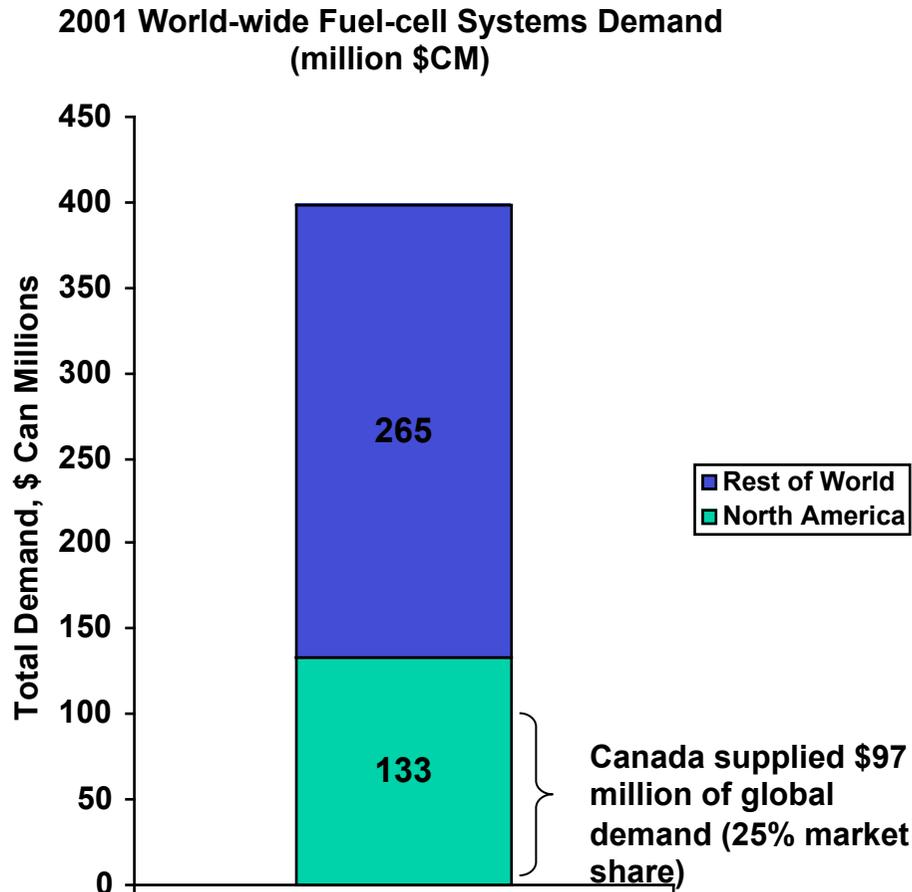


- **Background**
- **Analytical Approach**
- **Indigenous Resources Mapping**
- **Cluster Identification and Description**
- **Industry Cluster Assessments**
 - **Agriculture**
 - **Energy**
 - **Mining**
 - **Tourism**
 - **Marine**
- **Enabling Environment Assessment**
- **British Columbia's Competitiveness**
- **Regional Perspectives**
- **2010 Games--Leveraging Regional Benefits**
- **Economic Roadmap and Recommendations**
- **Bibliography**

- **Forest Products**
- **Technology**

Global Fuel-cell systems revenues were just \$398 million in 2001; Canada, and particularly British Columbia, are major players with 25% of the market share



Global Fuel Cell Industry Characteristics
<ul style="list-style-type: none"> • Proven technology with tremendous potential, but not yet commercialized • Strong interest from government agencies worldwide in promoting the technology and industry • Currently undergoing transition from Demonstration to Early Market stage • Production volumes are beginning to increase, as demand develops and costs decrease

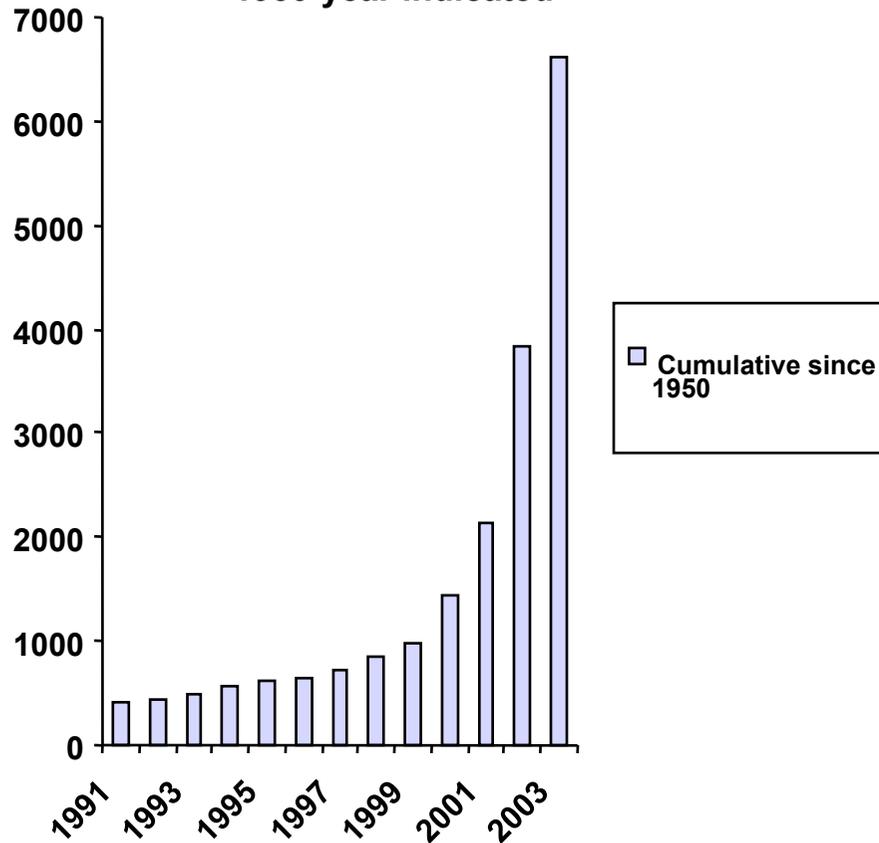
Source: "Fuel Cells: The Opportunity for Canada," Pricewaterhouse Coopers, June 2002; "2003 Fuel Cell Industry Survey," Pricewaterhouse Coopers, 2003; Signal Hill Advisors analysis

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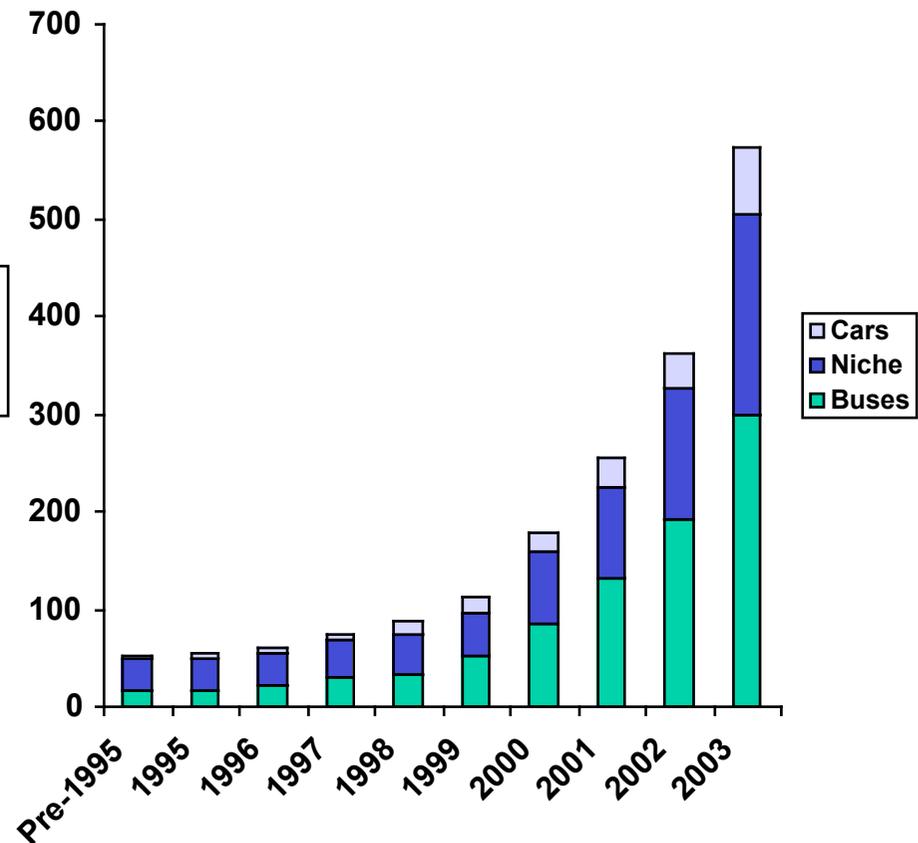
MARKET ATTRACTIVENESS...

The fuel cell market has been in a development stage for many years; as of 2003, fewer than 7000 total fuel cells had ever been produced (excluding small demonstration models), along with just 580 fuel-cell powered vehicles

Cumulative Global Production of Fuel Cells, 1950-year indicated



Cumulative Global Production of Fuel Cell-based vehicles (not including space vehicles), 1950-year indicated



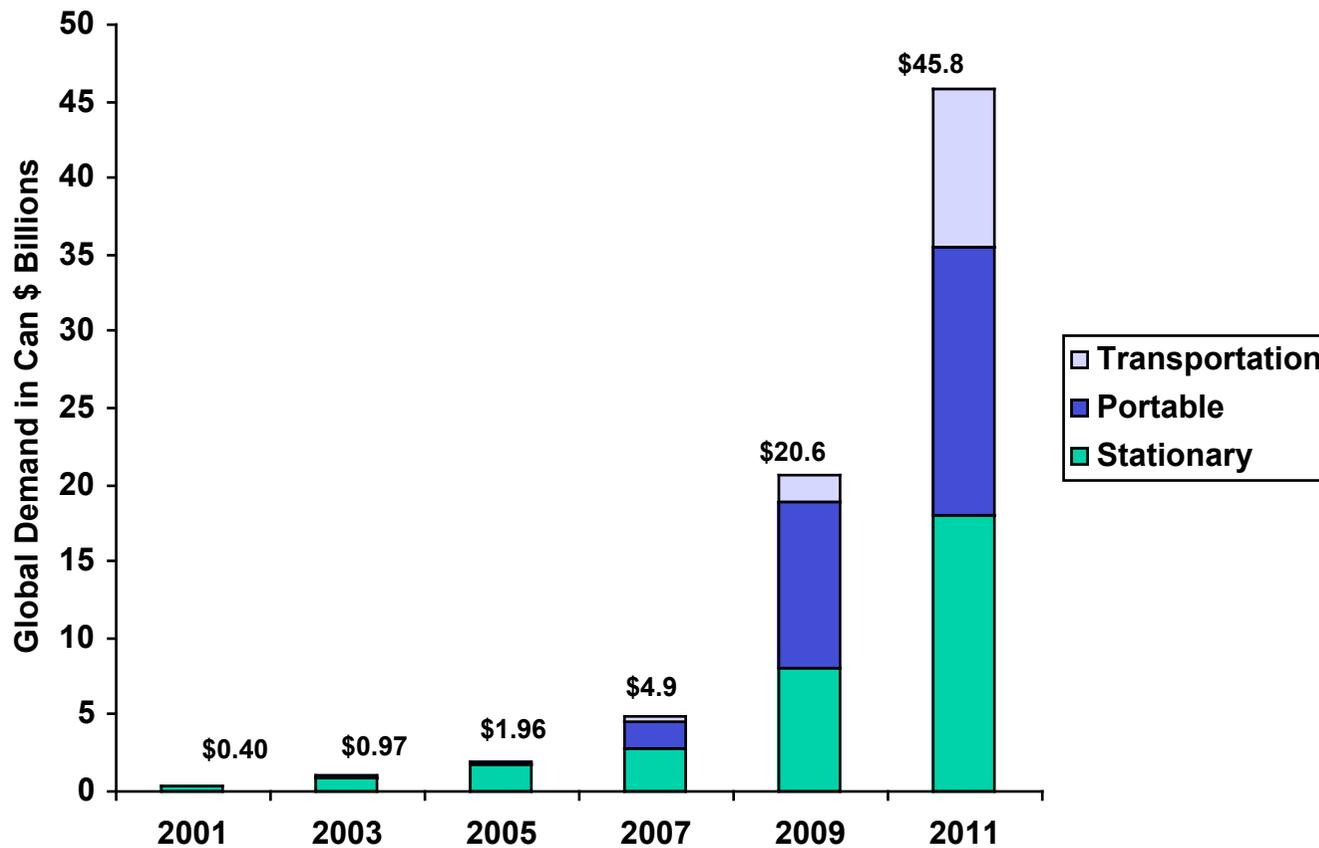
Source: "Fuel Cell Systems: A Survey of Worldwide Activity," Fuel Cell Today, 5 Nov 2003

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MARKET ATTRACTIVENESS...

The fuel cell market is widely expected to increase exponentially over the next decade as costs decrease, environmentally conscious governments and consumers promote adoption, and new applications are commercialized

Estimated Global Demand to 2011, by Market Segment

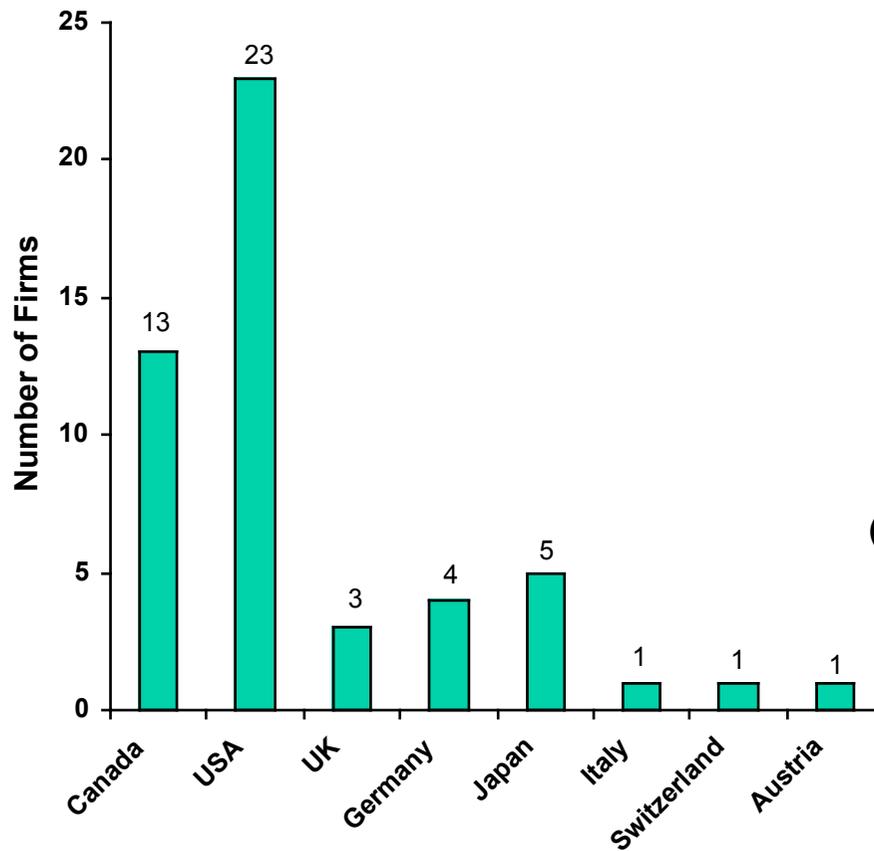


Source: "Fuel Cells: The Opportunity for Canada," PricewaterhouseCoopers, June 2002

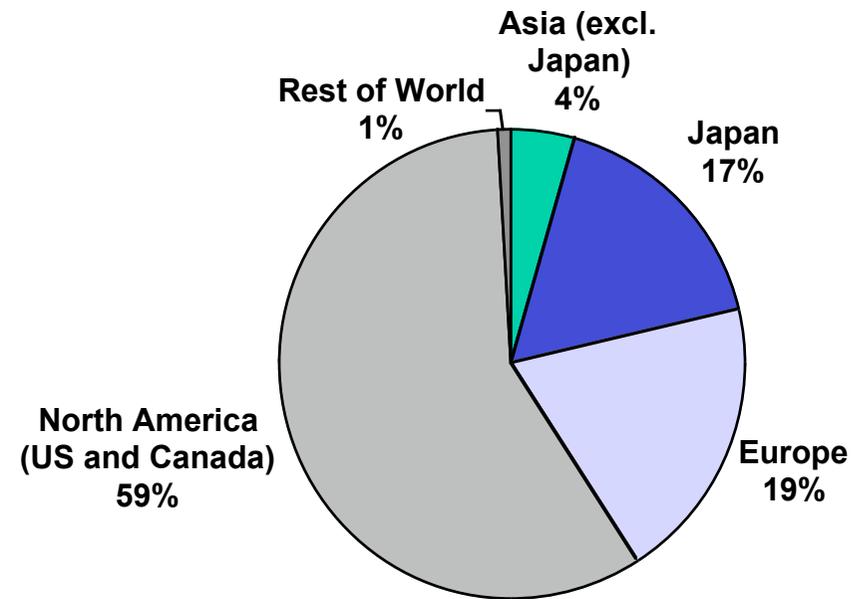
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Canada and the United States have the largest number of fuel-cell producing companies, and together have produced most (59%) of the world's fuel cells

2001 Number of Fuel Cell Producers per Country



Total Fuel Cell Systems Built, 1950-2003, by Region of Development

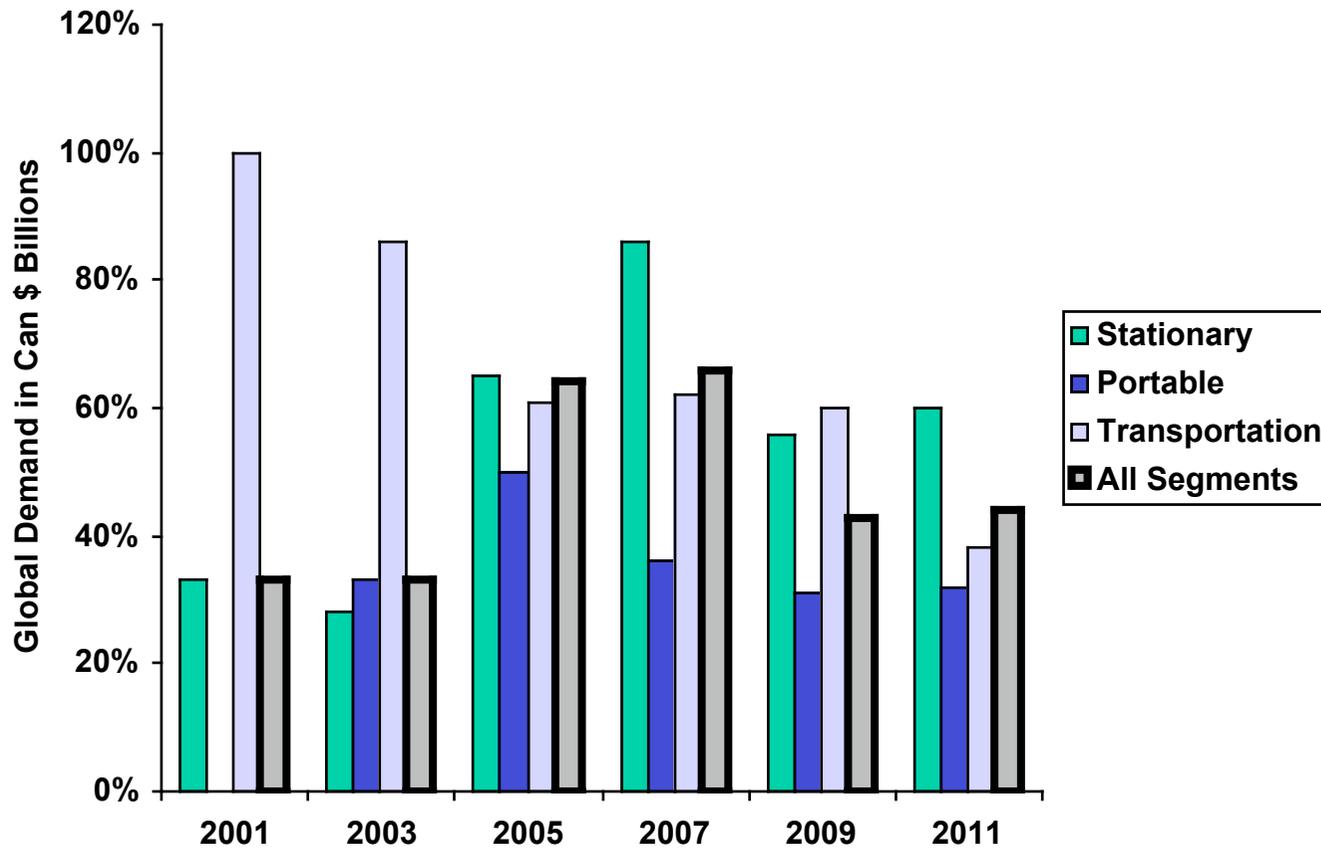


Source: "Fuel Cell Systems: A Survey of Worldwide Activity," Fuel Cell Today, 5 Nov 2003

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During the next decade, North America is expected to be the largest single market for fuel cells, with 44% of the total demand in 2011

North American share of global fuel cell demand to 2011, by segment and for all segments combined



Source: "Fuel Cells: The Opportunity for Canada," PricewaterhouseCoopers, June 2002

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Fuel cell technology is approaching maturity just as the market demand for a clean, reliable, efficient alternative energy source is rising

FUEL CELL INDUSTRY DEMAND DRIVERS

Environmental Concerns

•Demand: Many countries seek cleaner energy sources with lower greenhouse gas emissions to reduce global warming and comply with Kyoto protocol commitments

•Response: Fuel cells have zero or near zero greenhouse gas emissions

Energy Security

•Demand: US, Europe, Japan, China are heavily dependent on imported oil

•Response: Hydrogen for fuel cells can be produced in many ways, and are not necessarily reliant on fossil fuels

Energy Reliability

•Demand: Many countries, including US (e.g., California, Northeast) have experienced brownouts and blackouts

•Response: Fuel cells are very reliable backup power sources that can efficiently power critical equipment in a power emergency

Global Fuel Cell Industry

Distributed Power

•Demand: Access to electricity is currently limited to those areas reached by electrical power grids, leaving remote areas without power

•Response: Fuel cells can provide power to remote areas, such as distant villages or cellular telecommunications towers

Performance

•Demand: Electronics industry and others are seeking long-life replacements for rechargeable batteries

•Response: Micro-sized fuel cells have been developed to power laptop computers and cellular telephones from methanol

Fuel Stock Efficiency

•Demand: As petroleum prices rise, there is an incentive to maximize the power output per unit of fuel

•Response: Fuel cells offer double the energy efficiency of internal combustion engines

B.C. fuel cell companies address all of these needs – except for micro-sized fuel cells

Source: Signal Hill Advisors analysis

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Despite their promise, the structural barriers to widespread fuel cell adoption are significant

FUEL CELL INDUSTRY STRUCTURAL DRIVERS

	Consumer	Fuel Distribution	Fuel Production	Fuel Cell Manufacturing	Materials, Components
Input	<ul style="list-style-type: none"> Limited willingness to pay a high premium for new technology over existing, petroleum-based alternatives 	<ul style="list-style-type: none"> H₂ fueling stations are very rare, and exist only in some major cities (e.g., London, Los Angeles) Without a customer base, there's no economic support for new stations 	<ul style="list-style-type: none"> Current hydrogen fuel production capacity is small Many possible fuel formulations (e.g., compressed H₂ gas, methanol, metal-based storage), but no standard 	<ul style="list-style-type: none"> Current demand remains low; most manufacturers operate at a loss Production costs are high B.C. companies face shortage of skilled workers 	<ul style="list-style-type: none"> Fuel cells require platinum catalysts and other expensive materials, raising costs
Response	<ul style="list-style-type: none"> Sales unlikely to take off until price of fuel-cell based equipment (e.g., cars) and hydrogen fuel are competitively priced and abundant 	<ul style="list-style-type: none"> California, B.C. have both launched "hydrogen highway" initiatives, to make H₂ fueling stations available Government support will be essential to spread 	<ul style="list-style-type: none"> Government funded research is underway (US DoE, others) to explore fuel production options Different companies are competitively promoting their preferred formulation 	<ul style="list-style-type: none"> Governments worldwide are providing financial support and incentives to promote the industry Long-term financing is needed to resolve technical issues, endure until profitability 	<ul style="list-style-type: none"> R&D is underway to reduce the amount of platinum required and to seek alternative, cheaper catalysts

Source: Signal Hill Advisors Analysis

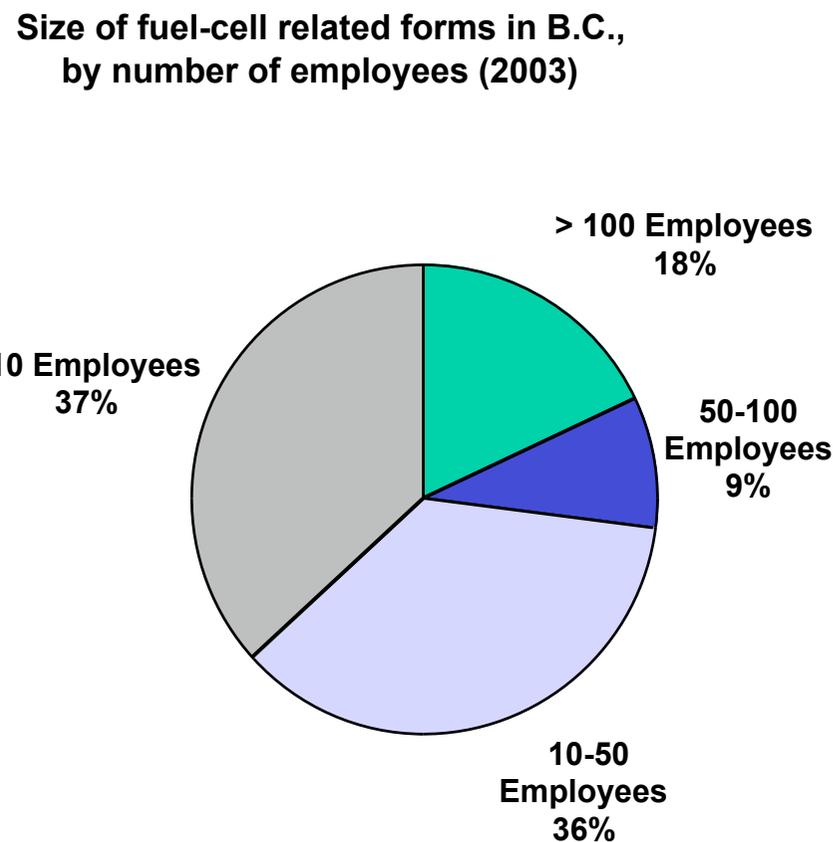
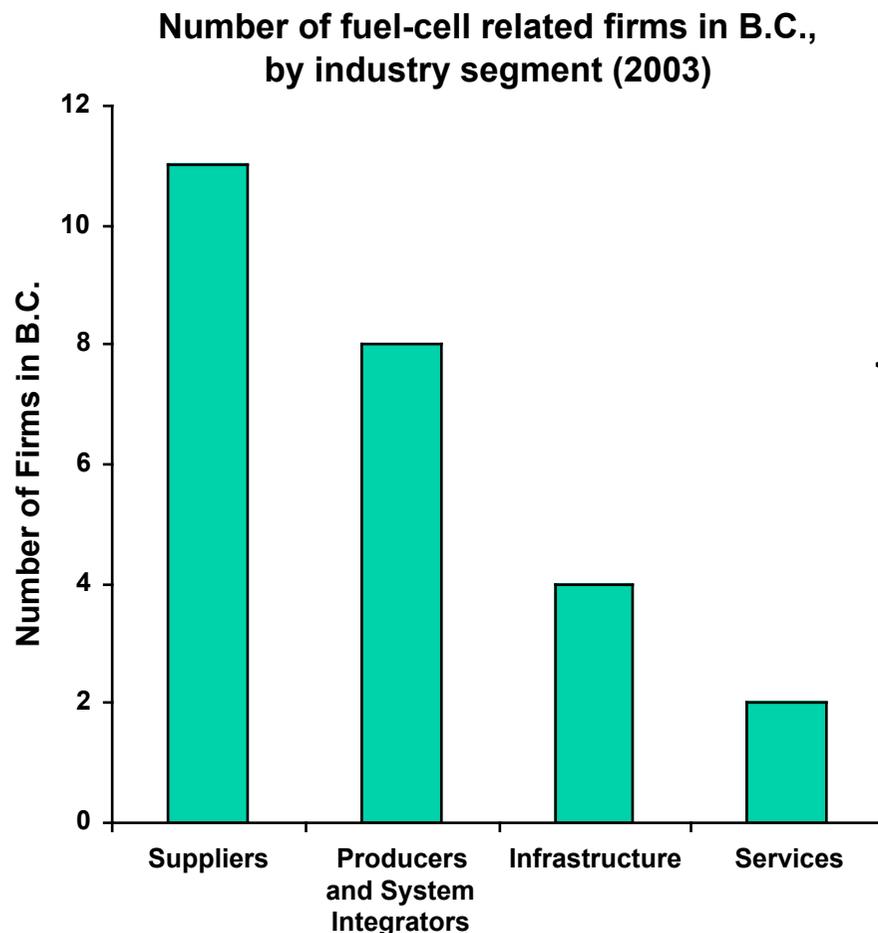
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A SWOT analysis of the British Columbia fuel cell industry shows that the cluster’s leading edge technologies make it strong, despite significant weaknesses and potential threats from international competitors--BC government and industry must focus on keeping commercialization in BC

BC FUEL CELL INDUSTRY ASSESSMENT

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> • Cluster “anchored” by Ballard Power Systems, a recognized pioneer and global leader in fuel cell technology; Ballard is the largest dedicated fuel cell company in North America • British Columbia’s fuel cell cluster is well established and older than competing clusters in other countries • Cluster includes diverse group of component suppliers, service providers, manufacturers, and OEMs • Located close to the United States, a high demand market which is home to the world’s largest number of fuel cell companies as potential customers or partners • B.C. has a very good higher education system, including several universities with graduate degrees in fuel cell engineering 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> • Fuel cell technology, while promising, remains unready for full commercialization; further advances to reduce cost will be essential • One firm, Ballard Power Systems, dominates the B.C. cluster with 60% of revenues • All firms in the B.C. cluster are small; the largest, Ballard, had US \$120 million revenues in 2003 • Qualified employees remain scarce in B.C., and are often hired into other high technology industries • Current demand remains too small to ensure profitability; small size of B.C. firms makes it more difficult to sustain financial losses while market develops • B.C. fuel cell technology is centered predominantly around one fuel cell type (PEM), rather than diversifying
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> • U.S. energy policy change to promote hydrogen fuel cell technology provides strong market and partnership opportunities • Leading-edge fuel cell technology from Ballard and other B.C. cluster members can be protected with patents, providing temporary monopoly • Larger, foreign companies may license B.C. fuel cell technology, or engage in partnerships with B.C. fuel cell firms, trading financial support for access to B.C. intellectual property • Kyoto protocol (now approved) will spur purchase of greenhouse gas-free electrical generating equipment including fuel cells 	<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> • Governments in other, larger countries are investing more heavily in fuel-cell related R&D than Canada • Competitors in the U.S. and Japan are subsidiaries of companies much larger than Ballard and more capable of funding large development projects • Fuel cell companies could go bankrupt without further funding; no North American fuel companies have reached profitability • Competing companies in other countries are developing, patenting key technologies; e.g., Fujitsu/NTT DoCoMo fuel cell for laptops, cell phones • Alternate (non-PEM) fuel cell types could achieve a technical breakthrough, leaving B.C. firms (based on PEM technology) to catch up from behind

British Columbia currently has the world's largest concentration of fuel-cell oriented businesses, although most are very small; total direct employment in B.C. is 1290, including 800 at Ballard Power Systems, the recognized global industry leader

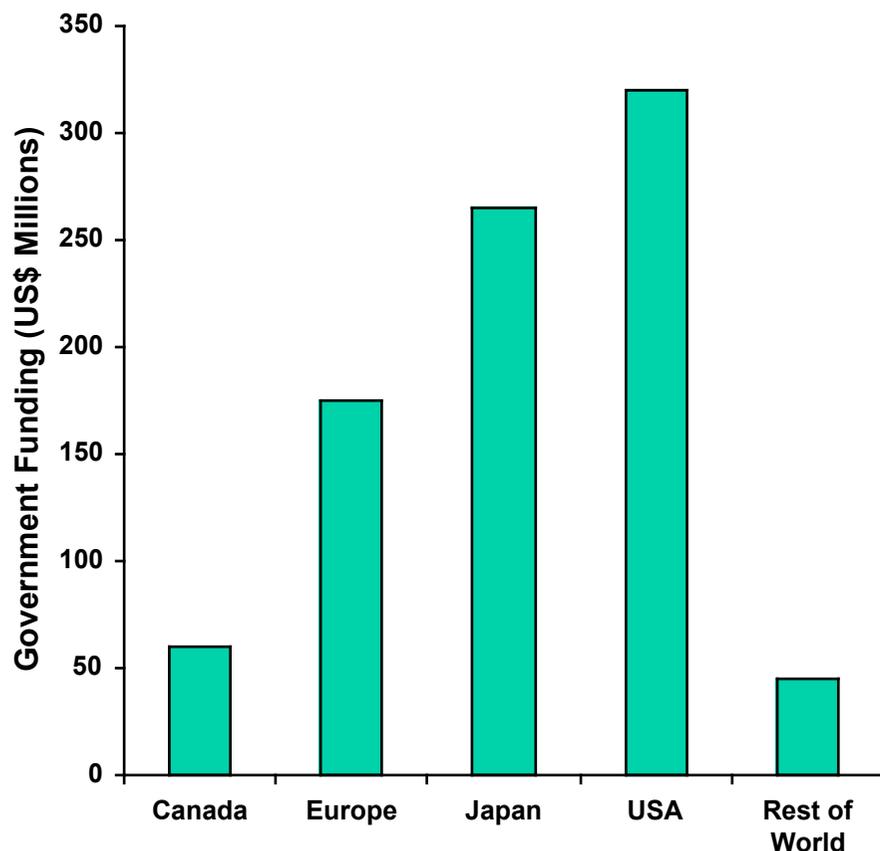


Source: "An Integrated Strategy for British Columbia's Technology Clusters," PricewaterhouseCoopers, 2003

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The Canadian government’s investment in fuel cell technology is significant (US\$60 million in 2003), but other countries are investing significantly more

2003 World-wide Government Support for Fuel-cell R&D

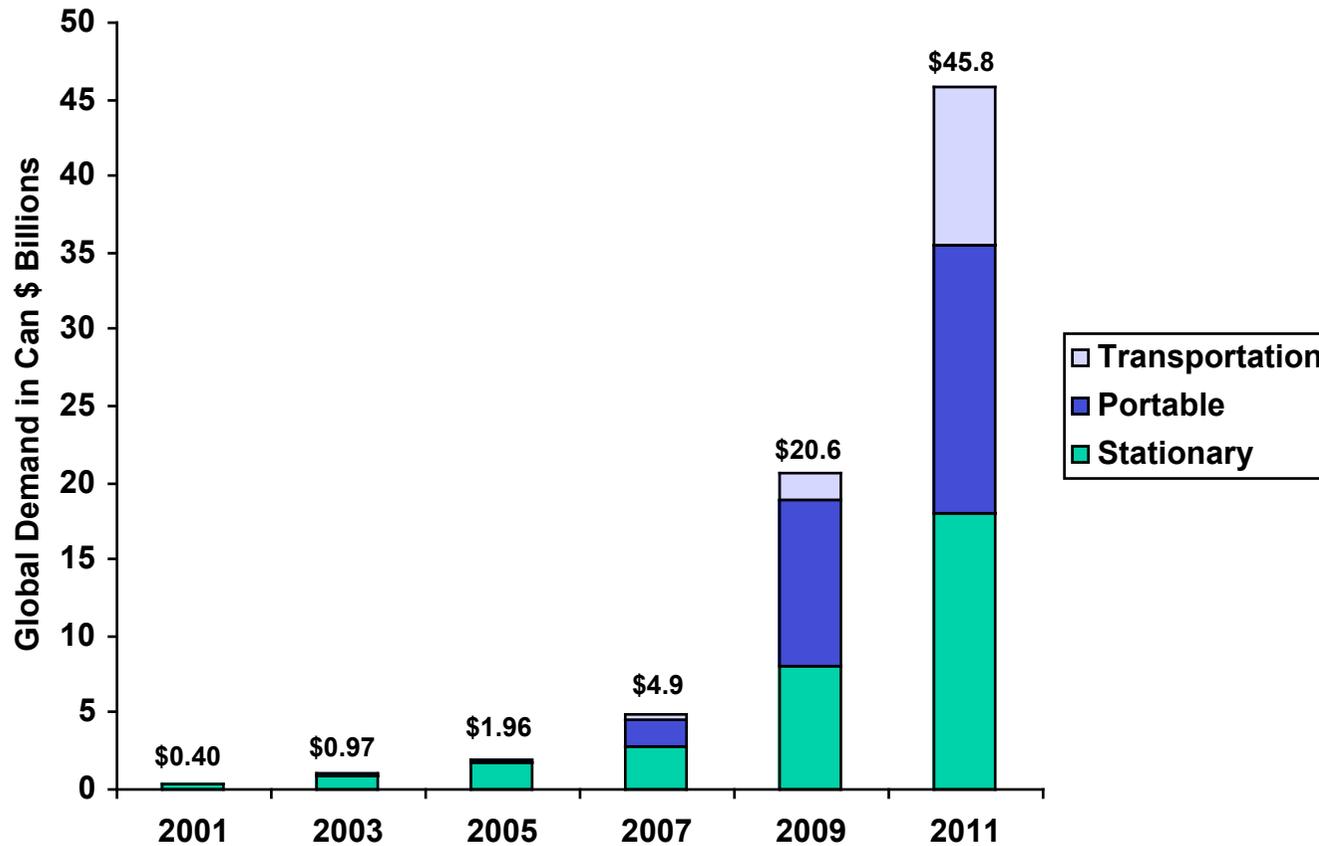


Canadian Government Support for Fuel Cell Industry
<ul style="list-style-type: none"> • B.C. provincial government will sponsor creation of “hydrogen highway” from Vancouver to Whistler for 2010 Olympics • Established Fuel Cells Canada and Canadian Transportation Fuel Cell Alliance to support fuel cell industry development • Provide direct grants for fuel cell related R&D through National Research Council at University of B.C.

Source: “Fuel Cell Systems: A Survey of Worldwide Activity,” Fuel Cell Today, 5 Nov 2003; Signal Hill Advisors analysis

As the current world leader in fuel cell production, British Columbia has a total world market opportunity of \$46billion by 2011

Estimated Global Demand to 2011, by Market Segment



Source: "Fuel Cells: The Opportunity for Canada," PricewaterhouseCoopers, June 2002

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The British Columbia fuel cell cluster is currently the world leader, thanks to Ballard Power Systems, its anchor tenant, but clusters in the United States, Japan and Europe could easily catch up as government support rises and market demand accelerates

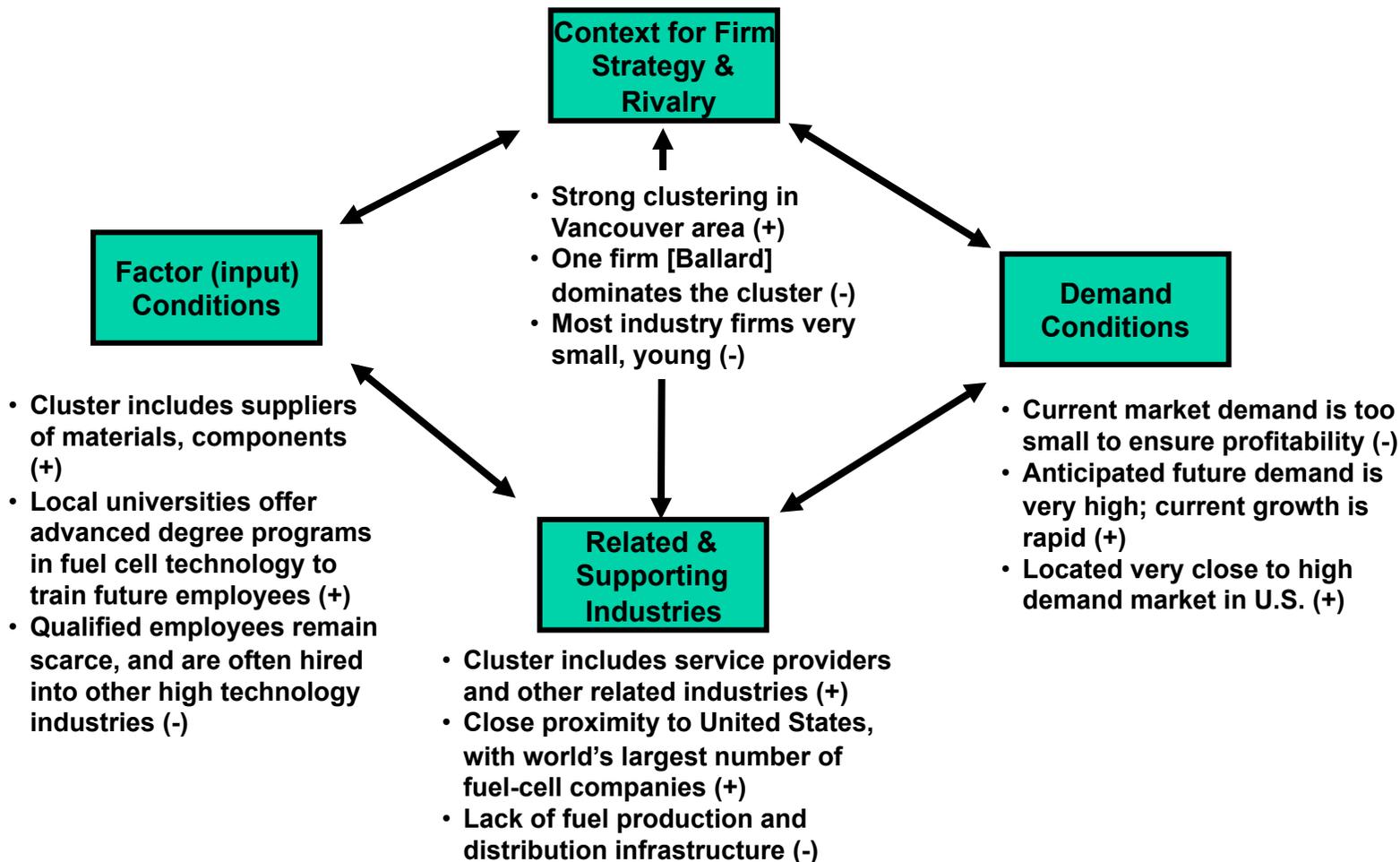
	British Columbia, Canada	Toronto, Canada	United States	Osaka, Tokyo Japan	Europe
Anchor Tenant	•Ballard, largest fuel cell company	•Fuel Cell Technologies, Hydrogenics, DuPont Canada	•Largest number of fuel cell companies in the world	•Toshiba, Toyota, Honda, Mitsubishi; large, but not specialists	•Several large companies in Germany, UK, Switzerland, but not specialists
Linkages Among Firms	•Strong collaboration within cluster and with key global partners	•Good collaboration	•Strong collaboration, but not concentrated in specific region	•Strong collaboration between firms on Tokyo, Osaka regions	•EU forming industry associations; not concentrated in specific regions
Proximity to Supportive Resources	•4 universities do research, grad education; industry, R&D organizations	•Univ. Toronto has fuel cell research, graduate education	•Good research labs, facilities, but not concentrated in specific location	•Numerous universities in Tokyo, Osaka, Nagoya doing fuel cell R&D	•Good research labs, facilities, but not concentrated in specific region
Self-sufficiency	•Critical mass of suppliers, service providers	•Close proximity to US, Canadian auto manufacturers	•Critical mass, but not critical density in any specific region	•Critical mass of supporting companies in Osaka and Tokyo regions	•Critical mass, but not critical density in any specific region
Access to Government Institutions	•Very strong federal, provincial gov't support	•Strong gov't support, but not as strong as B.C.	•Very large US research budgets for fuel cells	•Very strong support for fuel cell R&D by METI, NEDO	•Very large EU budgets for fuel cell R&D; EU trying to catch up to US, Japan

Source: Signal Hill Advisors Analysis, Industry Sources

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British Columbia’s fuel cell cluster is considered to be the strongest in the world today – but other countries are working to catch up

BC FUEL CELL INDUSTRY ASSESSMENT



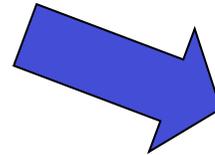
Source: Signal Hill Advisors analysis, interviews

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Assessment of British Columbia’s fuel cell industry shows that it is in an excellent position to compete in this developing market, but faces growing competition from emerging clusters in the United States, Europe, and Japan

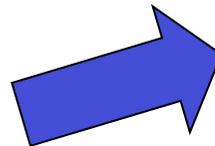
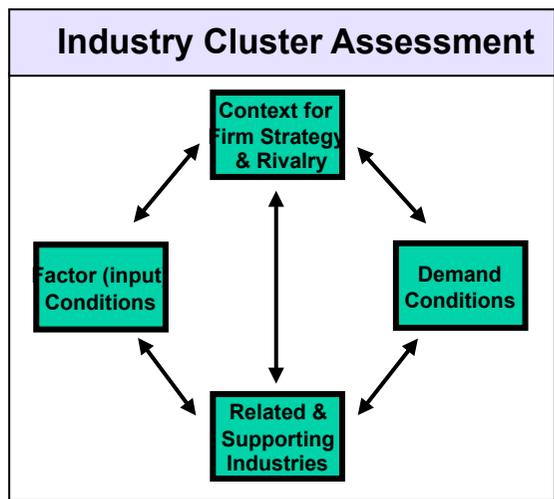
International Trends Assessment

- Exponentially growing demand
- Falling cost of production, lower selling price
- International support by governments for R&D, infrastructure development
- Increasing competition from U.S., Europe, Japan



**FUEL CELLS:
BRITISH COLUMBIA STRATEGIC ROADMAP**

- *Stimulate Early Market Demand* through visible demonstration projects such as the hydrogen highway or hydrogen powered buses for mass transit
- *Support R&D to reduce product cost* by funding fuel cell technology research at Canadian universities
- *Promote private sector financing* through tax incentives or loan guarantees to enable fuel cell companies to survive while market develops
- *Develop international standards* for fuel cells, hydrogen fuel storage
- *Expand educational and training programs* with fuel cell scholarships and grants to increase workforce size, quality



Source: Signal Hill Advisors Analysis, interviews

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