A Fiscal Framework for a Fuel Cell and Hydrogen Economy:

A review of international fiscal policy and program examples and precedents

By Amy Taylor, Jesse Row and Mark Winfield

October 2002

Produced by the Pembina Institute for Appropriate Development for Industry Canada

Table of Contents

Executive Summary

The purpose of this study is to conduct a comparative analysis of fiscal policies and programs related to hydrogen fuel and fuel cell development that have been implemented in Japan, Germany and the United States and to make recommendations for further development of the fuel cell and hydrogen fuel economy in Canada.

Along with Canada, Germany, Japan and the United States have established themselves as leaders in developing the hydrogen and fuel cell industries globally. They have done so by, among other activities, implementing fiscal policies and programs designed to support the hydrogen and fuel cell industries by helping to overcome economic and technical barriers related to fuel cell development. Japan, Germany and the United States appear to be leaders in supporting power generation fuel cell demonstrations. Japan and Germany are also leaders in infrastructure development for hydrogen fuelling stations, having built several such stations in recent years.

In comparison to those in Japan, Germany and the United States, fiscal policies and programs in Canada related to hydrogen and fuel cells have focused mainly on addressing technical barriers through research and development programs as opposed to product implementation and demonstration. Cost barriers have not been addressed through use of specific tax measures in Canada. Demonstration activities supported by Canadian governments have been mainly focused on mobile fuel cell applications and infrastructure instead of stationary and portable power generation applications. Canada lacks a federally coordinated, long-term national commitment and methodology for developing a fuel cell and hydrogen economy.

Specific recommendations for designing and implementing fiscal policies and programs for a fuel cell and hydrogen fuel economy in Canada include the following:

1. Employ a mix of fiscal policy instruments specifically targeted at current barriers.
2. Implement fiscal policies and programs that target both power generation (stationary and portable) and transportation (including infrastructure) fuel cell applications.
3. While maintaining support for research and development activities, focus on implementation and demonstration of fuel cell technologies and hydrogen infrastructure.
4. Encourage provincial governments to implement complementary fiscal policies and programs to substantially increase the attractiveness of Canada as a place to do business related to fuel cell technologies and hydrogen fuel.
5. Build and begin to implement a long-term, coordinated strategy for developing a fuel cell and hydrogen economy in Canada.
6. Back all policies and programs with sufficient financial resources.

1. Introduction

Hydrogen fuel and fuel cell technologies are quickly becoming recognized as key energy sources for the future. Driven by a variety of factors, including California's zero emission vehicle requirements, and increasing concerns about climate change, energy reliability and national security, fuel cells stand poised to compete with internal combustion engines, traditional power plants, and even the battery market in the short to medium term. Several North American cities[1] have or have had demonstration fuel cell buses and fuel cells for power production (stationary and portable), and fuel cell cars are planned for production within the next 10 years.

Depending on the hydrogen source and conversion process, the development of hydrogen fuel and fuel cell technologies carries the potential for tremendous environmental improvement. The fuel sources that can be used to produce hydrogen (methanol, ethanol, electrolysis from hydro, wind, photovoltaic, natural gas) offer various reductions in greenhouse gas emissions (GHGs). A Pembina Institute study concluded that hydrogen fuel derived from natural gas reformed in a large plant could reduce a vehicle's life cycle carbon dioxide emissions per 1,000 km traveled by approximately 72%;[2] hydrogen fuel derived from renewable energy sources such as hydroelectricity would reduce emissions even farther.[3] Other GHG life cycle comparisons also show impressive reductions: the Transportation Issue Table of the National Climate Change Process concluded that a fuel cell vehicle fuelled by natural gas-generated hydrogen would produce life cycle CO_2e emissions almost 55% lower than a low-sulphur gasoline vehicle, and 95% lower than a hydroelectricity vehicle.[4]

In addition to dramatically reducing CO_2 emissions, the introduction of hydrogen fuel cells can also reduce dependence on foreign oil (supplied from a limited number of geographic areas). This is relevant to the Canadian perspective because, as the United States strives to decrease its dependence on oil imports, the export market for fuel cells from Canada could increase. The Oxford Institute forecasts that hydrogen could reach production of 3.2 million barrels per day of oil equivalent by 2010, and 9.5 million barrels by 2020. Shell International scenarios anticipate that internal combustion engines will be displaced by fuel cells within two decades, and an energy economy running primarily on hydrogen will be established by 2050.[5]

Government policies are already in place to support the research and development of hydrogen fuel cells in Canada—for example, Technology Partnerships Canada's $29.7 million investment in the Ballard Proton Exchange Membrane (PEM) Fuel Cell Power Plant project. To move into the technology adoption stage of the hydrogen and fuel cell economy will depend on more robust investment and stimulation of both demand and supply for the new technologies in the following ways:

- Implementation of policies to increase the competitiveness of hydrogen and fuel cells with conventional fuel sources and technologies.

[1] Chicago, Vancouver, Palm Springs, and Washington DC.
[2] Pembina Institute and David Suzuki Foundation, *Climate Friendly Hydrogen Fuel: A Comparison of the Life-Cycle Greenhouse Gas Emissions for Selected Fuel Cell Vehicle Hydrogen Production*, March 2000.
[3] Pembina Institute and David Suzuki Foundation, op. cit.
[4] National Climate Change Process, *Transportation and Climate Change: Options for Action,* from Chart 4.2, "Passenger Cars – CO_2 Equivalent Emissions, Year 2010."
[5] Quoted in Worldwatch Institute, *State of the World 2001*, in Chapter 5, "Decarbonizing the Energy Economy" by Seth Dunn. (London: Norton and Company, 2001). p. 99

- Early adoption by governments of fuel cell technologies; and
- Support by governments for the development of enabling technologies and investment by governments in the distribution and fuelling infrastructure needed to maximize the environmental potential of fuel cells.

Other jurisdictions have begun to address these requirements; for example, the recently released US National Energy Policy contains several tax provisions related to the promotion of hydrogen fuel cell technologies. These include a consumer income tax credit for the purchase of fuel cell (and hybrid) vehicles valued at US $4.2 billion (CDN $6.6 million) over 10 years, and funds for the fuel cell-powered transit bus program.

If Canada is to use additional fiscal policies and programs to support the adoption and implementation stage of the fuel cell and hydrogen economy, it will be useful to consider the experiences of other countries.

Purpose, Objectives and Methodology

The purpose of this study is to conduct a comparative analysis of fiscal policies and programs related to hydrogen fuel and fuel cell development that have been implemented in key jurisdictions around the world and to make recommendations for further development of the fuel cell and hydrogen fuel economy in Canada.

The specific objectives of this study are to

1. Provide background information that can inform the fiscal framework for hydrogen fuel, infrastructure, and fuel cell technologies in Canada;
2. Document fiscal policies and programs used in other jurisdictions; and
3. Make recommendations on further developing the fuel cell and hydrogen economy in Canada through use of fiscal policies and programs.

To accomplish these objectives, the following methodology was employed:

1. Document fiscal policies and programs that have been implemented in Canada to develop the fuel cell and hydrogen economy.
2. Document fiscal policies and programs that have been implemented in regions considered leaders in developing hydrogen fuel, infrastructure, and fuel cell technologies. Regions included in this analysis are Germany, United States, Japan and the European Union.[6]
3. Identify factors that have contributed to the success of these leading countries in developing the fuel cell and hydrogen economy.
4. Evaluate Canada's success in incorporating the above factors into fiscal policies and programs for developing a fuel cell and hydrogen economy in Canada.
5. To the extent that Canadian governments have not incorporated factors identified above, make recommendations for further developing the fuel cell and hydrogen economy in Canada through use of fiscal policies and programs.

Section 2 of this paper, "Background and Context," provides a definition of fiscal policies and programs, describes the benefits and barriers to developing a fuel cell and hydrogen economy, describes the types of fiscal policies and programs that have been employed to develop the fuel cell and hydrogen economy and describes existing fiscal policies and programs in Canada related to hydrogen fuel, infrastructure and fuel cell technologies. Section 3, "International Examples and Precedents," describes fiscal policies and programs related to the fuel cell and hydrogen economy

[6] Iceland is also a world leader in developing a hydrogen economy but was not considered in this analysis.

in the United States, Japan, Germany and the European Union. Section 4, "Comparative Analysis and Evaluation," identifies factors that have contributed to the success of world leaders in developing a fuel cell and hydrogen economy and evaluates Canada's progress in incorporating those factors. Section 5, "Developing a Hydrogen and Fuel Cell Economy in Canada," provides recommendations on designing and implementing fiscal policies and programs for further developing the fuel cell and hydrogen economy in Canada.

2. Background and Context

Benefits of a hydrogen and fuel cell economy

As compared to the use of conventional technologies and fuels, the use of fuel cell technologies and hydrogen fuel has the potential to result in tremendous environmental improvements including reductions in greenhouse gas emissions and improvements in local air quality. The extent of the environmental gain depends on the hydrogen source and production method. For example, a fuel cell vehicle operating on hydrogen produced from steam methane reforming of natural gas produces almost 55% less greenhouse gases over its entire life cycle when compared with a conventional vehicle operating on low-sulphur gasoline.[7] In concert with these environmental benefits, as technology costs decrease with commercialization and increased economies of scale, the use of fuel cells and hydrogen fuel will potentially offer many economic benefits.

The fuel cell and hydrogen sector is poised to grow substantially in the next decade. Estimates by PricewaterhouseCoopers indicate that the global market for fuel cell systems will be $46 billion by 2011. Growth rates for the industry are projected to average more than 60% a year between 2003 and 2011. From 2007 to 2011, the industry is projected to grow at a compounded average annual rate of 75%. By maintaining leadership in this rapidly expanding field, Canada will take advantage of new employment opportunities as well as foster a competitive advantage that will manifest itself in increased economic activity and growth.

Along with environmental and economic considerations, hydrogen fuel is increasingly being touted as a solution to national energy security concerns in the United States. Because hydrogen can be derived from numerous sources, including renewable energy sources that are domestically available, countries pursuing hydrogen fuel development and consumption are able to reduce dependence on fossil fuel imports. In doing so, they are able to become less dependent on oil producing countries to meet their growing energy needs. As this transformation takes place in countries such as the United States, Canada will reap the benefits of increased export opportunities for hydrogen fuel and fuel cell technologies.

In addition, fuel cell technologies have the following benefits over conventional energy conversion devices: they can be applied to multiple applications (mobile, stationary, distributed, remote, electronic); they are more efficient and quiet; they are expected to be highly reliable and easy to maintain; and they provide a comparable level of safety.

Barriers to a hydrogen and fuel cell economy

While the use of fuel cells and hydrogen fuel is associated with numerous economic, environmental and social benefits, commercialization of fuel cells and widespread use of non-

[7] Edwards, W. et. al. 1999. *Alternative and Future Fuels and Energy Sources for Road Vehicles*. Prepared by Levelton Engineering Ltd. for the Transportation Issue Table – National Climate Change Process. Richmond, Canada.

industrial hydrogen as a fuel is still limited in Canada and most areas of the world. Several economic and technical barriers limit the market penetration of this innovative technology and fuel source.

Barriers Associated with Fuel Cells

The cost of fuel cell components/materials and production processes remains prohibitive. Current fuel cell cogeneration power plants cost about US $5,000 to $10,000/kW (CDN $7,666 to $15,333/kW) (groups such as the Solid State Energy Conversion Alliance (SECA) in the United States are working to bring the cost of a 5 kW fuel cell system to US $400/kW[8]). For broad market competitiveness in the utility and commercial on-site markets, the cost to purchase a fuel cell plant must be reduced to US $1,500/kW (CDN $2,230/kW) or less.[9] Decreasing costs by achieving mass production volumes is a critical challenge. Early adopters of fuel cell technologies are important for establishing start-up production levels and demonstrating the abilities of these new products.[10]

Along with the need to reduce the costs of fuel cells, fuel cell developers also face technical barriers. Durability is a critical hurdle to overcome if fuel cells are to be able to operate under a variety of conditions and provide the reliable, long-term service that customers expect. The ability to control the fuel quality and operating environment of the fuel cell, while allowing sufficient tolerance to variations in these parameters, is one of the primary challenges in successfully transferring a laboratory technology to the commercial market. Since fuel cells are expected to operate over long periods of time, new simulation technologies are required to test the lifetime and durability of fuel cells. These technologies are currently being developed and used for fuel cell life cycle testing.

Another technical challenge facing fuel cell developers, as with any new mass-produced product, is the optimization of manufacturing processes to keep costs low and obtain an acceptable level of product quality. For fuel cells, consistent product quality is very important to the consumer. The use of many novel materials and manufacturing processes increases both the challenge and importance of designing appropriate manufacturing processes.

A final major technical challenge facing fuel cell companies is the further development of materials and tools for decreasing the cost and improving the performance of fuel cells.

Barriers Associated with Hydrogen Fuel

In addition to being a barrier for the development of fuel cell technologies, cost is similarly a barrier for the development of a hydrogen production and distribution infrastructure. Compared with conventional fuels, the production of current volumes of hydrogen is very expensive, particularly when specialized transportation is needed to move the hydrogen to the point of use. To justify the cost of building the necessary infrastructure to produce and distribute hydrogen in mass quantities, a large demand for hydrogen within relatively concentrated areas may be required. Before costs will be competitive with conventional technologies, both hydrogen supply

[8] United States Department of Energy. 2000. "SECA: Solid State Energy Conversion Alliance." www.fe.doe.gov/coal_power/fuelcells/seca_brochure.pdf. Accessed July 2, 2002.
[9] Environmental and Energy Study Institute. February 2002. "Fuel Cell Fact Sheet." Washington, DC.
[10] Fuel cells can also be utilized in non-continuous power applications (for example back up power sources). Such applications may provide more attractive markets in the short term (because in the case of back up power, fuel cells would be competing with batteries).

and demand must evolve to large-scale proportions. Low prices for conventional energy sources and lack of environmentally oriented fuel pricing compound the economic barriers to further development of the fuel cell and hydrogen markets.

There are also several technological barriers associated with the development of a hydrogen infrastructure. First, given its low energy density, for hydrogen to be used effectively in a broad range of applications requires the development of advanced storage technologies. Research is currently underway to develop methods of storing hydrogen as a compressed gas, as a liquid, or by absorbing it into a chemical or metal hydride. Second, for many of the storage methods, hydrogen must be compressed to high pressures. This compression often requires the use of considerably more energy than is yielded by the hydrogen when used in a fuel cell. To reduce this major energy and cost expenditure, more efficient compressor technologies need to be developed. Third, as mentioned previously, to enable widespread use of hydrogen, distribution networks must be developed. To form these networks globally, and to ensure safe, reliable and cost-effective delivery, will require the advancement of many new technologies.

Finally, for both fuel cells and a hydrogen infrastructure, codes and standards need to be developed or modified to ensure that comparable levels of safety to incumbent technologies are maintained globally and different system components are compatible with one another. Both manufacturers and consumers may be hesitant to adopt a new technology until proper codes and standards have been established to reduce perceived and real safety and economic risks.

The table below summarizes the current economic and technical barriers associated with fuel cells and hydrogen fuel/infrastructure.

Sector	Economic Barriers	Technical Barriers
Fuel Cell Technologies	Cost of materials and components. Cost of production.	Durability, perfecting manufacturing processes and improving performance.
Hydrogen Fuel/Infrastructure	Cost of hydrogen production. Cost of hydrogen distribution.	Storage, compressors and distribution network.

Types of fiscal policies and programs implemented in various jurisdictions

To help overcome the various barriers associated with fuel cell technologies and hydrogen fuel/infrastructure, and to foster growth in the hydrogen and fuel cell industries, governments around the world have introduced and continue to implement fiscal policies and programs. Various types of fiscal policies and programs related to fuel cell and hydrogen fuel/infrastructure have been implemented:

1. **Direct expenditure** or grants for research and development, and equity for companies and research organizations.
2. **Loans** and repayable funds for companies and organizations.
3. Expenditures related to **program activities** such as establishing research groups, networks and other coordinating bodies.
4. **Tax measures** including tax credits, exemptions and rebates.
5. **Procurement** or guaranteed purchases/investment in prototype and demonstration technologies and products.

Canada has implemented a number of such policies and programs.

Existing Policies and Programs in Canada

Before evaluating fiscal policies and programs in other jurisdictions, it is useful to investigate the policies and programs that have been implemented in Canada related to hydrogen and fuel cell technologies. This will allow for a comparative analysis with other leading countries in this field. Listed below is a synopsis of each initiative included in this study, including type, relevant jurisdiction, brief description, year of implementation, and objective.

Name of initiative: Technology Partnerships Canada (TPC)
Type of initiative: Repayable investment
Jurisdiction: Federal
Description: TPC is a technology investment fund for research, development and innovation. The program is designed to encourage private sector investment, and maintain and grow the technology base and technological capabilities of Canadian industry. TPC has provided funds to Ballard ($29.7 million), Stuart Energy ($5.8 million), Questair ($4.95 million) and Dupont Canada ($19 million).
Year of implementation: 1996
Objective: To increase economic growth, create jobs and wealth, and support sustainable development in Canada.

Name of initiative: Partnership between Western Economic Diversification, National Research Council Innovation Centre, and Fuel Cells Canada
Type of initiative: Direct expenditure and program activities
Jurisdiction: Federal
Description: The federal government invested $2.7 million to help Fuel Cells Canada develop six new research laboratories in Vancouver. Western Economic Diversification is contributing $1 million and the National Research Council of Canada (NRC) $1.7 million towards the new hydrogen-safe laboratories located at NRC's Fuel Cell Technology Center at University of British Columbia.
Year of implementation: 2002
Objective: To further develop the fuel cell cluster in Vancouver, British Columbia.

Name of initiative: Western Economic Partnership Agreement (WEPA)
Type of initiative: Direct expenditure and program activities
Jurisdiction: British Columbia with funding from the federal government
Description: The federal and BC governments agreed, under WEPA, to invest $13 million in the fuel cell industry. Several projects were funded through WEPA:

- Six fuel cell projects in British Columbia received $5.2 million: a prototype of a fuel cell-powered industrial truck; a small-scale hydrogen generator unit; a working multi-fuel warehouse; a sustainable, integrated fuel-based system to generate electricity; a hydrogen fuelling station for fuel cell vehicles; and a 1.2 kW utility standby fuel cell system. Announced 2002.
- A $980,000 contribution to establish Fuel Cells Canada, a non-profit organization in Vancouver that was given the task of identifying, coordinating and presenting fuel cell demonstration projects for consideration. Announced in 2000.

- Almost $4.6 million was invested in testing and evaluating fuel cell bus engines. This WEPA funding allowed BC Transit to buy three fuel cell bus engines from Xcellsis,[11] a joint venture of DaimlerChrysler AG, Ballard Power Systems Inc., and the Ford Motor Co. Announced 2001.

Year of implementation: 2000 to 2003
Objective: The objective of WEPA is to extend the international competitiveness of the BC economy and provide economic development opportunities for communities throughout the province.

Name of initiative: Canadian Transportation Fuel Cell Alliance (CTFCA) (Part of Action Plan 2000 described in more detail below)
Type of initiative: Direct expenditure and program activities
Jurisdiction: Federal
Description: This is a $23 million federal government initiative that will demonstrate and evaluate fuelling options for fuel cell vehicles in Canada. By 2005, different combinations of fuels and fuelling systems will be demonstrated for light-, medium- and heavy-duty vehicles. The initiative will also develop standards and training and testing procedures related to fuel cell and hydrogen technologies. Funding for the initiative comes from Action Plan 2000, a package of activities to reduce greenhouse gas emissions in Canada.
Year of implementation: 2001
Objective: To demonstrate greenhouse gas emission reductions and evaluate different fuelling routes for fuel cell vehicles, and to develop the necessary supporting framework for fuelling infrastructure, including technical standards, codes, training, certification and safety.
Noteworthy: Several other initiatives related to fuel cell and hydrogen development have been funded through Action Plan 2000. Some of these are described in more detail below.

Name of initiative: Action Plan 2000
Type of initiative: Direct expenditure
Jurisdiction: Federal
Description: Action Plan 2000 is a $500 million, 5-year commitment from the federal government that contains a package of activities to reduce greenhouse gas emissions in Canada. Action Plan 2000 is comprised of 45 initiatives designed to help Canada achieve one third of its Kyoto Protocol greenhouse gas emission reductions commitment. Some of the initiatives included in Action Plan 2000 that relate to hydrogen and fuel cell development are described here:

- Hydrogen Refueller: Stuart Energy Systems developed a hydrogen fuel delivery system that uses water electrolysis to produce hydrogen. The objectives of the project were cost reduction in third generation electrolysis cells, an increase in hydrogen output and a decrease in hydrogen production costs of 75%. Funding: Climate Change Action Fund (CCAF) $1.5 million and Industry Canada $4.3 million.
- Technology Development for use in Natural Gas and Fuel Cell Vehicles: In partnership with Saskatchewan Research Council this project aimed to develop intelligent control systems that will render natural gas and fuel cell vehicles more cost competitive with conventional vehicles. This technology monitors and controls gaseous injection and fuel storage systems and makes the conversion of conventionally fuelled vehicles to natural gas simpler and therefore less costly. There is considerable crossover between fuel cell and natural gas vehicles in the technology associated with fuel storage tanks and gas regulators. Funding: CCAF $700,000 and Natural Resources Canada (NRCan) $350,000.

[11] Note that Xcellsis no longer exists; it was procured by Ballard in 2001.

- Gas Separation Technology for the Industrial Oxygen and Fuel Cell Markets: Questair Techs Inc. is developing a gas separation technology that strips nitrogen and other gases from an air stream leaving pure oxygen. The technology is also being studied for use in fuel cells. During this project, Questair will explore the use of its Pulsar technology to remove nitrogen and other components from the air stream that feeds the fuel cell, thereby increasing overall efficiency of the fuel cell by 20 to 25%. Funding: Industry Canada $3.44 million and CCAF $1.5 million.
- Solid Oxide Fuel Cell Combined Heat and Power Demonstration Plant: A project to build and demonstrate a prototype solid oxide fuel cell combined heat and power plant. Compared to coal-fired electricity generation, this plan could reduce CO_2 emissions by about 57%. Funding: CCAF $1.12 million and NRCan $373,000.
- Personal Fuel Appliances: Stuart Energy Systems Inc. is developing a hydrogen-refuelling appliance, consisting of a water electrolyser that produces hydrogen for zero emissions fuel cell vehicles. Stuart Energy Systems will construct and test two prototype hydrogen-refuelling appliances. The prototype will then be delivered to Ford Motor Co. for independent evaluation and testing. Funding: NRCan $373,000 and CCAF $2.12 million.

Year of implementation: 2001
Objective: To reduce greenhouse gas emissions in key sectors, positioning Canada for sustained economic growth and increased Canadian competitiveness.

Name of initiative: National Research Council (NRC)[12] Fuel Cell Program
Type of initiative: Direct expenditure and program activities
Jurisdiction: Federal
Description: NRC's Fuel Cell Program is housed within the NRC Innovation Center at the University of British Columbia. In collaboration with industry, universities and other government agencies, the program provides research and innovation support in the areas of component development, system integration and manufacturing, design, and environmental control and assessment of fuels research.
Year of implementation: 1999
Objective: To strengthen university research capacity in the area of fuel cells; link industries, universities and NRC institutes to encourage collaborative research; ensure effective and efficient technology transfer to industry; and provide scientific career and skills development opportunities to young Canadians.

Name of initiative: National Research Council Innovation Centre
Type of initiative: Direct expenditure and program activities
Jurisdiction: Federal
Description: The Innovation Centre is a strategic partnership between the National Research Council (NRC), the Natural Sciences and Engineering Research Council (NSERC) and Natural Resources Canada (NRCan). In August 1999, the federal government provided $30 million to further strengthen the fuel cell industries research and development, including $14 million managed by Natural Sciences and Engineering Council (NSERC) and NRC, designed to lever private sector support for new industry collaborations with researchers in NRC institutes and Canadian universities; $10 million from NSERC and $4 million from NRC for the creation of a Network Coordination Office; funding for the creation of five Industrial Research Chairs; targeted project funding for university research that involves collaboration with Canadian

[12] NRC is a science and technology research organization leading in scientific and technical research, the diffusion of technology and dissemination of scientific and technical information.

industry and NRC institutes; and support for the training and education of students through Industrial Postgraduate Scholarships. In 2002, Minister of Industry, Alan Rock, announced $20 million in additional funding to fuel cell research and development at its NRC Innovation Centre.
Year of implementation: 1999
Objective: To strengthen university research capacity in the area of fuel cells; link industries, universities and NRC institutes to encourage collaborative research; ensure effective and efficient technology transfer to industry; and provide scientific career and skills development opportunities to young Canadians.

Name of initiative: Transportation Energy Technologies Program (TETP)
Type of initiative: Direct expenditure and loans
Jurisdiction: Federal
Description: TETP works in several areas:

- The development of alternative fuels and advanced propulsion systems (gaseous fuels, alcohols, hydrogen, fuel cells, electric vehicles and hybrids and related systems);
- Advanced energy storage systems (lightweight cylinders, adsorption technologies and flywheels);
- Emissions control technologies (for diesel and alternatively fuelled engines, lean burn catalysts and enhanced combustion chamber design);
- Vehicle transportation systems efficiency (advanced materials and processes, driving cycle analysis, auxiliaries and regenerative breaking systems);
- Fuelling infrastructure (fuelling station hardware, hydrogen systems and battery charging systems).

Program activities of TETP include the following:

- R&D for technologies with short- to medium-term commercial market potential;
- Technology assessments conducted in the lab and through technical demonstration projects and field trials to provide data on factors such as fuel economy, reliability, safety, environmental impacts and costs/benefits;
- Development of technical and safety standards;
- Technology transfer through sponsorship of workshops and seminars, publication of technical reports, and information exchanges with public and private sector organizations.

Year of implementation: 1980 and now complete
Objective: Working in partnership with industry to develop and deploy leading-edge transportation technologies that minimize environmental impacts, increase the potential for job and wealth creation, and extend the lifespan of the energy resource base.
Noteworthy: TETP is a program of the CANMET Energy Technology Center (CETC). CETC's TETP program provided $1 million towards the Ballard fuel cell bus trial that took place in Vancouver, BC.

Name of initiative: BC Tax Credit for Alternative Fuel Vehicles and Alternative Motor Fuel Tax Concessions
Type of initiative: Tax measure
Jurisdiction: Provincial
Description: Several provisions are provided in BC for alternative fuels and alternative fuel vehicles. Alternative fuel vehicles qualify for a partial refund of the provincial social service tax. Alternative fuel vehicles that are passenger vehicles and that are subject to the 8%, 9% or 10% provincial sales tax rates may be eligible for a reduced tax rate. Kits to convert motor vehicles to eligible alternative fuels, and services to install, repair and maintain such equipment, are exempt from tax. And there are exemptions and preferential tax rates for certain alternative fuels that are

environmentally preferable to gasoline or diesel fuel. Qualifying alternative fuel vehicles include factory-manufactured vehicles that operate exclusively on electricity, ethanol, methanol, natural gas or propane; as hybrid electric vehicles that are propelled by a combination of stored electricity and gasoline, diesel, hydrogen, natural gas, propane, methanol or ethanol; or as bi-fuel vehicles that have two separate fuel storage tanks so the vehicles can be propelled by an alternative fuel or by gasoline or diesel fuel.

Year of implementation: Refunds, reduced rates and exemptions were introduced and revised in 2001 and 2002.

Objective: To increase purchases of alternative fuel vehicles and alternative fuels in British Columbia.

The following table summarizes the Canadian policies and programs presented above.

Summary of Policies and Programs in Canada

Initiative	Type Of Initiative	Jurisdiction
Technology Partnerships Canada	Repayable investment	Federal
Western Economic Diversification, National Research Council Innovation Centre and Fuel Cells Canada Partnership	Direct expenditure and program activities	Federal
WEPA	Direct expenditure and program activities	Federal and provincial
CTFCA	Direct expenditure and program activities	Federal
Action Plan 2000	Direct expenditure	Federal
NRC Fuel Cell Program	Direct expenditure and program activities	Federal
NRC Innovation Centre	Direct expenditure and program activities	Federal
TETP	Direct expenditure and loans	Federal
BC Tax Concessions for Alternative Vehicles and Fuels	Tax measure	Provincial

The following table offers an evaluation of whether the policies and programs that have been implemented address existing barriers; are targeted at fuel cells, infrastructure or hydrogen fuel; are unique to fuel cells and hydrogen; and include hydrogen from renewable energy sources.

Evaluation of Policies and Programs in Canada

Initiative	Sector Focus	Barriers Addressed	Focus On Hydrogen And Fuel Cells	Includes Renewable Energy Sources
Technology Partnerships Canada	Fuel cells	Technical, infrastructure, codes and standards	Yes	Yes
Western Economic Diversification, National Research Council Innovation Centre and Fuel Cells Canada Partnership	Fuel cells	Technical	Yes	Yes
WEPA	Fuel cells	Technical, infrastructure, codes and standards	Yes	Yes
CTFCA	Hydrogen, fuel cells and infrastructure	Technical, infrastructure and codes and standards	Yes	Yes
Action Plan 2000	Hydrogen, fuel cells and infrastructure	Technical, testing, demonstration, codes and standards	Yes	Yes
NRC Fuel Cell Program	Fuel cells	Technical	Yes	No
NRC Innovation Centre	Fuel cells	Technical	Yes	Yes
TETP	Hydrogen	Technical	No, focus is on developing a sustainable energy mix for roadways	No, includes natural gas and propane
BC Alternative Vehicle and Fuel Tax Concessions	Fuel cells and hydrogen	Cost	Not exclusively	Yes

As this table indicates, all of the policies profiled address a barrier. There is a strong focus on addressing technical barriers rather than cost barriers. In other words, at this stage there is a focus in Canada on research and development rather than commercialization. Canada provides limited support for larger scale demonstration programs (in the form of stationary fuel cell power generation units for the commercial or residential sectors for example). All but one of the policies profiled is explicitly applicable to fuel cells and hydrogen.

3. International Examples and Precedents

To benchmark the policies and programs in place in Canada, it is useful to investigate the kinds of policies and programs that other leading countries have implemented. Thus, in this section of the report, we highlight various fiscal policies and programs implemented in four key jurisdictions: the United States, Japan, Germany and the European Union. These jurisdictions were chosen based on their reputations as world leaders in promoting fuel cells and hydrogen fuel. As was the case with the Canadian examples above, for each international initiative, described below is the type of initiative, the relevant jurisdiction, a description of the initiative, the year of implementation, and the objective of the initiative. Note that this is not a comprehensive list of policies and programs related to fuel cell technologies and hydrogen fuel/infrastructure in the selected regions. Instead, these policies and programs were selected to demonstrate the range of options that have been implemented. Ultimately, the objective was to present key and innovative fiscal policies and programs that support fuel cells, hydrogen fuel and hydrogen infrastructure in key international jurisdictions.

United States: Federal

Name of initiative: Climate Change Fuel Cell Rebate Program
Type of initiative: Tax measure
Jurisdiction: Federal initiative through Department of Defence
Description: The program provides a financial incentive of up to US $1,000 (CDN $1,571) per kW of power plant capacity, not to exceed one-third of the total program costs for power plants that employ fuel cell technologies.
Year of implementation: 1995
Objective: To expedite the market introduction of fuel cell systems.

Name of initiative: Fuel Cell Residential Demonstration Project
Type of initiative: Procurement
Jurisdiction: Federal initiative through Department of Defence
Description: In 2001 and 2002 fuel cells ranging in size from 1 to 20 kW will be installed at US military bases. In 2003, up to US $18 million (CDN $28 million) will be spent on this initiative.
Year of implementation: 2001/2
Objective: To demonstrate the use of fuel cells and to expedite the market introduction of fuel cell systems.
Noteworthy: The Department of Defence has installed fuel cells at military bases around the country. A fuel cell at Vandenburg Air Force Base in California has replaced diesel generators as a backup source of electricity.

Name of initiative: Solid State Energy Conversion Alliance (SECA)
Type of initiative: Direct expenditure and program activities
Jurisdiction: Federal
Description: This is a US $1.5 billion (CDN $2.4 billion) new initiative to bring about dramatic reductions in fuel cell costs. If the policy objective is achieved, fuel cells will compete with gas turbines and diesel generators. SECA is designed to leverage resources to overcome the most difficult technical barriers, while enabling private partners to maintain a competitive position.
Year of implementation: 2002

Objective: To cut fuel cell costs to as low as US $400 (CDN $628) per kW by the end of this decade. The ultimate goal is to have the ultra-low cost fuel cell concept ready for commercial applications by 2010.

Name of initiative: Deduction for Clean Fuel Vehicles and Certain Refuelling Property
Type of initiative: Tax measure
Jurisdiction: Federal
Description: Income tax deductions for qualified clean-fuel vehicle properties, qualified clean-fuel vehicle refuelling properties and incremental costs associated with the purchase of vehicles propelled at least partially by a clean-burning fuel. Light-duty vehicles are eligible for a maximum deduction of US $2,000 (CDN $3,141); trucks or vans with gross weight rating greater than 10,000 pounds but not greater than 26,000 pounds are eligible for up to US $5,000 (CDN $7,852); and trucks and vans exceeding 26,000 pounds, along with buses with a seating capacity of at least 20 passengers, may qualify for a maximum deduction of US $50,000 (CDN $78,516). Clean-fuel refuelling properties are eligible for a deduction of up to US $100,000 (CDN $157,032). Clean-burning fuels include natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, electricity and any other fuel that is at least 85% methanol, ethanol, or any other alcohol or ether.
Year of implementation: 2001
Objective: To increase market penetration of clean-fuel vehicles.

Name of initiative: Transportation Fuel Cell Power Systems Program
Type of initiative: Direct expenditure
Jurisdiction: Federal through Department of Energy
Description: This program is lead by the US Department of Energy (DOE) and is a cost-shared, government-industry research and development program to develop automotive fuel cell power system technologies. These technologies are expected to be highly efficient with low or zero emissions, to be cost-competitive, and to operate on conventional and alternative fuels. Research and development is focusing on materials, components and enabling technologies for fuel processing and for fuel cell stack subsystems as well as fuels for fuel cells. Contracts and cooperative agreements with industry and universities are implemented through competitive processes while national laboratories are directly funded based on their capabilities and performance. The DOE fuel cell research and development projects require a minimum cost-share of 20% from industry partners (up to 50%). During fiscal year 2001, the program planned and executed a research and development solicitation that resulted in approximately US $80 million (CDN $126 million) (DOE share) in new research awards for more than 25 projects in the country.
Year of implementation: Began in 1990 and is now part of the Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program (see below)
Objective: To address the most critical challenges to the commercialization of transportation fuel cell power systems.

Name of initiative: Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program
Type of initiative: Direct expenditure
Jurisdiction: Federal
Description: On July 1st, 2002, the United States Department of Energy reorganized its Office of Energy Efficiency and Renewable Energy (EERE). As part of this reorganization, the Hydrogen Program was expanded to include fuel cells and infrastructure research and development efforts, in addition to the hydrogen system-specific research and development work

already underway (as part of the former Hydrogen Program). The new program is called the Hydrogen, Fuel Cells and Infrastructure Technologies Program. Work in this program focuses on fuel cells for transportation, fuel cells for buildings, and infrastructure technologies. Work related to fuel cells for buildings involves developing the PEM fuel cell as a cost-effective and efficient technology suitable for stationary applications. The infrastructure technologies work focuses on developing hydrogen storage technologies. As well, a "Blueprint for Hydrogen Fuel Infrastructure Development" has been developed and focus is now on a United States hydrogen roadmap and report to congress. This roadmap will outline a ten-year government-industry action plan to install the hydrogen vehicles when they appear on the market in the next three to five years.

Year of implementation: 2002

Objective: To conduct research and engineering development in the areas of hydrogen production, storage, and utilization for the purpose of making hydrogen a cost-effective energy carrier for utility, buildings, and transportation applications.

Name of initiative: Graduate Automotive Technology Education (GATE)

Type of initiative: Direct expenditure

Jurisdiction: Federal through Department of Energy

Description: The GATE program was developed jointly by Argonne and the Department of Energy and is designed to provide research and training at the graduate level on specific technologies critical to the development and production of cost-effective, light-duty vehicles capable of achieving up to 80 miles per gallon while maintaining the safety, performance, and affordability of conventional automobiles. GATE consists of two phases: developing programs of focused technology instruction; and providing fellowships for graduate students enrolled in the GATE Centers. Research related to fuel cells, advanced materials, energy storage, direct-injection engines, and hybrid electric vehicle drive trains and control systems is eligible for funding.

Year of implementation: 1997

Objective: To create a multidisciplinary program aimed at overcoming key barriers to achieve the goals of the Partnership for a New Generation of Vehicles (PNGV), which is now the FreedomCAR program described below.

Name of initiative: FreedomCAR (Cooperative Automotive Research)

Type of initiative: Direct expenditure

Jurisdiction: Federal through Department of Energy

Description: FreedomCAR is a US $150 million (CDN $236 million) joint private/public partnership to promote the development of hydrogen as a primary fuel for cars and trucks. The partners fund research on fuel cell technologies that use hydrogen to power automobiles without creating any pollution. This initiative replaced the Partnership for a New Generation of Vehicles (PNGV) program launched by the Clinton administration to promote the development of high fuel efficiency vehicles. FreedomCAR focuses on research needed to develop technologies such as fuel cells and hydrogen from domestic renewable sources.

Year of implementation: 2002

Objective: To develop technologies for hydrogen-powered fuel cell vehicles that will not require foreign oil or emit harmful pollutants or greenhouse gases.

Noteworthy: The Department of Energy's Transportation Fuel Cell Program supports this project.

United States: State

Name of initiative: California Fuel Cell Partnership
Type of initiative: Direct expenditure and program activities
Jurisdiction: State (state level partners include California Air Resources Board, California Energy Commission, and the South Coast Air Quality Management District) with support from federal agencies (including Department of Energy and Department of Transportation).
Description: The California Fuel Cell Partnership is a collaborative of auto manufacturers, energy companies, fuel cell technology companies, and government agencies. The California Fuel Cell Partnership expects to place up to 60 fuel cell passenger cars and fuel cell buses on the road between 2000 and 2003. In addition to testing fuel cell vehicles, the partnership is examining fuel infrastructure issues and beginning to prepare the California market for this new technology.
Year of implementation: 1999
Objective: To demonstrate fuel cell vehicle technologies by operating and testing the vehicles under real-world conditions in California; demonstrate the viability of alternative fuel infrastructure technology, including hydrogen and methanol stations; explore the path to commercialization, from identifying potential problems to developing solutions; and increase public awareness and enhance public opinion about fuel cell electric vehicles, preparing the market for commercialization.
Noteworthy:

- The South Coast Air Quality Management District in Southern California and regulatory authorities in Massachusetts and Connecticut have exempted fuel cells from air quality permitting requirements.
- Private and public partnerships related to hydrogen have also been established in other states including Texas. In 2001, the Texas Natural Resource Commission launched a new partnership with public and private sectors to demonstrate the environmental benefits of hydrogen fuel cells.
- California has implemented a quota, effective in 2003, for 10% of new automobile sales in the state to be zero- and low-emission new vehicles. This is a very important initiative that is largely responsible for driving fuel cell developments in California.
- The South Coast Air Quality Management District has signed a contract for a wind station in the wind farm area of Coachella Valley. The electricity of three wind turbines will be used to make hydrogen for all fuel cell buses put into service by SunLine Transit.
- The Board of Alameda-Contra Costa Transit voted in favour of buying four compressed hydrogen fuel cell buses, with three to be operated by AC and one to go to southern California's SunLine Transit system.

Name of initiative: Michigan NextEnergy Initiative
Type of initiative: Direct expenditure and tax measures
Jurisdiction: State
Description: NextEnergy is a comprehensive set of actions and incentives designed to position Michigan as the world's leading centre for alternative energy technology, research and development, education and manufacturing. Technologies for both mobile and stationary applications using renewable and distributed energy solutions will be supported. The legislation being considered by lawmakers in the State House and Senate includes several tax exemptions for firms that research and develop alternative energy systems in Michigan including a tax exemption for new alternative energy systems or vehicles; a property tax exemption for any property used to research, develop or manufacture alternative energy technologies; and a sales tax exemption for

purchases of new alternative systems or vehicles. Initial funding for this initiative is over US $52 million (CDN $82 million).
Year of implementation: 2002
Objective: The goal of the program is to attract new major stationary or mobile fuel cell development projects to Michigan.

Name of initiative: Muskegon Shoreline SmartZone
Type of initiative: Direct expenditure
Jurisdiction: State
Description: SmartZones are high-technology business centers that are expected to form the backbone of Michigan high-tech business development initiatives. Property taxes generated within a SmartZone, instead of going to local schools and governments, can be reinvested into research centres and business incubators and their operations within the zone. The state has committed US $2.6 million (CDN $4 million) to this project.
Year of implementation: 2001
Objective: Muskegon's SmartZone is dedicated to alternative energy issues revolving around commercializing technologies such as fuel cells, micro turbines, wind generators and solar panels. The goal is to create jobs and wealth in the region through a partnership of academic institutions, cities and the state. Muskegon Lakefront is a proposed US $50 million (CDN $79 million) mixed-use development.

Name of initiative: Ohio's Fuel Cell Program
Type of initiative: Direct expenditure, loans and tax measures
Jurisdiction: State
Description: This is a US $100 million (CDN $157 million), 3-year initiative for investment in research, project demonstration and job creation for Ohio citizens. The funding will support investment in technology development and commercialization through low-interest loans, tax-exempt bond financing and employee hiring and training credits. The US $100 million (CDN $157 million) fuel cell initiative is an integral part of the Third Frontier Project, a 10-year, US $1.6 billion (CDN $2.5 billion) plan to create high-tech, high-paying jobs though expansion of the state's high-tech research capabilities and promotion of start-up companies. The Fuel Cell Program component of the funding will be allocated as follows: US $75 million (CDN $118 million) for various funding projects; US $25 million (CDN $39 million) for research, development and demonstration; and US $3 million (CDN $4.7 million) for training.
Year of implementation: 2002
Objective: To move Ohio into the centre-ring of fuel cell development.

Name of initiative: Fuel Cell at Nikiski
Type of initiative: Procurement
Jurisdiction: State (Alaska) with funding from the federal government.
Description: BP is testing a US $6.5 million (CDN $10.2 million) fuel cell at a Nikiski gas to liquid plant. With help from the federal government and the National Rural Electric Cooperative Association, BP bought a US$ 6.5 million (CDN $10.2 million), 250 kW fuel cell to power the plant's administration building and warehouse.
Year of implementation: 2001
Objective: The goal is to meet the growing world demand for energy without increasing impacts to the environment. BP has committed to reducing its own greenhouse gas emissions by 10% by 2010 and to eliminating the flaring and venting of gases. Funding: BP US $4 million (CDN $6.3 million), US Department of Energy US $2 million (CDN $3.1 million), and the Chugach Electric

Association US $450,000 (CDN $706,539) by way of a grant from the Cooperative Research Network of the National Rural Electric Cooperative Association.

Name of initiative: US Postal Service Fuel Cell
Type of initiative: Procurement
Jurisdiction: State (Alaska) with funding from the federal government.
Description: The US Postal Service has installed a fuel cell system as part of the utility grid. This was the first fuel cell grid-connection in the US and, at 1 MW, it was the largest commercial fuel cell installation at the time of implementation. The US $5.5 million (CDN $8.6 million) system is operated and was installed by Chugach Electric Association Inc. for the Postal Service. Five fuel cells, connected in parallel to produce 1 MW of electricity, are the primary source of power for the Anchorage facility. Heat recovery from the fuel cells helps provide space heating to the facility. This project is largely funded by the Department of Defence, Army Corps of Engineers, Construction Engineering and Research Laboratories.
Year of implementation: 2001
Objective: To demonstrate technology application.

The following table summarizes the United States' fiscal policies and programs related to hydrogen fuel/infrastructure and fuel cell technologies presented above.

Summary of Policies and Programs in the United States

Initiative	Type of Initiative	Jurisdiction
Climate Change Fuel Cell Rebate	Tax measure	Federal
Fuel Cell Residential Demonstration Project	Procurement	Federal
Solid State Energy Conversion Alliance	Direct expenditure and program activities	Federal
Deduction for Clean Fuel Vehicles and Certain Refuelling Property	Tax measure	Federal
Transportation Fuel Cell Power Systems Program	Direct expenditure	Federal
Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program	Direct expenditure	Federal
Graduate Automotive Technology Education Program	Direct expenditure	Federal
FreedomCAR	Direct expenditure	Federal
California Fuel Cell Partnership	Direct expenditure and program activities	State
Michigan NextEnergy Initiative	Direct expenditure and tax measures	State
Muskegon Shoreline SmartZone	Direct expenditure	State
Ohio's Fuel Cell Program	Direct expenditure, loans and tax measures	State
Fuel Cell at Nikiski	Procurement	State
US Postal Service Fuel Cell	Procurement	State

While the focus in the United States seems to be on direct expenditure related to research and development, other types of fiscal policies and programs have also been implemented including tax measures, procurement, loans, and expenditure related to program activities. Private/public

partnerships have been established at both state (California Fuel Cell Partnership) and federal (FreedomCAR and Solid State Energy Conversion Alliance) levels. Indeed, the summary table reveals that the United States has employed a range of fiscal policies and programs to encourage growth in the hydrogen/fuel cell economy at both state and federal levels.

The next table offers an evaluation of the United States' fiscal policies and programs presented above according to the sector targeted, the barrier addressed, whether the policy is explicitly focused on hydrogen and fuel cells and whether the policy includes hydrogen from renewable energy sources.

Evaluation of Policies and Programs in the United States

Initiative	Sector Focus	Barriers Addressed	Focus On Hydrogen And Fuel Cells	Includes Renewable Energy Sources
Climate Change Fuel Cell Rebate	Fuel cells	Cost	Yes	Yes
Fuel Cell Residential Demonstration Project	Fuel cells	Cost	Yes	Yes
Solid State Energy Conversion Alliance	Fuel cells	Cost	Yes	Yes
Deduction for Clean Fuel Vehicles and Certain Refuelling Property	Hydrogen and infrastructure	Cost	No, applicable to natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, electricity and any fuel that is at least 85% methanol, ethanol or any other alcohol or ether	Yes
Transportation Fuel Cell Power Systems Program	Fuel cells	Technical	Yes	Yes
Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program	Hydrogen and fuel cells	Technical	Yes	Yes

Evaluation of Policies and Programs in the United States, Continued

Graduate Automotive Technology Education Program	Hydrogen and fuel cells	Technical	No, focus is broader and applied to light-duty vehicles capable of achieving up to 80 miles per gallon	Yes
FreedomCAR	Hydrogen and fuel cells	Technical	Yes	Yes, explicit focus on hydrogen from domestic renewable resources
California Fuel Cell Partnership	Fuel cells and infrastructure	Technical and infrastructure	Yes	Yes, there is a focus on hydrogen from wind power
Michigan NextEnergy Initiative	Hydrogen and fuel cells	Cost	No, applies to various forms of alternative energy	Yes
Muskegon Shoreline SmartZone	Fuel cells	Cost	No, applies to various forms of alternative energy	Yes, but focus is on high-tech sector generally
Ohio's Fuel Cell Program	Fuel cells	Cost and technical	Yes	Yes
Fuel Cell at Nikiski	Fuel cells	Cost	Yes	No
US Postal Service Fuel Cell	Fuel cells	Cost	Yes	No

As the table indicates, the majority of the policies considered in this analysis are geared toward fuel cell technology development, for both transportation and power generation (stationary and portable) applications, and hydrogen fuel development. The United States government has provided funds to develop one of the largest fuel cell stationary applications in the world (the US Postal Service fuel cell). The policies presented in this analysis are targeted at both economic and technical barriers to developing the hydrogen and fuel cell economy.

While the majority of the policies presented here are designed to target fuel cells and hydrogen, there are examples of policies that apply more broadly to low-emission vehicles and alternative forms of energy generation. Only one initiative, FreedomCAR, focuses explicitly on hydrogen generation from renewable energy sources. As well, while work related to developing a hydrogen and fuel cell economy was historically undertaken by more than one government agency (Energy and Defence), the reorganization of July 1st, 2002 formally placed one government agency in charge of hydrogen, fuel cell and infrastructure developments.

Japan

Name of initiative: World Energy Network (WE-NET)
Type of initiative: Direct expenditure
Jurisdiction: Federal

Description: WE-NET is a long-term plan to develop the hydrogen and fuel cell economy in Japan through the New Energy and Industrial Technology Development Organization (NEDO). NEDO is researching and developing hydrogen energy technologies in a joint industry-government-university effort, aiming at worldwide deployment by the year 2030. The program is divided into three phases. Phase I started in 1993 with the aim of establishing a wide range of basic technologies related to hydrogen production, transportation, storage and utilization. Phase II comprised a series of tasks, which are described below. In Phase III, now underway, practical technology will be developed and pilot plants will be constructed on an international scale to deploy the system for actual use. Phase II tasks include the following:

- Task 1 is to evaluate the energy efficiency, environmental impacts and economical considerations of renewable energy as well as various systems using hydrogen, including hydrogen produced from fossil fuels and renewables, so as to discuss a strategy for introducing hydrogen more broadly.
- Task 2 is to establish a safety evaluation methodology. Based on the results of preliminary safety evaluations, standards for safety design will be discussed.
- Task 3 is to promote international research cooperation and global information exchanges related to research and development.
- Task 4 is to come up with research and development challenges through development and continuous operation of a single cylinder 100 kW level hydrogen diesel engine for co-generation.
- Task 5 is to develop hydrogen fuel cell vehicles and hydrogen refuelling stations and to verify the technology and refuelling station through use while also evaluating the energy efficiency of the vehicles.
- Task 6 is to establish a PEM fuel cell generation system whose sending-end efficiency is about 45% (higher calorific value standard) to verify stationary generation system of 30–50 kW levels.
- Task 7 is to develop and verify a small-scale test system of about one tenth of full-scale capacity for hydrogen refuelling stations to establish standalone hydrogen refuelling stations.
- Task 8 is to develop solid polymer electrolyte and water electrolysis technologies. A small-scale hydrogen production system (with 1,000 cm^2 of electrode surface area, cell stack type) will also be developed in coordination with research and development of hydrogen refuelling stations.
- Task 9 is to develop insulation structures for transportation and storage equipment of liquid hydrogen. It is also to develop liquid hydrogen pump technologies and to develop conceptual designs of hydrogen compressors for liquefaction.
- Task 10 is to conduct tests of material properties of liquid hydrogen, to develop elemental technologies related to optimum welding materials and optimum welding methods, and to enrich the database of material properties.
- Task 11 is to develop hydrogen-absorbing alloys for hydrogen storage.
- Task 12 is to research innovative and leading technologies connected with hydrogen use, production, transportation and storage, except items in above-mentioned tasks.

Year of implementation: 1993; in March of 2003 the WE-NET program will come to a close and be replaced by the Millennium Project (described below)

Objective: To investigate the utilization of hydrogen energy and estimate the amount of hydrogen consumption potential in different sectors such as electric power, transportation, industry and public welfare. The utilization of liquid hydrogen for cryogenic energy will also be investigated and reviewed. If the WE-NET project is realized and disseminated globally by the beginning of the 21st century, hydrogen will be used not only to run automobiles and fly aircraft, but also to power all of the appliances used in daily living.

Name of initiative: Ministry of Economy, Trade and Industry (METI)
Type of initiative: Direct expenditure
Jurisdiction: Federal
Description: METI has invested substantial resources into fuel cell and hydrogen development and deployment. Specific initiatives include an expansion of the grant system for environmentally friendly companies, support for commercialization of fuel cell technologies, hydrogen station demonstration projects and the installation of home fuel cell units.
Year of implementation: Ongoing
Objective: To focus on technology development and commercialization.

Name of initiative: Sales Tax Reductions for Efficient Vehicles
Type of initiative: Tax measure
Jurisdiction: Federal
Description: In 1999, sales tax reductions were introduced for vehicles that meet certain fuel efficiency standards. In 2010, stringent minimum fuel efficiency standards are going to be introduced in Japan. In preparation for those standards, and to incent consumers to purchase efficient vehicles, cars that conform to the 2000 exhaust emission standards in Japan are eligible for a 1% reduction in the automobile tax; a family car meeting the 2010 minimum fuel efficiency standards will qualify for an automobile tax break of YEN 15,000 (CDN $191)
Year of implementation: 1999
Objective of policy: To reduce greenhouse gas emissions and air pollution.

Name of initiative: Millennium Project
Type of initiative: Direct expenditure
Jurisdiction: Federal
Description: The Millennium Project focuses on the development of safety codes and regulations related to the use of hydrogen fuel. Expenditure on the Millennium Project was YEN 1,350 million (CDN $17.2 million) in 2000. In 2002, expenditure increased to YEN 3,100 million (CDN $39.5 million) and requested funds for 2003, when the WE-NET program is completed, is YEN 3,900 million (CDN $49.66 million).
Year of implementation: 2000
Objective: To establish safety codes and regulations related to the use of hydrogen fuel.

Japan has made a national commitment to developing hydrogen as an alternative to oil.[13] In concert with this commitment, the government of Japan developed and implemented the WE-NET program, a highly integrated and long-term plan for developing a hydrogen and fuel cell economy that is coordinated by one government agency. In addition to the WE-NET program, the Ministry of Economy, Trade and Industry has developed and implemented a high level program to commercialize fuel cells in Japan, and the Millennium Project to develop codes and standards for hydrogen use is now underway. There is a substantial focus in Japan on infrastructure development and implementation. In the third phase of the WE-NET program, as with the METI program, Japan will progress beyond testing and product verification to product commercialization and implementation.

As the table below indicates, the WE-NET program is designed to target all aspects of the hydrogen and fuel cell economy: fuel cells, infrastructure and hydrogen fuel for both power

[13] Foley, Julie. H2: Driving the Future. Institute for Public Policy Research. 2001.

generation (stationary and portable) and transportation fuel cell applications. As well, the tasks that will be completed through the WE-NET program are designed to address all barriers to developing a hydrogen and fuel cell economy. In most cases, the tasks are explicitly targeted at hydrogen and fuel cells rather than renewable energy in general. Given that the fundamental driver behind WE-NET is the development of a renewable hydrogen infrastructure in Japan, all of the tasks of the WE-NET program are focused to a degree on renewable energy sources.

Evaluation of Policies and Programs in Japan

Initiative	Sector Focus	Barriers Addressed	Focus On Hydrogen and Fuel Cells	Includes Renewable Energy Sources
WE-NET Task 1	Hydrogen	Cost and technical	No	Yes
WE-NET Task 2	Hydrogen, infrastructure and fuel cells	Codes and standards	Yes	Yes
WE-NET Task 3	Hydrogen, infrastructure and fuel cells	Focus on international coordination	Yes	Yes
WE-NET Task 4	Hydrogen	Technical	No	Yes
WE-NET Task 5	Hydrogen, infrastructure and fuel cells	Cost and technical	Yes	Yes
WE-NET Task 6	Fuel cells	Technical	Yes	Yes
WE-NET Task 7	Infrastructure	Cost, technical and infrastructure	Yes	Yes
WE-NET Task 8	Infrastructure	Infrastructure	Yes	Yes
WE-NET Task 9	Infrastructure	Technical and infrastructure	Yes	Yes
WE-NET Task 10	Infrastructure	Technical and infrastructure	Yes	Yes
WE-NET Task 11	Infrastructure	Technical and infrastructure	Yes	Yes
WE-NET Task 12	Hydrogen	Technical and infrastructure	Yes	Yes
METI	Hydrogen, infrastructure and fuel cells	Cost, technical and infrastructure	Promotion of fuel cell technologies is one of the many activities of METI	Yes
Tax Reduction for Efficient Vehicles	Fuel Cell	Cost	No, applies to vehicles that meet efficiency standards	Yes
Millennium Project	Hydrogen	Codes and standards	No, focus is mainly on hydrogen	Yes

Germany

Name of initiative: Munich Airport Hydrogen Project
Type of initiative: Procurement
Jurisdiction: State (Bavaria)
Description: In addition to the on-site production and storage of gaseous hydrogen, the project will test the fully automatic refuelling of cars with liquid hydrogen and the use of airport buses for passenger transport under the safety requirements of an international airport. The total costs of around DM 34 million (CDN $26.5 million) were borne by the project partners and the Free State of Bavaria, which provided 50% of the finances from public funds.
Year of implementation: Public filling station opened in 1999
Objective: To gain insights into the routine use and economic feasibility of hydrogen as a fuel.

Name of initiative: Clean Energy Partnership (CEP)
Type of initiative: Direct expenditure
Jurisdiction: Federal
Description: The CEP is part of the German national strategy for sustainability that seeks to demonstrate innovative technologies and identify the technical and economic prerequisites for establishing alternative fuels in road transportation. A fundamental component of this program is to demonstrate positive environmental effects. The hydrogen for this project will be produced from renewable sources of energy as far as possible.
Year of implementation: 2002 and projected for a five-year period
Objective: To demonstrate that hydrogen is a viable fuel for everyday life. In Berlin, an Aral fuelling station will be established where hydrogen will be produced on site.

Name of initiative: Future Technology Fuel Cell Rhineland Palatinate
Type of initiative: Program activities
Jurisdiction: State (Rhineland Palatinate)
Description: This network will be a forum for parties active in the state in the fuel cell field. The driving force for this initiative was the Ministry of Environment. The Ministries for Science and Economy and Transport also support the partnership.
Year of implementation: 2002
Objective: To encourage the transition to a hydrogen economy on the basis of renewable energies.

Name of initiative: Hydrogen and Fuel Cell Initiative in Hesse
Type of initiative: Direct expenditure
Jurisdiction: State (Hesse)
Description: Provides funds to develop and publish a Competency Map for Fuel Cells for the state of Hesse that shows the fields of activities and the resources of the parties in the state.
Year of implementation: 2002
Objective: To publish, in the summer of 2002, a Competency Map for Fuel Cells for the state of Hesse.
Noteworthy: A similar initiative was implemented in the state of Mecklenburg, Western Pomerania in February of 2002 funded by the state Ministry for Economy.

Name of initiative: Fuel Cells for Telephone and Internet Services
Type of initiative: Procurement

Jurisdiction: Federal
Description: There are about 2,700 diesel generators with a total output of about 750 MW distributed all over Germany to keep telephone and Internet connections operational even if the normal power grid should fail. Dete Immobilien, infrastructure subsidiary of Deutsche Telekon, intends to replace these generators with fuel cells. A first plant will begin operating in Munich in September 2002. The plant will operate in cogeneration mode to provide a particularly high efficiency. The federal Ministry of Economical Affairs supports this project financially.
Year of implementation: 2002
Objective: The end result will be the installation of about 100 fuel cells, which could save a total of 60,000 tonnes of CO_2 per year.

Name of initiative: Production Incentive
Type of initiative: Tax measure
Jurisdiction: Federal
Description: The Production Incentive includes combined heat and power based on fuel cells in the legal measures for the support of cogeneration. Cogeneration units based on fuel cells will be supported with an amount of Euro 0.05/kWh (CDN $0.08/kWh) as long as the output is below 2 MW. The funds will be provided by a general rise in power prices.
Year of implementation: 2001
Objective: To facilitate the entry of fuel cells into the stationary energy market while costs are above those for competing technologies.

Name of initiative: ZIP Program
Type of initiative: Direct expenditure
Jurisdiction: Federal (German Ministry of Economics and Technology)
Description: Up to 2003 a total of Euro 120 million (CDN $186.9 million) will be allocated to the ZIP Program for research and development work related to environmentally friendly technologies. Euro 60 million (CDN $92 million) is targeted at the development and demonstration of portable, mobile and stationary fuel cells.
Year of implementation: Funding allocated until 2003
Objective: To develop and demonstrate portable, mobile and stationary fuel cell applications.

Name of initiative: Biogenous Gases for Fuel Cells
Type of fiscal initiative: Program activities
Jurisdiction: Federal
Description: The Society for the Promotion of Renewable Energy started a federal task group called “Biogenous Gases for Fuel Cells.” The group is searching for ways to use gases and liquids from biomass for power and heat generation by fuel cells. The project is promoted by the Federal Ministry of Consumer Protection, Food and Agriculture.
Year of implementation: 2002
Objective: To investigate the possibility of using biogenous gases for fuel cells.

The following table summarizes the German fiscal policies and programs related to hydrogen fuel/infrastructure and fuel cell technologies presented above.

Summary of Policies and Programs in Germany

Initiative	Type of Initiative	Jurisdiction
Munich Airport Hydrogen Project	Procurement	State
Clean Energy Partnership	Direct expenditure	Federal
Future Technology Fuel Cell Rhineland Partnership	Program activities	State
Hydrogen and Fuel Cell Initiative in Hesse	Direct expenditure	State
Fuel Cells for Telephones and Internet Services	Procurement	Federal
Production Incentive	Tax measure	Federal
ZIP Program	Direct expenditure	Federal
Biogenous Gases for Fuel Cells	Program activities	Federal

As the table indicates, a number of fiscal policy instruments have been implemented in Germany at both state and federal levels. A production incentive in place in Germany related to cogeneration applies to the use of fuel cells in cogeneration applications. A second relevant tax measure, not presented above but worthy of mention, is that all fuels made from biomass are temporarily exempt from the fuel tax in Germany. This exemption applies to biogas, synthetic gasoline and diesel made from biomass, bioethanol, biomethanol and hydrogen from biomass. Tax measures are less prevalent at the state level due to limited jurisdiction over taxes of state governments. Policies at the state level appear instead to focus more on private/public partnerships; several state level public/private partnerships were established Germany in 2002.

The next table reveals that fiscal policies and programs in Germany related to hydrogen and fuel cells have targeted infrastructure, fuel cell technologies and hydrogen fuels. Several hydrogen fuelling stations are now in place in Germany. There has been a substantial focus on both power generation (stationary and portable) and transportation applications. Cost, technical and infrastructure barriers have been addressed through use of fiscal policies and programs in Germany. Also noteworthy is that two policies are explicitly geared to developing hydrogen from renewable sources.

Evaluation of Policies and Programs in Germany

Initiative	Sector Focus	Barriers Addressed	Focus on Hydrogen and Fuel Cells	Includes Renewable Energy Sources
Munich Airport Hydrogen Project	Infrastructure	Infrastructure	Yes	Yes
Clean Energy Partnership	Hydrogen and fuel cells	Cost and technical	No, applies more broadly to alternative fuels in road transportation	Yes, focus is explicitly on renewable energy sources
Future Technology Fuel Cell Rhineland Palatinate	Fuel cells	Cost and technical	Yes	Yes
Hydrogen and Fuel Cell Initiative in Hesse	Hydrogen and fuel cells	N/A, through this project a competency map will be created showing the various companies working in this area in the state	Yes	Yes
Fuel Cells for Telephone and Internet Services	Fuel cells	Cost	Yes	No
Production Incentive	Fuel cells	Cost	No, applies to cogeneration units in general	Yes
ZIP Program	Fuel cells	Technical	No, focus is on environmentally friendly technologies generally	Yes
Biogenous Gases for Fuel Cells	Fuel cells	Technical	Yes	Yes, focus on biomass as a source of hydrogen

European Union

Name of initiative: Framework Programs
Type of initiative: Direct expenditure
Jurisdiction: International
Description: Funding for research, development and demonstration work in the EU is channelled through periodic Framework Programs that have an average budget of Euro 3 to 4 billion (CDN $4.6 to $6.1 billion) managed by the Directorate of Research of the EU Commission. The 5th Framework Program (1998–2002) awarded Euro 150 million (CDN $229 million) to fuel cell and hydrogen storage technology development. The 6th Framework Program

(2002–2006) has a substantial increase in funding allocated to fuel cell and hydrogen storage technology. At present, the detailed allocations have not been released but estimates allocate approximately Euro 620 million (CDN $946 million) to fuel cell and hydrogen storage technology. In the 6th Framework Program there will be a strong focus on large integrated projects. The Clean Urban Transport for Europe (CUTE) project is one component of the 5th Framework Program. Through the CUTE program, the European Commission awarded Euro 18.5 million (CDN $28.2 million) to nine European cities to introduce hydrogen into their public transport system. The European cities awarded the funds were Amsterdam, Barcelona, Hamburg, London, Luxembourg, Madrid, Porto, Stockholm and Stuttgart.
Year of implementation: The 5th Framework Program will be completed in 2002 and the 6th Framework Program is currently under development.
Objective: To contribute to the international competitiveness of European industry and to support the European Union's policies in fields such as environment, energy and transport. The major policy driver is economic development, but air quality and climate change, security of energy supply and noise pollution from transport also play prominently.

The main fiscal program in place in the European Union is the Framework Program. This program provides direct expenditure in the form of funds for research and development and procurement. The policies are designed to address fuel cells, hydrogen fuel and infrastructure requirements. The main focus of this program as it relates to hydrogen and fuel cell developments is on cost barriers.

It is also worth highlighting the European Integrated Hydrogen Project (EIHP). In the second phase of the EIHP, EIHP2, the draft regulation documents for Europe related to hydrogen (developed in the first stage) will be improved and developed to a global regulation for hydrogen fuelled road vehicles. Regulations for periodic vehicle inspections, re-fuelling procedures and periodic inspections for hydrogen refuelling infrastructure components and systems will be developed. EIHP2 will strive to validate the EIHP1 draft regulations by developing and implementing hydrogen components and vehicles in accordance with the draft regulations.

4. Comparative Analysis and Evaluation

This section of the report highlights fiscal policy and program trends in developing fuel cell technologies and hydrogen fuel and infrastructure in Germany, Japan and the United States. Here, factors that have likely contributed to the success of these leading countries in developing the hydrogen and fuel cell economy are identified and Canada's progress in incorporating these factors is evaluated.

Along with Canada, Germany, Japan and the United States have established themselves as leaders in developing the hydrogen and fuel cell industries globally. They have done so through, among other activities, implementing fiscal policies and programs designed to support the hydrogen and fuel cell industries. These policies have been implemented to help overcome economic and technical barriers that exist with respect to fuel cell development. Japan, Germany and the United States appear to be leaders in supporting power generation fuel cell application demonstrations and Japan and Germany are leaders in infrastructure development for hydrogen fuelling stations, having built several such stations in recent years.

Substantial evidence of the success of individual policies in influencing the growth of the hydrogen and fuel cell economy is unfortunately somewhat limited due to several factors. First, countries supporting hydrogen and fuel cells through fiscal policies and programs have tended towards packages of policies rather than individual policies. Thus, it is difficult to discern the

effect of one policy from another. Second, as the countries considered in this analysis are all leaders in the field, there is little basis for comparison. To compare the overall effect of these policies requires comparing the growth of the hydrogen economy in leading countries with that in non-leading countries. Third, because many of these policies have been implemented relatively recently, evidence of their impact is still not documented.

Nonetheless, indications of the expanding fuel cell and hydrogen industries are mounting. The current market for fuel cells is estimated at US $218 million (CDN $334 million). According to estimates by the Business Communications Company, the market will rise to US $2.4 billion (CDN $3.7 billion) by 2004, and US $7 billion (CDN $10.7 billion) by 2009. Allied Business Intelligence (ABI) estimates that by 2010 automotive fuel cells will occupy 4% of market share of vehicles in the United States. That is the equivalent of 608,000 vehicles. Similarly, ABI estimates that the current US $40 million (CDN $61 million) stationary fuel cell market will grow to more than US $10 billion (CDN $15 billion) by 2010 and the overall fuel cell energy generating capacity will increase by a factor of 150, with global stationary fuel cell electricity generating capacity increasing to over 15,000 MW by 2011 from just 75 MW in 2001.[14] Recent estimates presented by PricewaterhouseCoopers[15] indicate that between 2007 and 2011 the fuel cell industry[16] will grow at a compounded average annual rate of 75%. Specific examples of the growth in the industry indicate the effectiveness of fiscal policies and programs in influencing hydrogen and fuel cell market penetration. A number of such examples are provided below:

- In 2001, Japan completed its first two hydrogen filling stations: a plant with a natural gas reformer was built in Osaka and another with an electrolyzer was installed in the Shikoku Research Institute at Taka matsu. The refuelling stations are currently able to handle 24 to 30 fuelling operations per day. July 2002 saw a third station completed and five more are planned for the end of 2003.
- In Germany, three state level private/public partnerships were introduced in 2002.
- Also in 2002 in Germany, plans to install fuel cells at a power plant were finalized. The fuel cell system will be installed in an existing power plant in the summer of 2003 and will deliver heat and electricity. The investment for this project is about Euro 6.2 million (CDN $9.4 million) and is funded in part by the German Federal Economics Ministry.
- Some of the largest fuel cell installations in the world are in the United States. Alaska is home to one of the largest fuel cell power plants in the world (five PC25 fuel cell power units were installed at a postal facility in Anchorage, Alaska less than one year ago). One of the world's largest fuel cell installations will be built in Connecticut. Six PC25 fuel cell power units, which each produce 200 kW of electricity and 900,000 Btu's of heat, will provide primary power to the Connecticut Juvenile Training School in Middletown, Connecticut.
- In Japan, the government has a stated goal of 50,000 fuel cell cars circulating on Japan's roads by 2010. This initiative, lead by the Ministry of Economy, Trade and Industry, is valued at about Euro 32 million (CDN $48.5 million) and is a joint project with General Motors, Toyota, Nissan, Honda and DaimlerChrysler.
- A German utility will install 25 fuel cells for heating in houses in 2002. By the end of 2004, a total of 55 such units will be in place.
- Plug power, a fuel cell technology company in the United States, delivered 132 fuel cell systems in 2001; of these, 81 were delivered in the fourth quarter.

[14] See www.fuelcells.org
[15] PricewaterhouseCoopers. 2002. "Fuel Cells: The Opportunity for Canada". PricewaterhouseCoopers.
[16] Defined as comprising companies and organizations involved in fuel cell and fuel cell component research, development, production, system integration and distribution as well as companies and organizations that currently derive or plan to derive a significant portion of their income from the sale of goods and services to the former group.

- The United States has a program to facilitate the use of fuel cells at landfills and wastewater treatment plants, with several fuel cells already installed across the country.
- The US Department of Defence Climate Change Fuel Cell Program has awarded more than US $18.8 million (CDN $28.8 million) toward the purchase of 94 fuel cell units. The Residential Fuel Cell Demonstration Program has implemented 21 units at 12 military locations in the country.

In comparing the approaches these leading countries have taken to facilitate the growth of the fuel cell and hydrogen industries, several trends are revealed. These factors have likely contributed to the success of fiscal policies and programs in influencing the fuel cell and hydrogen industries in Japan, Germany and the United States. The trends are described below.

1. The countries considered in this analysis have implemented a range of fiscal policies and programs. While substantial focus has been on direct expenditure, Japan, Germany and the United States have also implemented tax measures, loans, procurement programs and expenditure related to program activities. By using a mix of fiscal policies and programs, these jurisdictions have been able to target and overcome a range of economic and technical barriers.
2. Fiscal policies and programs in the countries under consideration have focused on both power generation (stationary and portable) and transportation applications. Numerous examples now exist where fuel cell technologies are in use in power generation applications. Examples include fuel cells for phone and Internet services, fuel cells in cogeneration units, use of fuel cells by energy utilities and fuel cells for home heating.
3. Fiscal policies and programs are increasingly targeted not just at research and development but also at technology and infrastructure implementation. Examples of real world applications of fuel cells (for both transportation and power generation) are steadily increasing and have been facilitated through fiscal policies and programs in Japan, Germany and the United States.
4. Policies and programs have been implemented at both federal and state levels in Germany and the United States. Given the global nature of the fuel cell and hydrogen industries, and the ability of companies to relocate based on the competitiveness of various regions, such coordinated federal and state level programs are essential.
5. There is a trend towards development and implementation of a long-term, coordinated approach to advancing fuel cell technologies and hydrogen fuel/infrastructure. Japan is a leader in this area having developed a 30-year strategy, the WE-NET program, for developing a hydrogen economy. Also in Japan, METI has involved the development and implementation of a comprehensive and long-term plan for the commercialization of fuel cell technologies. The United States is moving in the same direction through development of a hydrogen roadmap and report to Congress and having just completed (as of July 1st, 2002) a restructuring of the Department of Energy so that the majority of work related to fuel cell technologies and hydrogen fuel/infrastructure is now coordinated by one group, namely the Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program.
6. Fiscal policies and programs need to be backed by sufficient financial resources. Until the high costs associated with fuel cells and hydrogen fuel/infrastructure decline, it is important for governments to provide sufficient funds to overcome existing barriers, drive costs down and increase market penetration.

To formulate recommendations related to the kind of fiscal policies and programs that should be implemented in Canada, it is appropriate to consider how well the factors described above are applicable to current Canadian fiscal policies and programs. As the table below reveals, relative

to Japan, Germany and the United States, Canada has not employed a mix of policy instruments for developing the fuel cell and hydrogen fuel economy. Fiscal policies and programs in Canada related to hydrogen and fuel cells have focused mainly on addressing technical barriers through research and development programs as opposed to product implementation and demonstration. Cost barriers have not been addressed through use of tax measures in Canada. In the past, Canada has provided relatively less support for large-scale demonstration programs and appears to have focused more on transportation fuel cell applications. Demonstration activities supported by Canadian governments have been mainly focused on mobile fuel cell applications and infrastructure rather than stationary and portable power generation applications. Germany has a demonstration program for bringing fuel cell applications to the residential sector and is installing fuel cells to power phone and Internet service in the country. The United States has supported the implementation of large-scale stationary power applications in institutional and commercial buildings. Programs of this nature and scale are absent in Canada. Canada lacks a federally coordinated, long-term national commitment and methodology for developing a hydrogen and fuel cell economy.

Factor Contributing To Success	Progress In Canada
Implement various types of fiscal policies and programs	Canada has not employed the mix of policies and programs that are evident in Japan, Germany and the United States. Canada has focused largely on direct expenditure. There is a significant gap in use of tax measures for developing a hydrogen and fuel cell economy in Canada.
Focus on both power generation (stationary and portable) and transportation applications	Demonstration activities supported by Canadian governments have been mainly focused on mobile fuel cell applications and infrastructure rather than stationary and portable power generation applications. In contrast, Germany and the United States have programs designed to implement fuel cell power generators in the residential and commercial/institutional sectors. As well, Germany is using fuel cells to power the Internet and phones.
Focus on implementation	Canada lags behind other countries with respect to commercializing technologies and demonstrating infrastructure.
Implement state and federal level policies	While there has been progress in implementing fiscal policies and programs in British Columbia, other provinces lag behind.
Develop a coordinated, long-term strategy	Canada does not have one government agency solely dedicated to work on fuel cells and hydrogen and has yet to develop a long-term strategy for developing fuel cells and hydrogen fuel/infrastructure in Canada.
Ensure sufficient financial backing	Funding in Canada is insufficient when compared with that provided by the United States, Japan and Germany.[17]

5. Developing a Hydrogen and Fuel Cell Economy in Canada

Given the above analysis, several specific recommendations for designing and implementing fiscal policies and programs for a hydrogen and fuel cell economy in Canada are warranted. These are identified and described below.

[17] PricewaterhouseCoopers. 2002. “Fuel Cells: The Opportunity for Canada”. PricewaterhouseCoopers.

1. The Canadian government should employ a **mix of fiscal policies and programs** specifically targeted at current barriers.[18]

This will include not only the direct expenditure programs currently in place, but also increased funding for procurement and demonstrations and the introduction of tax measures over time. Demonstration and procurement programs are important in the short term while technological advancements and cost remain significant barriers to widespread adoption of fuel cells and hydrogen. Governments are well positioned to act as catalysts for market creation through demonstration and procurement programs. Such programs serve to exhibit the viability and commercialization of fuel cells and have been employed in the United States, Germany and Japan.

Once technical barriers have been largely addressed, tax measures are especially important to help overcome cost barriers and increase market penetration in the long term. Tax measures can be implemented by all levels of government in Canada to adjust the cost of producing and using hydrogen and fuel cell technologies. The federal government can focus on income and capital tax credits, research and development tax credits, and fuel and sales tax exemptions. Provincial governments can pursue fuel and sales tax exemptions and research and development tax credits, while municipal governments can adjust property taxes and utility payments.

2. Implement fiscal policies and programs that target both **power generation (stationary and portable) and transportation fuel cell applications.**

Canada has the opportunity to gain significant market share for fuel cells in both the power generation (stationary and portable) and transportation fuel cell markets. According to studies by the Business Communications Company, by 2004 the fuel cell market for electric power generators will be worth US $850 million (CDN $1,303 million), for portable electronic equipment will be worth US $200 million (CDN $307 million), for military/aerospace applications will be worth US $200 million (CDN $307 million), and for fuel cell motor vehicles will be worth US $750 million (CDN $1,150 million).[19]

Demonstration activities supported by Canadian governments have focused heavily on mobile fuel cell applications and infrastructure. Indeed, the infrastructure needed to support the mobile fuel cell sector is significant. One strategy for addressing some of the barriers associated with infrastructure development in the short term is to use existing infrastructure to the extent that is possible. The federal government in its quest to make Canada the most connected country in the world has used a similar strategy. To accomplish this goal, the federal government has implemented a package of policies, targeted at different sectors, designed to increase Internet connections in Canada. One of the key factors contributing to the success of these programs is the use of existing infrastructure (phone and cable lines), at least initially, to bring the Internet to Canadians. A similar strategy could be employed to develop the transportation fuel cell sector in Canada. Hydrogen creation capacity could be targeted at existing fuelling infrastructure, including facilities and other feedstock supplies, to make it accessible and to minimize new infrastructure requirements in the short term. In the

[18] Use of non-fiscal policies such as efficiency standards and quotas for low and zero emission vehicles will also play an important role in developing the hydrogen economy in Canada.
[19] See www.fuelcells.org

long term, to maximize environmental benefits, focus should shift to producing hydrogen from renewable energy sources.

At same time, however, it is important to develop the market for power generation (stationary and portable) fuel cell technologies. The United States, Japan and Germany are providing substantial funds to develop this complementary fuel cell market. And as the figures above demonstrate, the power generation fuel cell market is poised to become significant.

It is also important to implement fiscal policies and programs that explicitly target hydrogen from renewable energy sources. Japan, Germany and the United States are all pursuing such policies as part of their comprehensive plans to develop the fuel cell and hydrogen sector. Canada's policies and programs in this area are lagging behind these leading countries. The environmental benefits of pursuing fuel cells are diminished if policies do not focus on developing a sustainable energy source for hydrogen. Furthermore, environmental improvements are one of the main drivers for fuel cells and hydrogen development. This implies that, over time, as actions to improve environmental conditions mount, countries that are already leaders in this area will benefit. Thus, while short- and medium-term policies can be geared towards producing hydrogen from sources with relatively lower greenhouse gas emissions, long-term policies should focus on hydrogen from renewable energy sources.

3. While maintaining support for research and development activities, expand the **focus to implementation and demonstration of fuel cell technologies and hydrogen infrastructure**.

Product demonstration is an important factor in developing a hydrogen and fuel cell economy. Product demonstration plays a crucial role in promoting faster adoption of emerging technologies such as fuel cells by proving potential uses and benefits, creating public awareness of safety and effectiveness, establishing initial performance and reliability, reducing costs and improving durability and efficiency. Fiscal policies and programs are needed to support demonstration projects for both fuel cell technologies and hydrogen infrastructure. This can be accomplished by increasing procurement programs for transportation and power generation fuel cell applications and distribution and fuelling infrastructures. Real life applications of the technologies are needed to demonstrate product viability and move towards widespread commercialization.

4. **Encourage provincial governments to implement complementary fiscal policies and programs** to substantially increase the attractiveness of Canada as a place to do business related to fuel cell technologies and hydrogen fuel.

Provinces should also pursue a mix of fiscal policies and programs targeted at both transportation and power generation fuel cell applications. The federal government can facilitate the introduction of such policies and programs through discussions with provinces and by implementing complementary policies at the federal level. Canada needs to get provinces other than BC moving forward on implementing fiscal policies and programs for a hydrogen and fuel cell economy. This is especially true for Ontario and Québec, which are centres for the transportation equipment industry and key industrial consumers of energy. The BC and federal government tax credits for research and development provide a good example of such coordinated fiscal policies.

5. Develop and begin to implement a **long-term, coordinated strategy for developing a hydrogen and fuel cell economy** in Canada.

The long-term strategy should include specific plans, actions, programs and policies that will be pursued to overcome identified barriers over time. It should include a timeline for accomplishing defined objectives and should be coordinated by one main government agency as is now done in the United States. The long-term plan should be developed in consultation with industry and relevant organizations in Canada. The government of Canada has committed to making Canada the most connected country in the world. To help accomplish that objective, the federal government implemented the Connecting Canada program. This program is a comprehensive plan to bring Internet access to all sectors and regions of Canada. A similar commitment and strategy is needed with respect to fuel cells and hydrogen.

6. Finally, all fiscal policies and programs need to be **backed by sufficient financial resources**.

If Canada is to remain competitive with countries such as the United States, Japan and Germany, fiscal policies and programs in Canada need to be at least as aggressive as the policies and programs implemented in other jurisdictions.