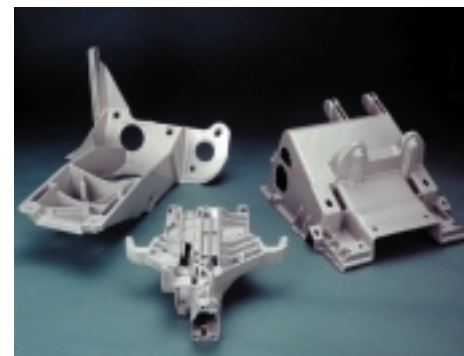
- improved materials engineering performance
- improved manufacturing technologies
- improved component and vehicle systems

RECENT HIGHLIGHTS INCLUDE:

- development and evaluation of corrosion-resistant coatings for light-weight aluminum heat exchangers
- a better understanding of the mechanical behaviour and thermophysical properties of magnesium alloys
- improved properties of magnesium extrusions for automotive applications
- studies of corrosion mechanisms and protective coating systems in the corrosion control of magnesium alloys
- development of a laboratory technique to produce semi-solid die cast and forged parts of magnesium and aluminum alloys
- a study aimed at a 20 percent weight reduction using components for heavy-duty, urban and inter-urban buses
- comprehensive prototype sections of lighter bus components that could yield up to five percent energy savings
- development and demonstration of the feasibility of a patented light-weight metals matrix composite for use in brake rotors

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HYDROGEN PRODUCTION, STORAGE AND INFRASTRUCTURE

This PERD program supports the development of technologies for the cost-competitive production, use, storage and safety of hydrogen. Using hydrogen in fuel cells or internal combustion engines is a cleaner alternative to conventional gasoline- and diesel-powered engines. When hydrogen fuel combines with oxygen from the air, water is the by-product – one can readily see the benefits to Canadians from reduced greenhouse gases and improved urban air quality.

R&D activities are focused in the following areas:

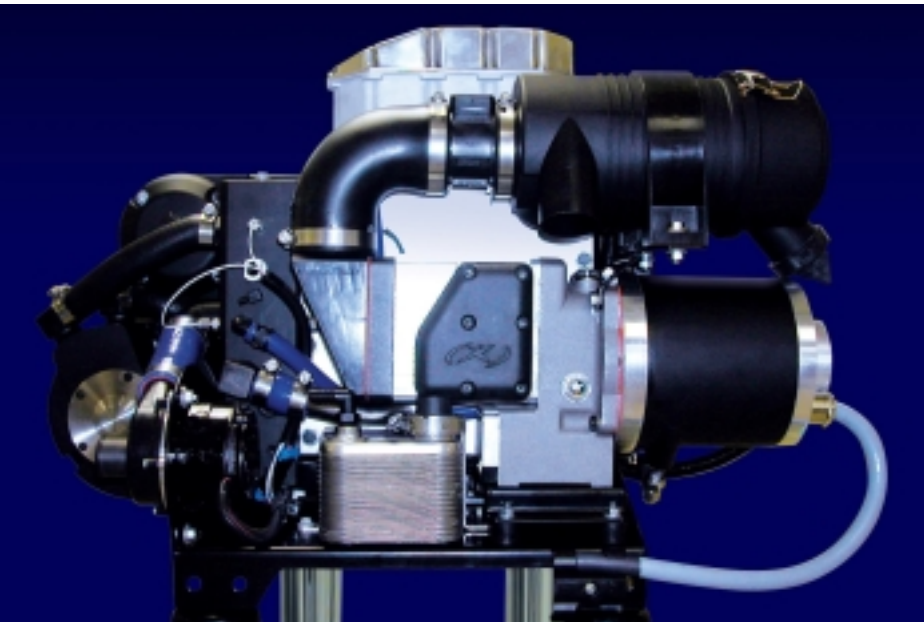
- investigation and evaluation of promising new technologies
- prototype development and testing
- development of safety standards, guidelines and policies

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RECENT HIGHLIGHTS INCLUDE:

- development by Dynetek Industries Ltd. of Calgary of a complete line of high-pressure hydrogen gas storage cylinders for vehicles. These cylinders have design modifications that significantly improve their storage capacity, while still meeting safety factor requirements, thereby increasing the driving range of the vehicles. Over 370 of these cylinders have been sold in North America, Europe and Japan for hydrogen storage for prototype fuel cell vehicles.
- prototype testing of Stuart Energy Systems Inc.'s Personal Fueling Appliance to refuel hydrogen-powered cars
- testing of a fuel-delivery system that uses electrolysis to produce hydrogen for large fueling stations





ENERGY-EFFICIENT BUILDINGS AND COMMUNITIES

Buildings and their equipment in Canada account for 27 percent of greenhouse gas emissions. The Government of Canada wants to reduce those emissions through better energy efficiency, the use of renewable energy technologies and better life-cycle performance of buildings. At the same time, it aims to support healthier and more comfortable indoor environments and help Canadian companies supply high-performance building technologies to domestic and global markets.

The Government of Canada is also playing a greater direct role with communities. An important objective is to encourage the use of environmentally acceptable energy technologies in urban, rural and remote communities to reduce their overall energy intensity and reduce greenhouse gas and other air emissions.

For example:

INTELLIGENT BUILDINGS

PERD R&D is helping develop computer hardware and software tools to make currently available control systems achieve their full potential. Conventional control systems in four commercial and institutional buildings were improved through the installation of the *Diagnostic Agent for Building Operators* (DABO). These buildings (a laboratory, airport, prison complex and office) are now operating more efficiently using the diagnostic messages from DABO. Additional requests have been received from the RCMP Training Centre in Chilliwack, B.C., Natural Resources Canada in Quebec City and Hydro-Québec.

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PERD ACTIVITIES FOCUS ON:

- technologies for residential, commercial and institutional buildings
- waste recovery and use
- integration of energy efficiency and renewable energy technologies
- design concepts, planning tools and technologies to reduce energy consumption, emissions and wastes in communities
- district heating and cooling



RECENT HIGHLIGHTS INCLUDE:

- an estimated annual savings of 35,000 tonnes of CO² emissions by the communities using thermal networks
- a new Canadian standard on the design and installation of underground thermal energy storage systems



COMMUNITY ENERGY SYSTEMS

PERD-funded R&D delivers technology for building, operating and managing thermal networks that link cost-effective and environmentally sound heating or cooling sources to communities' space heating or cooling requirements.

R&D activities of this program are focused on:

- planning and implementing projects in both urban centres and remote communities
- developing software for system design
- improving the performance of district heating and cooling systems
- promoting the adoption of integrated energy systems
- encouraging the use of local sources of renewable energy, particularly wood or agricultural waste materials

A Natural Resources Canada laboratory tests and develops district energy technologies. The program works with provincial and municipal governments, engineering firms, energy equipment manufacturers, and utilities.

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RENEWABLE ENERGY TECHNOLOGIES IN OFF-GRID/REMOTE COMMUNITIES

More than 200,000 Canadians live in Canada's 310 remote communities. Remote communities are not connected to the main electricity grid or to natural gas networks and usually depend on oil from the south for heating and electricity.

This PERD program fosters the advancement of renewable energy technologies (e.g. solar, photovoltaic, wind, biomass and hybrid applications) and integrated systems in Canada's remote, off-grid communities. Efforts are focused on improving reliability, cost effectiveness and social and environmental advantages. For example, by 2005, the program is aiming for a 10 percent reduction in the cost of renewable energy technology systems as well as a 10 percent reduction in fuel use in remote communities.

RECENT HIGHLIGHTS INCLUDE:

- development of the *ECONOMAD*[™] utility module, a portable, self-contained unit that integrates the use of renewable energy systems with a diesel co-generation system which is remotely monitored from any location
- improved standards for photovoltaic products
- use by several remote communities of biomass as a principal heating material

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ENERGY-EFFICIENT INDUSTRY

Manufacturing, process and resource industries use 42 percent of all energy consumed in Canada and generate 34 percent of the greenhouse gas emissions. The Government of Canada conducts energy R&D to provide knowledge, technologies and tools to improve energy efficiency in key industrial processes such as combustion, refrigeration, drying and separation. Efforts are focused on the agricultural, fisheries, forestry, and mining and metals sectors.

For example:

INDUSTRY ENERGY RESEARCH AND DEVELOPMENT

The Industry Energy Research and Development (IERD) program provides direct, cost-shared funding to industry for R&D in support of new and improved products, processes and systems which increase energy efficiency.

In 2001 IERD added 14 projects to the 56 that were already active. Recent highlights include:

- development of a high-efficiency air-cooled refrigerant compressor which achieved energy savings of over 30 percent
- development of an electronic instant hot water heater which achieves energy savings of 15 to 32 percent over conventional electric water heaters
- development of an energy-efficient septic tank service truck which will achieve annual savings of over 70,000 litres of fuel, 400 litres of lube oil, and 20 tires, per truck
- development of an energy-efficient process for exhaust treatment of marine power plants, with projected energy savings of up to 21 percent of fuel used on board ships

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ENERGY EFFICIENCY IN CANADA'S AGRI-FOOD SECTOR

The two main objectives of this program are to:

- 1) improve the energy efficiency of Canada's food production and processing industry; and
- 2) reduce the use of energy-intensive fossil fertilizers and pesticides on Canadian farms.

RECENT HIGHLIGHTS INCLUDE:

- the use of anaerobically digested pig slurry instead of fossil fertilizer for hay production resulted in energy savings up to 65,000 MJ/ha, including energy available from the biogas produced during anaerobic digestion
- up to 69 percent reduced fossil fuel consumption when zone tillage in corn production replaces conventional tillage methods
- a prototype forced air dryer for water removal from leafy vegetables uses 70 percent less energy than conventional centrifugation (separation by high-speed rotation)
- replacement of the conventional three-step water process with a one-step steam process for producing fresh or frozen potatoes can reduce energy use by up to two-thirds

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REDUCED ENVIRONMENTAL IMPACTS OF CANADA'S ELECTRICITY INFRASTRUCTURE

Fossil fuels in Canada account for 27 percent of the electricity generated. The combustion of these fuels is a major source of emissions which affect air quality and climate change. The Government of Canada supports energy R&D to help reduce such environmental emissions while also preserving the benefits of hydrocarbons, particularly coal, as plentiful and inexpensive fuels for electricity power production.

PERD activities are focused on:

- electric power generation from renewable energy sources
- cleaner conversion of coal to electricity
- small-scale or distributed generation, with an emphasis on combined heat and power applications
- carbon dioxide capture and storage

For example:

CHARACTERIZATION OF FUELS AND THEIR EMISSIONS

Canada's largest remaining source of hydrocarbons is contained in coal seams. As well, these coal seams often contain in-situ unconventional methane resources, i.e. natural gas resources within the coal seams which rival the size of conventional gas resources in western Canada and the frontiers. In addition, coal could be a major source of petrochemical products now refined from oil and gas.

With better efficiency and emissions control technologies, coal-fired electrical generation can contribute to greenhouse gas reduction targets while maintaining environmental standards. It may provide an acceptable solution to electricity supply deficits now being experienced in parts of western Canada and the United States. New uses of coal, including gasification and liquefaction, may replace conventional oil and gas as these resources are depleted. Technology now under development for hydrogen production from coal could very well provide the bridge to the "hydrogen economy" of the future.

Canadian researchers are also investigating the use of deep coal seams as storage sites for greenhouse gases from electricity generation and conventional oil and gas production.

The main purpose of this PERD program is to characterize Canadian coals and their emissions for more efficient and environmentally acceptable electricity generation. The National Coal Inventory is a unique knowledge base which can be used to optimize how coal is used and minimizes its environmental impacts. It is also a valuable tool for assessing Canada's coalbed methane resources which, although vast, have had limited commercial production in Canada to date.

Technologies and the knowledge base developed through this program were instrumental in facilitating Canada's first commercial development of coalbed methane through a partnership with the private sector.

RECENT HIGHLIGHTS INCLUDE:

- monitoring of contaminants from power plant emissions to obtain baseline data
- successful testing of technologies to reduce contaminant emissions from conventional power plants

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CARBON DIOXIDE CAPTURE AND STORAGE

A possible solution to reducing Canada's greenhouse gas emissions may be to capture and store the carbon dioxide produced by large power plants.

The R&D conducted by this PERD program focuses on:

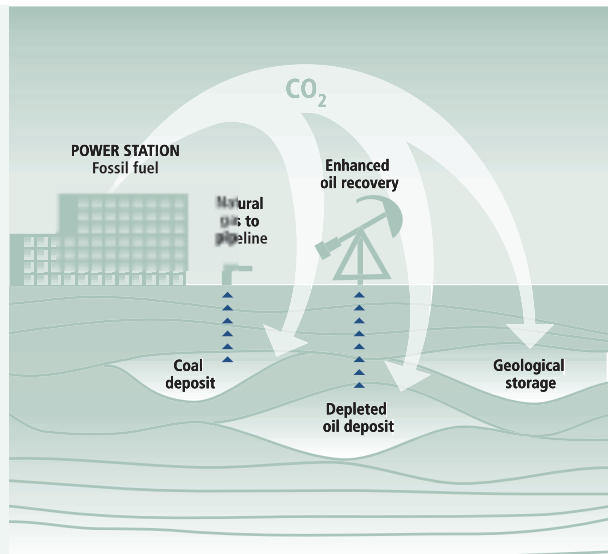
- development of combustion techniques using oxygen instead of air to effect an enrichment of carbon dioxide in the products of combustion, allowing recovery of the entire product stream for sequestration
- geological investigations to determine the capacity of underground coal beds for the storage of carbon dioxide and recovery of trapped methane
- oceanic investigations to characterize seawater chemistry changes that take place during carbon dioxide injection

RECENT HIGHLIGHTS INCLUDE:

- completion of a proprietary simulation model for predicting the performance of coal-fired boilers using oxygen combustion techniques. This tool is currently being used to support an engineering feasibility study by the Canadian Clean Power Coalition to identify the best technology and site in Canada for a Zero Emission Power Plant
- pilot tests in the Western Canadian Sedimentary Basin to develop optimum injection strategies and assess the carbon dioxide storage potential of deep coal seams that cannot be mined
- field studies of the carbon dioxide adsorptive capacity of two coals extracted from coalbed methane exploration wells in east central Alberta

Contact:

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CLIMATE CHANGE

PERD supports work which investigates the potential impacts of climate change on energy production, transmission and demand. It is also analyzing the role of forests, agricultural landscapes and oceans in the removal of carbon dioxide from the atmosphere. The program provides information to industry, regulatory bodies and government policy makers. It ensures the integration of S&T knowledge into policy and planning.

For example:

ENHANCEMENT OF GREENHOUSE GAS SINKS

The natural cycles of carbon and nitrogen that control the release and uptake of greenhouse gases are complex and sensitive to changes in the environment. Understanding these cycles and the processes that control them is key to quantifying the amount of greenhouse gases that can be removed from the atmosphere.

The use of “sinks” to reduce greenhouse gas emissions means the removal of carbon dioxide from the atmosphere by forests, agricultural landscapes and oceans. Sinks may play an important role in helping Canada meet its climate change obligations under the Kyoto Protocol. This PERD program is aimed at further studies to add to the existing body of knowledge in this area.

R&D activities are focused on:

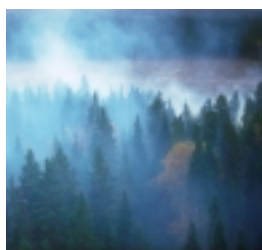
- forest sinks
- agricultural soil sinks
- ocean sinks
- hydro-electric reservoirs

RECENT HIGHLIGHTS INCLUDE:

- analysis of boreal forest data which indicates that carbon sequestration may be mainly affected by factors such as levels of rain and snowfall, and spring temperature levels
- ocean carbon studies which demonstrate the significant influence of El Nino on the biogeochemistry and uptake of carbon in the northeast Pacific Ocean
- significant scientific input towards development of a Canadian international negotiating position on carbon sinks

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PERD's International Connections

Although PERD funds energy R&D in Canada, its reach extends beyond Canada's borders. As we become more competitive in global markets, energy technologies developed here are being successfully commercialized and marketed at home and abroad. PERD helps build our national capacity for innovation in energy technology by strengthening the R&D capacity of Canadian companies. It often can play a gatekeeper role in facilitating international trade by helping its partners access energy R&D knowledge and expertise in other countries.

For example:

- Canadian energy-efficient housing technologies are being widely used in Japan
- the Canadian-developed SOLARWALL®, which offers users pre-heated ventilation air and improved exterior wall insulation, has been successfully demonstrated in Europe, Asia and Latin America
- a Canadian company, Powerbase Automation Systems, is demonstrating a turbine control unit at small-hydro plants in China – the aim is to use Canadian automatic control systems to: increase the efficiency of existing small-hydro plants; permit rehabilitation of thousands of plants now sitting idle; and make the construction of new plants more economically viable

Many PERD programs coordinate their research with the International Energy Agency (IEA) through Implementing Agreements such as Production and Utilization of Hydrogen, Advanced Fuel Cells, Bioenergy, Greenhouse Gas R&D, Process Integration, and Fisheries.

The Government of Canada also collaborates with the United States via its Memorandum of Understanding on Energy R&D with the U.S. Department of Energy, and with Mexico and the United States under trilateral agreements.

Looking Ahead

What are Canada's energy R&D priorities for the future? Security and reliability of supply, climate change, air quality, innovation – in all likelihood PERD will continue to work in these important areas over the coming years. The program continually responds to changing needs and energy policy directions. It regularly consults with its partners and stakeholders. It seeks input from national and international experts. So, while we can look ahead with some certainty about future priorities, PERD's future directions are never written in stone. Whatever the future holds, NRCan is committed to energy research today for energy solutions tomorrow.

Contact Us

If you want to know more about PERD, please contact us. For general telephone inquiries, call 613-947-3481. Or if you prefer, send us a fax (613-995-6146) or an e-mail (oerd.brde@nrcan.gc.ca).

Our Web site address is:

<http://www2.nrcan.gc.ca/es/oerd>

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Federal Government Laboratories Conducting Energy R&D

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Semiarid Prairie Agricultural Research Centre

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Saskatoon Research Centre

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Eastern Cereal and Oilseed Research Centre

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Agriculture and Agri-Food Headquarters

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Dairy and Swine Research and Development Centre

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Atlantic Food and Horticulture Research Centre

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ENVIRONMENT CANADA

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National Water Research Institute

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Atmospheric and Climate Science Directorate

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Environmental Technology Centre

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Ice and Marine Services Branch

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Canadian Meteorological Centre

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FISHERIES AND OCEANS CANADA

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DFO Central and Arctic Region facilities

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Institut Maurice-Lamontagne

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Bedford Institute of Oceanography

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Northwest Atlantic Fisheries Centre

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Atlantic Forestry Centre
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Appendix B

Panel on Energy Research and Development

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Appendix C

PERD Programs and Program Leaders

SUSTAINABLE HYDROCARBONS

Advanced Separation Technologies (\$2.468 M)

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Conversion of Bitumen, Heavy Oil, Natural Gas and Waste Oils (3.887 M)

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Offshore Environmental Factors for Regulatory, Design, Safety and Economic Purposes (\$2.688 M)

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Northern Hydrocarbon Production (\$624 K)

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Marine Transportation and Safety (\$702 K)

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Regulatory Requirements for Offshore Drilling and Production Wastes, Assessment of Cumulative Effects, and Remediation of Accidental Offshore Discharge and Spills (\$760 K)

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Flaring Research Initiative (\$657 K)

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Regulation, Construction and Maintenance of Pipelines (\$1.503 M)

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Soil and Groundwater Remediation (\$954 K)

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CLEANER TRANSPORTATION

Support the Development of Technological and Other Measures to Control and Reduce Emissions of Particulate Matter (\$759 K)

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Advanced Fuels and Transportation Emissions Reduction (\$1.768 M)

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Transportation Fuels from Renewable Sources (\$939 K)

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Canadian Light Weight Materials Research Initiative (CLIMRI) (\$807 K)

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Fuel Cells, Electric and Hybrid Vehicles (\$2.692 M)

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Hydrogen Production, Storage and Infrastructure (\$1.498 M)

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Optimization of the Energy Efficiency of Transportation Systems (\$2.262 M)

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ENERGY-EFFICIENT BUILDINGS AND COMMUNITIES

Buildings (\$4.562 M)

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Application of Renewable Energy Technologies and Integrated Systems in Off-grid/Remote Communities (\$583 K)

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Energy Management for Sustainable Communities (\$957 K)

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ENERGY-EFFICIENT INDUSTRY

Industry Energy Research and Development (IERD) (\$4.162 M)

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Reduction of Fossil Fuel Energy Intensity in Canada's Agri-Food Sector (\$791 K)

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Reduce the Fossil Energy Intensity of Canada's Fishing Industry (\$374 K)

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Forest and Forest Products Industry (\$1.248 M)

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Reduction of the Fossil Energy Intensity of Canada's Mining and Metals Industries (\$149 K)

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Agricultural and Forestry Biomass Supply for Energy (\$433 K)

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Research, Development and Deployment for Industrial Sensors and Controls (\$373 K)

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Process Integration (\$800 K)

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Research, Development and Deployment for Industrial Separation and Refrigeration (\$1.059 M)

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Clean and Efficient Industrial Combustion Technologies (\$1.302 M)

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REDUCED ENVIRONMENTAL IMPACTS OF CANADA'S ELECTRICITY INFRASTRUCTURE

Electricity From Renewable Energy Technologies (\$1.203 M)

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Distributed Generation – Fossil Fuel (\$716 K)

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Characterization of Canadian Fuels and Their Emissions (\$704 K)

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Clean and Efficient Combustion Technologies for Large Utility Electricity Generation (\$1.935 M)

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CO₂ Capture and Storage (\$1.036 M)

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CLIMATE CHANGE

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