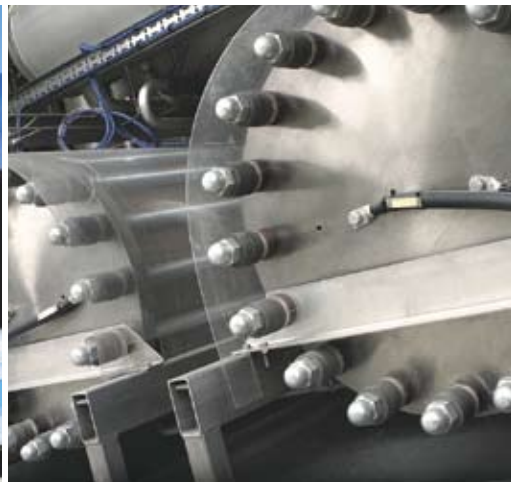


## Canadian Hydrogen and Fuel Cell Sector Profile 2007



Since 2004, the Government of Canada, Hydrogen & Fuel Cells Canada and PricewaterhouseCoopers have partnered to develop a comprehensive profile of the Canadian hydrogen and fuel cell sector. Building on the success of its previous three editions, the Canadian Hydrogen and Fuel Cell Sector Profile has been updated for 2007. The 2007 Sector Profile responds to the needs of industry stakeholders—companies, governments, academia and investors—to obtain the current economic and corporate information required to assess and benchmark the progress of the industry. The profile describes the sector in terms of revenue, research, development and demonstration activity and employment. These statistics are needed to keep policy-makers, investors and other stakeholders informed, and assess Canada's position within the international hydrogen and fuel cell community.

The Profile is published annually to ensure that this important sector of the Canadian economy is consistently measured, its trends tracked and its achievements and growth recognized. We thank all the companies and organizations that contributed to the development of the Canadian Hydrogen and Fuel Cell Sector Profile 2007.

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*Aussi offert en français sous le titre Profil 2006 du secteur canadienne  
de l'hydrogène et des piles à combustible.*

# Canadian Hydrogen and Fuel Cell Sector Profile 2007

## Introduction

The Canadian Hydrogen and Fuel Cell Sector Profile 2007 measures several key performance indicators and helps to provide an objective assessment of Canada's position within the increasingly competitive global industry. As the industry advances towards commercialization, the Canadian sector continues to mature and build its reputation globally.

This year's Profile describes a stable Canadian sector. The core metrics of revenue and employment correspond closely to the previous year's assessment of the sector. Revenue for 2006 was reported at \$133 million, similar to \$135 million reported for 2005. Product sales, the largest revenue stream, was reported at \$89 million for 2006, the same amount reported in 2004. Employment in this year's survey was reported at 2,043 compared to 1,902 in 2005. Research, development and demonstration (RD&D) expenditures continued a declining trend, being reported at \$193 million in 2006 compared with \$218 million in 2005 and \$237 million in 2004.

These results suggest a technology sector heading towards commercial product sales in early markets, while continuing to strongly invest in R&D.

### The industry at a glance

- Revenue stood at \$133 million in 2006, similar to \$135 million reported in 2005.
- Product sales were at \$89 million in 2006, a drop of 8% from \$97 million in 2005.
- Research, development and demonstration expenditures decreased 11% to \$193 million in 2006 from \$218 million in 2005.
- Employment increased to 2,043 in 2006 compared to 1,902 in 2005.
- The number of demonstration projects declined 12% to 125 in 2006 from 142 in 2005.
- The number of strategic alliances reported in 2006 was 124.
- There were 221 research partnerships reported in 2006.

# Organization profile

## Organization type

Corporate organizations, both public and private companies, represented almost two-thirds (61%) of total responses. As private companies are not obliged to provide financial or other data to the market, their voluntary participation in these profiles continues to provide a more thorough appreciation of the size and activities of the hydrogen and fuel cell industry in Canada. Government and government agencies accounted for almost one quarter of respondents (24%), with academic organizations, non-profit organizations and NGOs representing the remaining 15% of respondents.

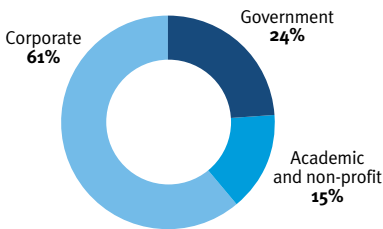
## Number of years involved in hydrogen / fuel cell activities

The vast majority of organizations (75%) reported ten years or less involvement in hydrogen and fuel cell activities, with 58% of respondents reporting between five and ten years of activity. This indicates an experienced but still maturing Canadian industry sector.

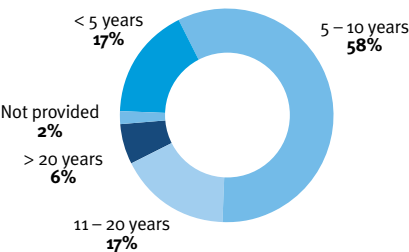
## Areas of expertise

The Canadian hydrogen and fuel cell sector has a broad foundation of expertise. Conducting research, closely followed by fuel cell development and manufacturing were identified as the top areas of expertise. Other notable areas include hydrogen production, commercialization support and supplier to developer or manufacturer. The results indicate that the Canadian sector participants continue to maintain and develop expertise in a wide range of areas across both hydrogen and fuel cell categories, with activities ranging from manufacturing, distribution, education and training, through to sales. 'Other' areas cited by participants included battery integration, Formira fuel cell development, hydrogen inhibitors, and engineering consulting.

Organization type

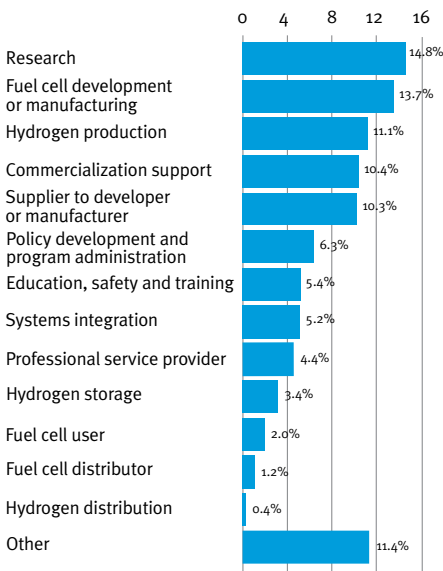


Number of years involved in hydrogen/fuel cell activities



Areas of expertise

(Respondents may be included in several categories)



Market focus

The mobile (34%) and stationary applications (29%) both represented the largest market focus, followed by fueling infrastructure and portable. This split of market focus was consistent with the previous year.

Technology focus

Consistent with the results of the 2006 Profile, technology activities were primarily focused (37%) on Proton Exchange Membrane (PEM) fuel cells. These reflect Canada’s global recognition as a leader in the development of PEM fuel cell technology for mobile, small stationary and portable applications. Other areas of technology focus (16%) cited by

respondents include: hydrogen internal combustion engines (H-ICE), power supply packs, hydrogen purification, batteries, Magnesium Air (MAFC) and Formira fuel cells along with hydrogen safety and infrastructure related products.

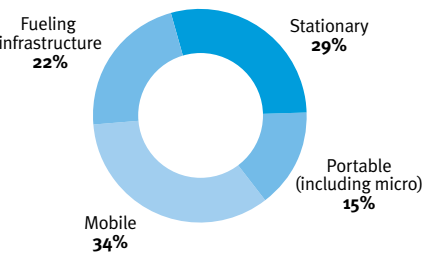
Location of hydrogen/ fuel cell facilities

Respondents reported the bulk of hydrogen and fuel cell-related facilities are in Western Canada (47%) and Eastern Canada (25%). Consistent with prior years, additional fuel cell related activity was conducted at facilities in the United States, Germany and Japan. Activity was also conducted in other countries, including Australia, Belgium, China, Czech Republic, Korea, Mexico and Spain.

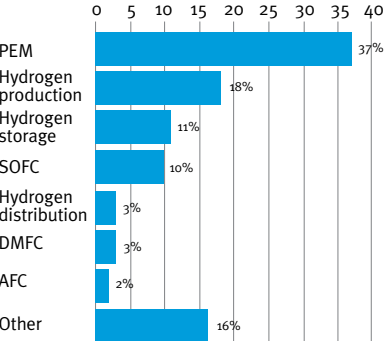
\* Definitions

- AFC = Alkaline fuel cell
- DMFC = Direct methanol fuel cell
- SOFC = Solid oxide fuel cell
- PEM = Proton exchange membrane

Market focus



Technology focus\*



Location of hydrogen/fuel cell facilities

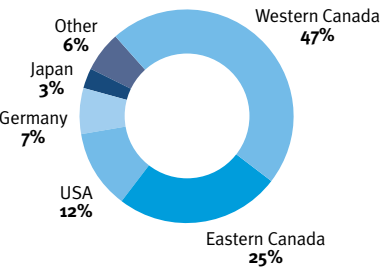




Photo courtesy of Powertech Labs.

## Revenue

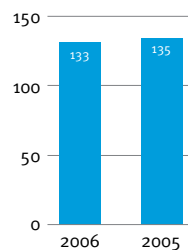
Total revenue from hydrogen and fuel cell activities reported by respondents was \$133 million in 2006 compared to \$135 million in 2005.

### Revenue by type

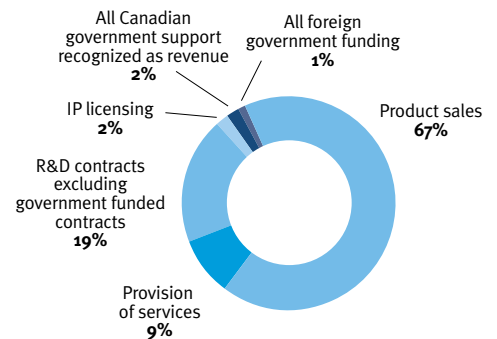
Product sales continue to comprise the largest revenue stream at \$89 million for 2006, a drop of 8% from the \$97 million observed in 2005. It is worth noting that the 2006 product revenue is consistent with that reported in 2004 of \$89 million, demonstrating the ability of the sector to consistently generate revenue as it moves towards early commercialization.

R&D contracts, excluding government funded contracts, were reported at \$25 million, followed by the provision of services reported at \$12 million. It should be noted that although some organizations recognize support from Canadian governments as revenue, the bulk of this support is provided through funding, as outlined in the research, development and demonstration section of this profile.

### Total revenue



### Revenue by type



# Research, development and demonstration

As in 2006, the 2007 survey asked respondents to supply information on research, development and demonstration expenditures for hydrogen and fuel cell activities, as opposed to strictly research and development (R&D) expenditures as was the case in previous years of the survey. Total RD&D expenditures were reported at \$193 million in 2006, a decrease of 11%

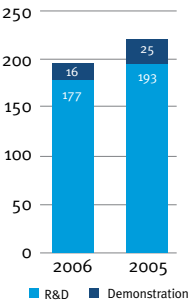
from \$218 million in 2005. Of this total, \$177 million (92%) was reported for R&D and the balance of \$16 million (8%) was for demonstration projects. The 2006 results compare with \$193 million (89%) reported for R&D in 2005 and \$25 million (11%) for demonstrations projects. These results again showing consistency in spending proportions for the sector.

## Research, development and demonstration by region

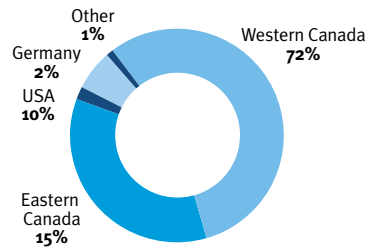
Geographic data was provided for \$186 million of the total RD&D dollars. Consistent with prior years, Western and Eastern Canada accounted for the majority of RD&D expenditures in 2006.

Total RD&D in 2006			
\$ million	R&D	Demonstration	Total
Corporate	\$133.4	\$7.9	\$141.3
Government	\$37.9	\$8.1	\$46.0
Academic and non-profit	\$5.9	–	\$5.9
Total RD&D	\$177.2	\$16.0	\$193.2

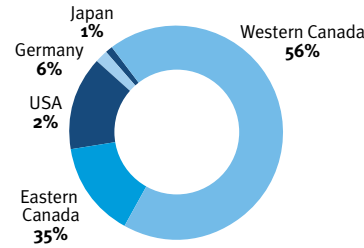
Total research, development and demonstration



Research and development by region



Demonstration by region





# Research and development

## Source of funding for R&D

The table indicates the split of R&D expenditure by source. Corporate respondents receive almost half their R&D funding from equity finance (48%).

Sources of R&D funding for government organizations were predominantly from internal sources. Academic and non-profit respondents cited Canadian government (76%) and academic institutes (19%) as their top sources of R&D funding.

# Patents

Corporate respondents reported 84 newly approved patents in 2006, up from 64 reported in 2005. With a total of 918 patents held, this demonstrates an ongoing commitment to innovation within the Canadian industry.

Total R&D expenditure by source	Total \$ million
Corporate operations	\$25.1
Parent, affiliated or subsidiary organization	\$11.6
Canadian government (all levels)	\$27.0
Foreign government	\$5.3
Contract work conducted for another institute	\$1.3
Academic institute	\$0.7
Research, non-profit, non-governmental institute	\$0.1
Equity finance	\$36.7
Other	\$0.7
Total	\$108.5

Sources of R&D expenditure data was only provided for \$108.5 million of the total R&D dollars.

## Relative R&D expenditures by respondent type (%)

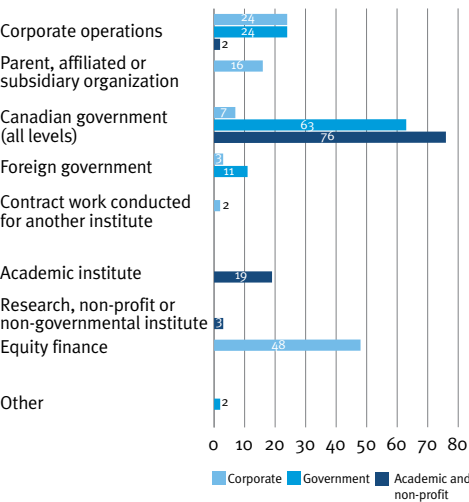


Photo courtesy of Questair Technologies.





# Demonstration projects

Respondents reported fewer demonstration projects in 2006 (125) compared with 2005 (142). The number of mobile demonstration projects and fueling infrastructure projects were virtually even in terms of numbers. There has been a steady reduction in demonstration projects reported since 2004. Demonstration projects represent a valuable opportunity to increase public and investor knowledge, and most expenditure takes place in the earlier years of product development.

Geographic data was provided for \$16 million of the total demonstration expenditure. The majority of demonstration projects (66%) are Canadian-based, which is consistent with that reported for 2005, with almost half of the demonstration projects taking place in Western Canada.

## Demonstration focus

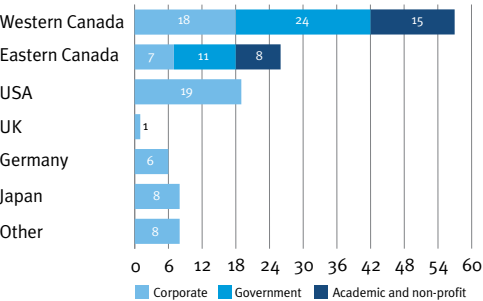
Corporate respondents were primarily involved in mobile (39%), portable (25%), and stationary demonstration projects (21%),

whereas government respondents remained focused on fueling infrastructure projects (50%), followed by mobile demonstration projects (28%). Academic respondents also indicated fueling infrastructure (39%) as their primary focus, followed by mobile (31%) and stationary (26%) demonstration projects.

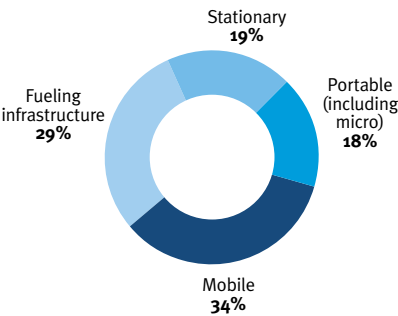
Overall, fueling infrastructure is the primary focus for the government and academic participants but less of an area of focus for the corporate sector.

Category of Demonstrations	Corporate	Government	Academic and non-profit
Stationary	21%	11%	26%
Portable (including micro)	25%	11%	4%
Mobile	39%	28%	31%
Fueling infrastructure (including hydrogen production, distribution and storage)	15%	50%	39%
Total	100%	100%	100%

Location of demonstration projects (number)



Overall focus of demonstration projects



## Employees

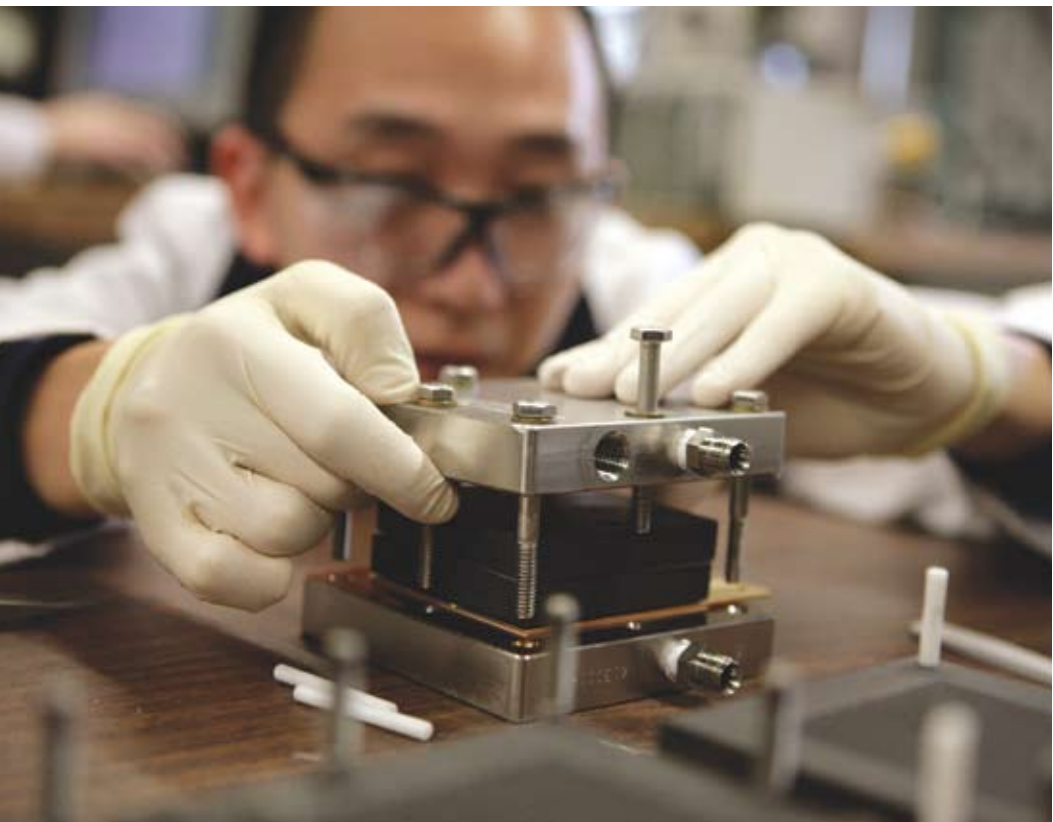


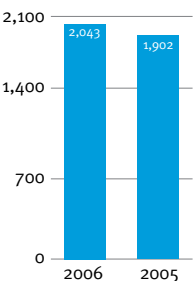
Photo courtesy of BC Hydrogen Highway.

Respondents reported a total of 2,043 employees focused on hydrogen and fuel cell activities in 2006, compared with 1,902 in 2005.

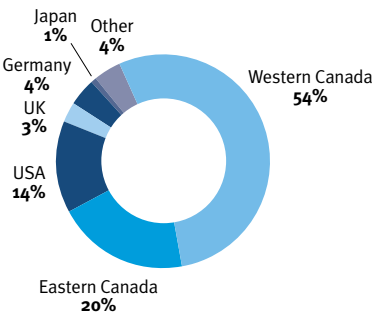
The largest employment cluster reported was in Western Canada (54%), followed by Eastern Canada (20%), for a total of 1,512 employees across the country as a whole. Consistent with prior years, other countries represented included United States, Germany, Japan and the United Kingdom. The fact that many partners and markets are located outside of Canada illustrates that the Canadian hydrogen and fuel cell sector has a global outlook.

Not all respondents provided data on number of employees and total salaries. Based on the data provided on the number of employees and total salaries, the average annual salary paid to hydrogen and fuel cell employees in Canada increased 14% to \$63,256 in 2006 from \$55,262 in 2005. Extrapolating the average salary for 2006 to the total 1,512 employees in Canada, the sector contributes \$96 million in salaries to the national economy.

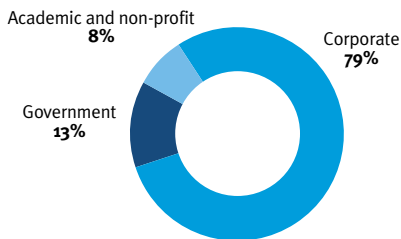
Employment



Employees by region



Employees by respondent type



# Funding requirements

Continued education of governments and public capital markets on the benefits of investing in the hydrogen and fuel cell industry is an important part of the industry's efforts to secure funding. Given the industry's long development period and demanding RD&D requirements, patient financing is necessary to bring commercial products to market.

## Corporate

Corporate respondents were asked to identify their capital requirements for the period 2008 to 2013 and, if possible, to break down their requirements by year and expected funding source. Respondents estimated total capital requirements for this period at \$864 million with

operations (37%), private equity (23%) and public capital markets (18%) identified as the leading expected sources of this funding.

## Government

Government respondents indicated that their total budget for hydrogen and fuel cell related activities in 2006, excluding employee salaries and benefits, was \$30 million. Sources of this funding were programs (71%), departmental operating budgets (24%) and other (5%).

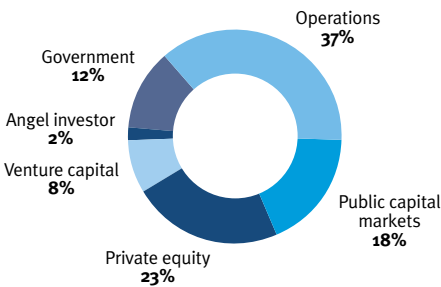
The bulk of funding (72%) was expected to be allocated to Western Canada, with intramural R&D (34%), in-house R&D and pilot projects both identified at 30%, as the primary funding areas.

## Academic and non-profit

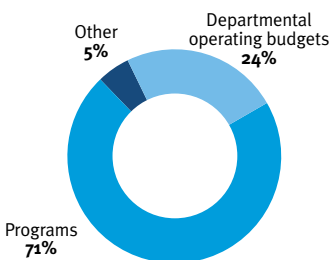
Academic and non-profit respondents indicated that their total 2006 budget for hydrogen and fuel cell related activities, excluding employee salaries and benefits, was \$6 million. Other federal government funding (34%) constituted the top source of funding. Private investor and donation (24%) and NSERC/Canadian Foundation for innovation (22%) were the next two main funding sources.

In-house R&D (47%) and demonstration and pilot projects (34%), were identified as the two primary areas for funding allocation.

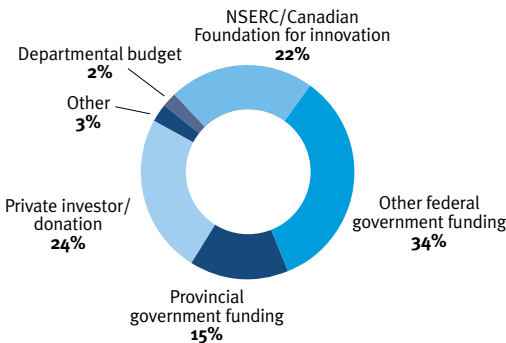
Expected funding sources – Corporate



Expected funding sources – Government



Expected funding sources – Academic and non-profit

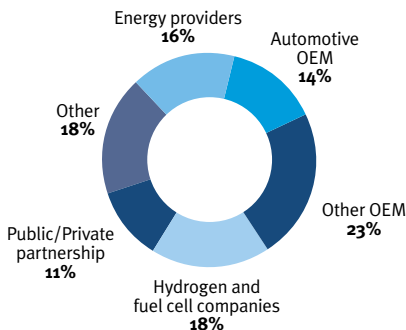


## Strategic alliances

A total of 124 strategic alliances were reported in 2006, confirming the continued value and importance of key relationships and partnerships in the industry.

Other OEMs represented almost a quarter (23%) of strategic alliance partnerships. Hydrogen and fuel cell companies accounted for 18%, followed by energy providers (16%) and automotive OEM at 14%.

Strategic alliances



## Research partnerships

This year's survey included questions on research partnerships which promote closer collaboration between the university research community and other sectors, including government and Canadian industry. There were 221 research partnerships reported in 2006.

Partnerships with industry in Canada represented almost a third (32%) of all research partnerships. Twenty-seven percent of organizations were in

partnership with Canadian academic and non-profit associations.

The number of research partnerships signifies the necessity of pre-commercial collaboration in order to address common technical challenges.

The chart below illustrates the many varied types of partnerships and collaboration in the hydrogen and fuel cell sector within Canada and outside the country.

Research partnerships (number)	Corporate	Government	Academic and non-profit	Total
In partnership with all levels of Canadian governments (federal, provincial/territorial and municipal)	14	11	8	33
In partnership with foreign government	7	11	1	19
In partnership with Canadian academia/ non-profit/associations	15	28	16	59
In partnership with industry in Canada	14	41	16	71
In partnership with industry out of Canada	27	8	—	35
Other	4	—	—	4
Total	81	99	41	221

## Methodology and response rates

The 2007 Sector Profile is the fourth annual publication of information on the Canadian Hydrogen and Fuel Cell Industry. As in previous years, existing and potential members of Hydrogen & Fuel Cells Canada, academic institutions, government stakeholders and partners in current hydrogen and fuel cell demonstration activities were asked to voluntarily complete a survey questionnaire.

While the survey questionnaire has remained substantially consistent from the survey's inception, each year the organizers have refined the questions in order to gather more detailed information to better reflect the industry and its trends. For 2007, in sections relating to RD&D and funding, specific questions were asked for three types of stakeholders:

- Corporate (public and private organizations);
- Government (government and government agencies); and
- Academic and non-profit (educational organizations, non-profit, and non-governmental organizations (NGO)).

All monetary results are presented in Canadian dollars.

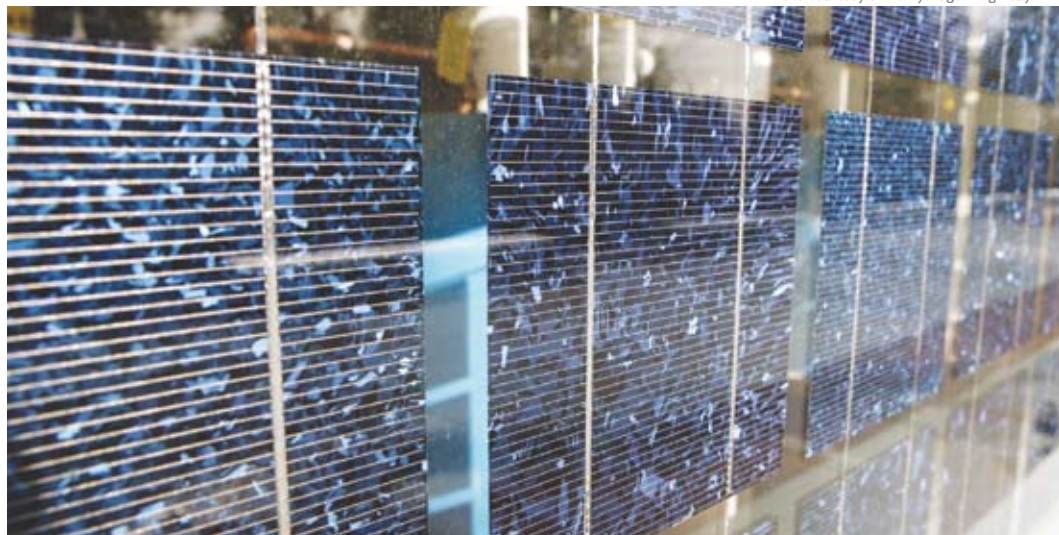
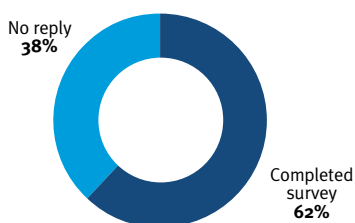
A total of 87 organizations associated with hydrogen and fuel cells in Canada were invited to participate in the development of this sector profile. Fifty-four completed responses were received, representing an overall response rate of 62%. A complete distribution list is included at the end of this report.

Not all respondents provided data for every category requested. No investigation was conducted as to the completeness of data provided by respondents or reasons for non-provision.

### Presentation of data

Figures presented for 2006 were collected by survey questionnaire in 2007/08. Figures presented for 2005 are as reported in the 2006 Sector Profile and therefore may not be fully comparable due to differing respondents and/or the basis of individual responses.

### Profile response rates



## Conclusion

- Revenue was reported at \$133 million in 2006 similar to \$135 million in 2005, with product sales being the largest category of revenue.
- Product sales remain consistent at \$89 million in 2006, the same was reported in 2004 (\$89 million), a decrease of 8% from \$97 million in 2005.
- Research, development and demonstration expenditure decreased 11% to \$193 million in 2006 versus \$218 million in 2005. This is the second consecutive year of decrease.
- Employment increased to 2,043 in 2006 compared to 1,902 in 2005, with Western Canada once again accounting for the largest employment cluster.
- The number of demonstration projects declined 12% to 125 in 2006 from 142 in 2005.
- The number of strategic alliances reported in 2006 was 124.
- There were 221 research partnerships reported in 2006.

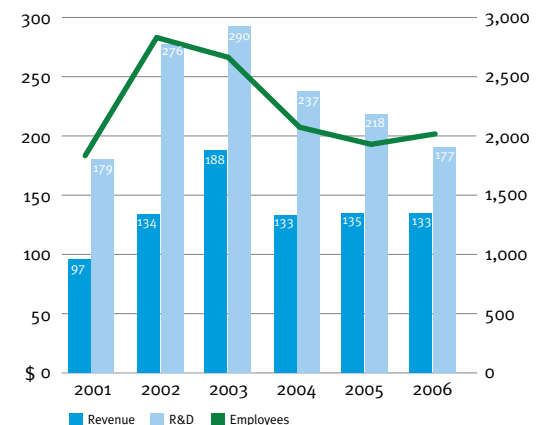
The data collected for this sector profile shows overall that the hydrogen and fuel cell sector in Canada remains stable as it concentrates on building commercial product sales. While research and development remains an important constituent of this maturing technology sector, the consistency of the largest revenue stream – product sales – demonstrates the sector is moving towards early commercialization.

The Government of Canada, Hydrogen & Fuel Cells Canada and PricewaterhouseCoopers would like to thank the organizations that took part in this survey. By participating, stakeholders from private industry, government and academia showed their support for improving publicly available industry intelligence. This information will be used to support funding decisions, influence alliance partnerships, and strengthen the overall competitive position of the Canadian hydrogen and fuel cell industry.

## Growth since 2001

An initial sector profile, *The Economic Impact of Industrial Hydrogen Activity in Canada*, conducted by Sypher Mueller and Natural Resources Canada in 2001, provided the first glimpse into the sector's early days. Subsequent Government of Canada, Hydrogen & Fuel Cells Canada and PricewaterhouseCoopers Sector Profiles have updated the original industry benchmark study to demonstrate an active hydrogen and fuel cell sector within Canada. Although some data may not be fully comparable due to differing methodology, we can see significant growth in the industry over the six-year period:

- Revenue has grown 37% – from \$97 million in 2001 to \$133 million in 2006.
- R&D expenditures have decreased 1% from \$179 million in 2001 to \$177 million in 2006.
- Employment in the industry has seen an increase of 15% from 1,772 in 2001 to 2,043 in 2006.





## Industry Canada

Industry Canada's goal is to enhance the competitiveness of Canadian industry. The organization is responsible for maintaining channels of communication with key sectors to facilitate informed advocacy of industry interests in government decision-making and to convey the government perspective back to industry; analyzing the challenges and opportunities that face key sectors in the economy; developing policy options for possible government response to extraordinary challenges and opportunities; and delivering the subsequent program and services.

## Hydrogen & Fuel Cells Canada

As a collective voice for the industry, Hydrogen & Fuel Cells Canada works to raise awareness of the economic, environmental and social benefits of hydrogen and fuel cell technologies and products. We are the prime source of services and support to Canadian corporations, governments and educational institutions promoting, developing, demonstrating and deploying fuel cell and hydrogen products and services in Canada.

## PricewaterhouseCoopers

PricewaterhouseCoopers understands and supports the fuel cell industry in Canada and around the world. Our Alternative Energy network of professional staff drawn from over 150,000 people in over 150 countries has a firm grasp of the issues facing companies in the industry as it evolves towards commercialization. We are continually expanding our knowledge and client base with the goal of being the pre-eminent advisor to the industry in local, national and global markets.

For more information on the Canadian hydrogen and fuel cell sector profile please contact:

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# Invited to participate

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Air Liquide Canada  
Alberta Research Council Inc.  
Angstrom Power Inc.  
Armstrong Monitoring Corporation  
Atlantic Hydrogen Inc.  
Ballard Power Systems Inc.  
BC Transit  
Canadian Hydrogen Energy Corporation Ltd.  
Cimtex Industries Ltd.  
Dana Canada Corporation  
Dpoint Technologies  
DuPont Canada Inc.  
Dynetek Industries Ltd.  
Eagle Graphite Corporation  
Enbridge Gas Distribution  
Energix Research Inc.  
Energyor Technologies Inc  
EnergyQBD Inc.  
Ford Motor Company  
FuelCon Systems Inc.  
FuelMaker Corporation  
General Motors of Canada  
Government of BC, Ministry of Energy, Mines Petroleum  
Government of Manitoba  
Heliocentris Energy Systems  
HSM Systems  
HTC Hydrogen Technologies Corp.  
Hydrogen & Fuel Cells Canada  
Hydrogen Research Institute

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Industry Canada – Resource Processing Industries Branch  
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(formerly TPC h2EA and TPC R&D)  
INRS (Institut national de la recherche scientifique)  
Institute for Integrated Energy Systems (IESVic)  
University of Victoria  
Kraus Global Inc.  
Linde Gas  
MagPower Systems Inc.  
MARCON Management Consultants  
McGill University  
Membrane Reactor Technologies Ltd.  
Mitsubishi Canada  
MKU Canada Inc. o.a. Astris Energi  
Mountain Power Inc.  
National Research Council Canada, Institute for  
Chemical Process and Environmental Technology  
National Research Council, Institute for Fuel Cell Innovation  
National Research Council, H2FC Program  
Natural Resources Canada, CANMET  
Natural Sciences and Engineering Council of Canada  
Neodym Technologies  
NORAM Engineering & Constructors Ltd.  
NxtGen Emission Controls  
Ontario Ministry of Research and Innovation  
Palcan Power Systems  
PEM Engineers

Plug Power Canada  
PolyFuel Inc.  
Power Air Corporation  
PowerDisc Development Corporation Ltd.  
PowerTech Labs  
Purolator  
Queens RMC Fuel Cell Research Centre  
QuestAir Technologies Inc.  
Reknewco  
Sacre-Davey Engineering  
Sarnia-Lambton Economic Partnership  
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Stantec Consulting Ltd.  
Sustainable Energy Technologies Ltd.  
Tekion Inc.  
Teleflex Canada Inc.  
Toyota Canada  
University of Alberta  
University of British Columbia  
University of Calgary  
University of Waterloo  
Versa Power Systems  
Viridis Technologies  
Western Economic Diversification Canada  
Westport Innovations Inc.