A Fiscal Framework for a Hydrogen Economy:

A review of international fiscal policy examples and precedents

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Executive Summary:

The purpose of this study is to conduct a comparative analysis of fiscal policies related to a hydrogen economy that have been implemented in Japan, Germany and the United States and to make recommendations for developing fiscal policies for a hydrogen 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 through, among other activities, the implementation of fiscal policies 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, with the United States housing two of the largest stationary fuel cells in the world. Japan and Germany are leaders in infrastructure development for hydrogen fueling stations, having built several such stations in recent years.

In comparison to Japan, Germany and the United States, Canada appears have focused more on transportation fuel cell applications as opposed to power generation (stationary and portable) applications. As well, fiscal policies 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. Canada provides very little support for demonstration programs and infrastructure development. Canada lacks a federally coordinated, long-term national commitment and methodology for developing a hydrogen economy in Canada.

Specific recommendations for designing and implementing fiscal policies identified in this analysis for a hydrogen economy in Canada include the following:

1. Employ a mix of fiscal policy instruments specifically targeted at current barriers.
2. Implement fiscal policies that target both power generation (stationary and portable) and transportation fuel cell applications.
3. While maintaining support for research and development activities, expand the focus to implementation and demonstration of fuel cell technologies and hydrogen infrastructure.
4. Incent provincial governments to implement complimentary fiscal policies to substantially increase the attractiveness of Canada as a place to do business related to fuel cell technologies.
5. Develop and begin to implement a long-term, coordinated strategy for developing a hydrogen economy in Canada.
6. Back all policies 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 increasingly by concerns about climate change, energy reliability and national security, fuel cells stand poised to compete with internal combustion engines, central and distributed power plants, and even portable electronics in the short to medium term. Several North American cities[1] have or have had demonstration fuel cell buses, and mass production of power generation fuel cells (stationary and portable) and fuel cell cars is planned within the next 2–5 years.

Depending on the hydrogen source and conversion process, these developments carry the potential for tremendous environmental improvement. 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 fueled by hydrogen produced from natural gas would produce life-cycle CO2e emissions almost 55% lower than a low-sulphur gasoline vehicle, and one fueled by hydroelectricity 95% lower.[4]

In addition to dramatically reducing carbon dioxide emission, the introduction of hydrogen fuel cells will also reduce our dependence on foreign oil (supplied from a limited number of geographic areas). 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 the displacement of the internal combustion engine by fuel cells within two decades, and an energy economy running primarily on hydrogen by 2050.[5]

Canada is a leader in the development of fuel cell technology, and Industry Canada identified the hydrogen economy as a priority in its Sustainable Development Strategy. While the momentum around hydrogen and fuel cell technology development continues to increase, the widespread introduction of the cleanest methods to manufacture hydrogen faces tough economic challenges.

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[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 – CO2 Equivalent Emissions, Year 2010.

[5] Quoted in Worldwatch Institute, "State of the World 2001," Chapter 5: *Decarbonizing the Energy Economy* by Seth Dunn. (London: Norton and Company, 2001). p.99

Existing fossil fuel pipelines and fueling infrastructures can be used to generate hydrogen. For this reason, the use of on-board fuel processors to strip hydrogen from gasoline is the preferred method of hydrogen generation for several large industry players. Producing hydrogen in this way yields few life-cycle environmental gains; in fact, in some cases fuel cell technology powered by hydrogen produced in this way is only a marginal improvement over existing fuel vehicle systems such as a turbo direct injection diesel.[6] On-board processing of methanol is also advocated by some because compared to compressed hydrogen, methanol has superior energy storage capabilities. However, this option is less beneficial to the environment than many of the direct hydrogen-based fueling options,[7] requires extensive infrastructure modifications and currently has only limited industry support. Other industry players are advocating off board hydrogen production (with on board storage of hydrogen). Centralized reforming of hydrogen from natural gas and from electrolysis using renewable energy sources delivers much greater life-cycle environmental gains, but still requires substantial infrastructure investments.[8]

Parallel to the development of hydrogen technologies, there is a growing global recognition of the need for appropriate price signals to influence environmental choices. A recent OECD Economic Survey of Canada states, "more extensive use of economic instruments [for environmental protection] will be necessary." A second OECD publication[9] states that "[i]t will be necessary to employ a mix of policy instruments . . . a robust regulatory framework combined with a variety of other instruments, including strong pricing mechanisms." Federal Environment Minister David Anderson identified the same need in his speech at the Globe 2000 conference where he launched his vision of a new architecture of environmental management, featuring expanded use of market-based and incentive mechanisms.

The use of hydrogen fuel and fuel cell technologies has the potential to play a key role in reducing greenhouse gas emissions in Canada. In the words of the Transportation and Climate Change Issue Table, "the ultimate GHG reduction potential is huge should hydrogen significantly displace fossil fuels as an energy carrier." Fiscal incentives have already been used to support the research, development, and early commercialization of hydrogen fuel cells in Canada—for example, Technology Partnerships Canada's $26 million investment in the Ballard PEM Fuel Cell Power Plant project. But to move into the technology adoption stage of the hydrogen economy will depend on more robust investment and stimulating both demand and supply for the new technologies by:

- Adjusting price signals related to the production and consumption of hydrogen fuel and fuel cell technologies;
- Governments being early adopters of fuel cell technologies; and

[6] Pembina Institute and David Suzuki Foundation, op.cit.
[7] Pembina Institute and David Suzuki Foundation, op.cit.
[8] Marc Jensen and Marc Ross, "The Ultimate Challenge: Developing an Infrastructure for Fuel Cell vehicles," *Environment*, September 2000.
[9] OECD. "OCED Environmental Outlook 2001" Paris, France: OECD.

- Government support for the development of enabling technologies and government investment in the distribution and fueling infrastructure that is 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 over 10 years, and funds for the fuel cell-powered transit bus program. German government subsidies to hydrogen amounted to DM 32 million (CDN$24.85 million) between 1996 and 1999—including funding for the development of a hydrogen refueling facility at the Munich airport.

If Canada is to use additional fiscal policies to support the adoption and implementation stage of the hydrogen economy[10], it is 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 related to a hydrogen economy that have been implemented in key jurisdictions around the world and to make recommendations for developing fiscal policies for a hydrogen 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 innovative fiscal policies used in other jurisdictions;
3. Document innovative fiscal policies used for other new economy industries in Canada; and
4. Make recommendations on further developing the hydrogen economy in Canada through use of fiscal policies.

To accomplish these objectives, the following methodology was employed:

1. Document fiscal policies that have been implemented in regions that are 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[11].
2. Document fiscal policies that have been implemented in Canada for developing other new economy industries.
3. Identify factors that have contributed to the success of leading countries in developing the hydrogen economy.
4. Evaluate Canada's success in incorporated the above factors into fiscal policies for developing a hydrogen economy in Canada.

[10] For purposes of this study, the hydrogen economy includes the fuel cell industry as well as hydrogen fuel and associated infrastructure.

[11] Iceland is also a world leader in developing a hydrogen economy.

5. To the extent that Canadian governments have not incorporated factors identified above, make recommendations for further developing the hydrogen economy in Canada through use of fiscal policies.

Following this Introduction, the Background and Context section of this paper provides a definition of fiscal policies, describes the benefits and barriers to developing a hydrogen economy, describes the types of fiscal policies that have been employed to develop the hydrogen economy and describes existing fiscal policies in Canada related to hydrogen fuel, infrastructure and fuel cell technologies. The International Examples and Precedents section of the report describes fiscal policies related to a hydrogen economy in the United States, Japan, Germany and the European Union as well as fiscal policies in Canada related to other new economy industries. The Comparative Analysis and Evaluation section identifies factors that have contributed to the success of world leaders in developing a hydrogen economy and evaluates Canada's progress in incorporating those factors. The final section of the report, Developing a Hydrogen Economy in Canada, provides recommendations on designing and implementing fiscal policies for further developing the hydrogen economy in Canada.

2 Background and Context:

Definition of fiscal policy

For the purposes of this report, fiscal policy is defined broadly to include tax policy initiatives (taxes, credits, refunds and exemptions), and government expenditure initiatives (direct financial support, procurement programs, research and development funding, demonstration initiatives and programmatic expenditure).

Benefits of a hydrogen economy

The use of fuel cell technologies and hydrogen fuel has the potential for tremendous environmental improvement including reductions in greenhouse gas emissions and improvements in local air quality. The extent of the environmental gains 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 approximately 50% less greenhouse gases over its entire life-cycle when compared with a conventional vehicle operating on low-sulphur gasoline[12]. In concert with these environmental benefits, the use of fuel cells and hydrogen fuel has many economic benefits.

The hydrogen economy 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 increasing field, Canada will take advantage of increasing

[12] 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.

export opportunities and expanding employment opportunities as well as foster a competitive advantage that will manifest itself in increased economic activity and growth in Canada.

Along with environmental and economic considerations, hydrogen fuel is increasingly being touted as a solution to national security concerns. Because hydrogen can be derived from numerous sources, including renewable energy sources which 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 increasingly self sufficient and less dependent on oil producing countries to meet their growing energy needs. Even though Canada is a net exporter of energy, including crude oil, there are security and economic advantages to diversifying domestic energy sources.

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

Fuel Cells:

The cost of fuel cell components/materials and production processes must continue to be reduced. Current fuel cell cogeneration power plants cost about US$5,000 to US$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[13]). 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[14]. 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.

Along with reducing 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

[13] 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.

[14] 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).

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, it takes many years to test and advance the durability of a fuel cell.

The second 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 of high importance to the consumer. The use of many novel materials and manufacturing processes increases both the challenge and importance of designing appropriate manufacturing processes.

The third 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.

Hydrogen:

Cost is also 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 and demand must evolve to large-scale proportions. Low prices for conventional energy sources and lack of environmentally oriented fuel pricing compound economic barriers to further developing 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 develop these networks globally, and to ensure safe, reliable and cost-effective delivery, will require the development 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 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. Five types of fiscal policies 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.

Existing Policies in Canada

Before evaluating fiscal policies in other jurisdictions, it may be useful to investigate policies implemented in Canada related to hydrogen and fuel cell technologies. This will allow for a comparative analysis with other leading countries in this field. For each policy included in this study, described below is the type of fiscal policy, the relevant jurisdiction, a description of the policy, the year of implementation, and the objective of the policy.

Name of policy: Technology Partnerships Canada
Type of fiscal policy: Repayable investment
Jurisdiction: Federal
Description: Technology Partnerships Canada (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. Technology Partnerships

Canada 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/time span: 1996 and ongoing
Objective of policy: To increase economic growth, create jobs and wealth, and support sustainable development in Canada.

Name of policy: Western Economic Partnership Agreement (WEPA)[15] fuel cell funding
Type of fiscal policy: Direct expenditure
Jurisdiction: Federal
Description: The federal government invested $2.7 million to help Fuel Cells Canada develop six new research laboratories in Vancouver. Western 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 UBC. The $2.7 million is in addition to the $13 million already dedicated to fuel cell development through WEPA (see below).
Year of implementation/time span: 2002
Objective of policy: 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 policy: WEPA
Type of fiscal policy: 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. Projects funded through WEPA include

- 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 fueling 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.
- The federal and provincial government invested almost $4.6 million in testing and evaluating fuel cell bus engines. This WEPA funding allowed BC Transit to buy three fuel cell bus engines from Excellsis[16] , a joint venture of DaimlerChrysler AG, Ballard Power Systems Inc. and the Ford Motor Co. Announced 2001.

Year of implementation/time span: 2000 and now complete
Objective of policy: The objective of WEPA is to extend the international competitiveness of the BC economy and provide economic development opportunities for communities throughout the province.

[15] WEPA is a $40 million five-year federal-provincial agreement to strengthen new growth industries and sectors through investments in new technologies, products and markets.
[16] Note that Excellsis no longer exists, it was procured by Ballard in 2001.

Name of policy: Canadian Transportation Fuel Cell Alliance (CTFCA)
Type of fiscal policy: Direct expenditure and program activities
Jurisdiction: Federal
Description: This is a $23 million federal government initiative that will demonstrate and evaluate fueling options for fuel cell vehicles in Canada. By 2005, different combinations of fuels and fueling 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 the Action Plan 2000, a package of activities to reduce greenhouse gas emissions in Canada.[17]
Year of implementation/time span: 2001
Objective of policy: To demonstrate greenhouse gas emission reductions and evaluate different fueling routes for fuel cell vehicles, and to develop the necessary supporting framework for the fueling infrastructure, including technical standards, codes, training, certification and safety.
Noteworthy: Other initiatives funded through the Action Plan 2000 related to fuel cells and hydrogen development include-

- Hydrogen Refueler: 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 the gaseous injection and fuel storage systems and makes the conversion of conventionally fueled vehicles to natural gas simpler and therefore less costly. There is considerable crossover in the technology associated with fuel storage tanks and gas regulators between fuel cell and natural gas vehicles. Funding: CCAF $700,000 and NRCan $350,000.
- 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.

[17] Action Plan 2000 is a $500 million commitment on the part of the federal government.

- Personal Fuel Appliances: Stuart Energy Systems Inc. is developing a hydrogen refueling 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 refueling 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.

Name of policy: National Research Council (NRC)[18] Fuel Cell Program
Type of fiscal policy: 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. In 2002, Minister of Industry, Alan Rock announced additional funding to fuel cell research and development at its NRC Innovation Center by a total of $20 million over the proceeding five years. Alan Rock also announced that the Center would become a full NRC research institute for fuel cell and hydrogen technologies. The Innovation Center already contained the National Fuel Cell Research and Innovation Initiative, a strategic partnership between the National Research Council (NRC), the Natural Sciences and Engineering Research Council (NSERC) and Natural Resources Canada (NRCan) established in 1999. As part of that initiative, the National Fuel Cell Research and Testing Facility was established. Also under that initiative, a joint Fuel Cell Research Network Program was implemented.
Year of implementation/time span: The National Fuel Cell Research and Innovation Initiative was established in 1999. In 2002 Minister Alan Rock announced $20 million in additional funding for fuel cell and hydrogen technology research and development.
Objective of policy: 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 policy: Transportation Energy Technologies Program (TETP)
Type of fiscal policy: Direct expenditure and loans
Jurisdiction: Federal
Description: TETP works in several areas including:
- 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);

[18] 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.

- Emissions control technologies (for diesel and alternatively fueled 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);
- Fueling infrastructure (fueling station hardware, hydrogen systems and battery charging systems).

Program activities of TETP include:

- 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 cost 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/time span: 1980
Objective of policy: 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 policy: BC Tax Credit for Alternative Fuel Vehicles and Alternative Motor Fuel Tax Concessions
Type of fiscal policy: Tax measures
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/time span: Refunds, reduced rates and exemptions were introduced and revised in 2001 and 2002.
Objective of policy: To increase purchases of alternative fuel vehicles and alternative fuels in British Columbia.

The following table summarizes the Canadian policies presented above.

Summary of Policies in Canada:

POLICY	TYPE OF POLICY	JURISDICTION
Technology Partnerships Canada	Repayable investment	Federal
WEPA Fuel Cell Funding	Direct expenditure	Federal
WEPA	Direct expenditure and program activities	Federal and provincial
CTFCA	Direct expenditure and program activities	Federal
NRC Fuel Cell Program	Direct expenditure and program activities	Federal
TETP	Direct expenditure and loans	Federal
BC Alternative Vehicle and Fuel Tax Concessions	Tax measures	Provincial

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

Evaluation of Canadian Policies:

POLICY	SECTOR FOCUS	BARRIERS ADDRESSED	FOCUS ON HYDROGEN AND FUEL CELLS	FOCUS ON RENEWABLE ENERGY SOURCES
Technology Partnerships Canada	Fuel cells	Technical	No	No
WEPA Fuel cell Funding	Fuel cells	Technical	Yes	No
WEPA	Fuel cells	Technical	Yes	No
CTFCA	Hydrogen, fuel cells and infrastructure	Technical, infrastructure and codes and standards	Yes	No
NRC Fuel Cell Program	Fuel cells	Technical	Yes	No
TETP	Hydrogen	Technical	No, focus is on developing a cleaner more sustainable energy mix for roadways generally	No, includes natural gas and propane
BC Alternative Vehicle and Fuel Tax Concessions	Fuel cells and hydrogen	Cost	Not exclusively	No

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 very little support for larger scale demonstration programs and infrastructure development. All but one of the policies profiled is explicitly applicable to fuel cells and hydrogen but none of the policies specifically address hydrogen from renewable energy sources.

3 International Examples and Precedents:

In addition to considering policies already in place in Canada, it is useful to investigate the kinds of policies that other leading countries have implemented. Thus, in this section of the report, we highlight various fiscal policies 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 for the Canadian examples above, for each international policy, described below is the type of fiscal policy, the relevant jurisdiction, a description of the policy, the year of implementation, and the objective of the policy. Also in this section are presented key policies in place in Canada to support other new economy industries.

Note that this is not a comprehensive list of policies related to fuel cell technologies and hydrogen fuel/infrastructure in the selected regions. Instead, these policies were selected to demonstrate the range of policy options that have been implemented. Ultimately, the objective was to present key and innovative fiscal policies that support fuel cells, hydrogen fuel and hydrogen infrastructure in key international jurisdictions.

United States: Selected Federal Policies

Name of policy: Climate Change Fuel Cell Rebate Program
Type of fiscal policy: Tax measure
Jurisdiction: Federal initiative through Department of Defence
Description: The program provides a financial incentive of up to US$1,000 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/time span: 1995 and ongoing
Objective of policy: To expedite the market introduction of fuel cell systems.

Name of policy: Fuel Cell Residential Demonstration Project
Type of fiscal policy: 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 will be spent on this initiative.
Year of implementation/time span: 2001/2
Objective of policy: 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 policy: Solid State Energy Conversion Alliance (SECA)
Type of fiscal policy: Direct expenditure and program activities
Jurisdiction: Federal
Description: A major 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/time span: 2002
Objective of policy: To cut fuel cell costs to as low as US$400 per kW by the end of this decade. The goal is to have the ultra-low cost fuel cell concept ready for commercial applications by 2010.

Name of policy: Deduction for Clean Fuel Vehicles and Certain Refueling Property
Type of fiscal policy: Tax measure
Jurisdiction: Federal
Description: Income tax deductions for qualified clean-fuel vehicle properties, qualified clean-fuel vehicle refueling 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$8,000 for hydrogen; 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$8,000 for hydrogen; 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. Clean-fuel refueling properties are eligible for a deduction of up to US$100,000. 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, any other alcohol or ether.
Year of implementation/time span: 2001
Objective of policy: To increase market penetration of clean-fuel vehicles.

Name of policy: Transportation Fuel Cell Power Systems Program
Type of fiscal policy: 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 (DOE share) in new research awards for more than 25 projects in the country.
Year of implementation/time span: Began in 1990 and is now part of the Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program (see below)
Objective of policy: To address the most critical challenges to the commercialization of transportation fuel cell power systems.

Name of policy: Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program
Type of fiscal policy: 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/time span: 2002
Objective of policy: The mission of the DOE's Hydrogen, Fuel Cell and Infrastructure Program is 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 policy: Graduate Automotive Technology Education (GATE)
Type of fiscal policy: 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/time span: 1997

Objective of policy: 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 Freedom CAR program described below.

Name of policy: Freedom CAR (Cooperative Automotive Research)
Type of fiscal policy: Direct expenditure
Jurisdiction: Federal
Description: Freedom CAR is a US$150 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. Freedom CAR will focus on research needed to develop technologies such as fuel cells and hydrogen from domestic renewable sources.
Year of implementation/time span: 2002
Objective of policy: 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: Selected State Policies

Name of policy: California Fuel Cell Partnership
Type of fiscal policy: 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/time span: 1999 and ongoing
Objective of policy: 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 policy: Michigan NextEnergy Initiative
Type of fiscal policy: Direct expenditure and tax measures
Jurisdiction: State
Description: The NextEnergy proposal was unveiled in 2002. NextEnergy is a comprehensive set of actions and incentives designed to position Michigan as the world's leading center 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.
Year of implementation/time span: 2002
Objective of policy: The goal of the project is to attract new major stationary or mobile fuel cell development projects to Michigan.

Name of policy: Muskegon Shoreline SmartZone
Type of fiscal policy: 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 centers and business incubators and their operations within the zone. The state has committed US$2.6 million to this project.
Year of implementation/time span: 2001
Objective of policy: 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 mixed-use development.

Name of policy: Ohio's Fuel Cell Program
Type of fiscal policy: Direct expenditure, loans and tax measures
Jurisdiction: State
Description: This is a US$100 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 fuel cell initiative is an integral part of the Third Frontier Project, a 10-year, US$1.6 billion plan to create high-technology, high-paying jobs though expansion of the states' 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 for various funding projects; US$25 million for research, development and demonstration; and US$3 million for training.
Year of implementation/time span: 2002
Objective of policy: To move Ohio into the center-ring of fuel cell development.

Name of policy: Fuel Cell at Nikiski
Type of fiscal policy: Procurement
Jurisdiction: State (Alaska) with funding from the federal government.
Description: BP is testing a US$6.5 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, 250 kW fuel cell to power the plant's administration building and warehouse.
Year of implementation/time span: 2001
Objective of policy: 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, US Department of Energy US$2 million, and the Chugach Electric Association US$450,000 by way of a grant from the Cooperative Research Network of the National Rural Electric Cooperative Association.

Name of policy: US Postal Service Fuel Cell
Type of fiscal policy: 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 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, now are the primary source of power for the Anchorage facility. Heat recovery from the fuel cells helps provide space heating to the facility. The fuel cells operate in parallel with the grid. This project is largely funded by the Department of Defence, Army Corps of Engineers, Construction Engineering and Research Laboratories.
Year of implementation/time span: 2001
Objective of policy: To demonstrate technology application.

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

Summary of Policy in the United States:

POLICY	TYPE OF POLICY	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 Refueling 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 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 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 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 focuses on hydrogen from renewable energy sources.

Evaluation of United States Policies:

POLICY	SECTOR FOCUS	BARRIERS ADDRESSED	FOCUS ON HYDROGEN AND FUEL CELLS	FOCUS ON RENEWABLE ENERGY SOURCES
Climate Change Fuel Cell Rebate	Fuel cells	Cost	Yes	No
Fuel Cell Residential Demonstration Project	Fuel cells	Cost	Yes	No
Solid State Energy Conversion Alliance	Fuel cells	Cost	Yes	No
Deduction for Clean Fuel Vehicles and Certain Refueling Property	Hydrogen and infrastructure	Cost	No, applicable to natural gas, liquefied natural gas, liquefied petroleum gas, hydrogen, electricity and other fuel that is at least 85% methanol, ethanol or any other alcohol or ether	No, includes natural gas and petroleum gas along with renewables such as hydrogen and methanol.
Transportation Fuel Cell Power Systems Program	Fuel cells	Technical	Yes	No
Department of Energy's Hydrogen, Fuel Cell and Infrastructure Program	Hydrogen and fuel cells	Technical	Yes	No
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	No, focus in on minimum efficiency requirements
FreedomCAR	Hydrogen and fuel cells	Technical	Yes	Yes, focus is on hydrogen from domestic renewable resources
California Fuel Cell Partnership	Fuel cells and infrastructure	Technical and infrastructure	Yes	Not exclusive, although 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	No, focus is more broadly placed on renewables and distributed energy
Muskegon Shoreline SmartZone	Fuel cells	Cost	No, applies to various forms of alternative energy	No, focus is on high-tech sector generally
Ohio's Fuel Cell Program	Fuel cells	Cost and technical	Yes	No
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 two of the largest fuel cell stationary applications in the world. The policies presented in this analysis are targeted at both economic and technical barriers to developing the hydrogen economy.

While the majority of the policies presented here are explicitly 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 economy was historically undertaken by more than one government agency (Energy and Defence), the reorganization of July 1st, 2002 explicitly placed one government agency in charge of hydrogen, fuel cell and infrastructure developments.

Japan

Name of policy: World Energy Network (WE-NET)
Type of fiscal policy: Direct expenditure
Jurisdiction: Federal
Description: WE-NET is a long-term plan to develop the hydrogen economy in Japan through the New Energy and Industrial Technology Development Organization (NEDO). The program is divided into three phases extending over a 28-year period from 1993 to 2020. NEDO is researching and developing hydrogen energy technologies in a joint industry-government-university effort, aiming at worldwide deployment by the year 2030. 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 was comprised of a series of tasks, which are described below. In Phase III, which is now underway, practical technology will be developed and pilot plants will be constructed on an international scale in order to deploy the system for actual use.

- 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 fuel 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 refueling stations and to verify the technology and refueling station through use while also evaluating the energy efficiency of the vehicle.
- 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 refueling stations to establish standalone hydrogen refueling 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 refueling 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/time span: 1993 to 2020
Objective of policy: The WE-NET project will 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 policy: Ministry of Economy, Trade and Industry (METI)
Type of fiscal policy: 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/time span: ongoing
Objective of policy: Focus is on technology development and commercialization.

Name of policy: Sales Tax Reductions for Efficient Vehicles
Type of fiscal policy: 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 and a family car meeting the 2010 minimum fuel efficiency standards will qualify for an automobile tax break of 15,000 YEN.
Year of implementation/time span: 1999
Objective of policy: To reduce greenhouse gas emissions and air pollution.

Japan has made a national commitment to developing hydrogen as an alternative to oil.[19] In concert with this commitment, the government of Japan has developed and implemented the WE-NET program, a highly integrated and long-term plan for developing a hydrogen 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. 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 economy: fuel cells, infrastructure and hydrogen fuel for both power 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 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 source.

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

Evaluation of Japan's WE-NET Policy:

POLICY	SECTOR FOCUS	BARRIERS ADDRESSED	FOCUS ON HYDROGEN AND FUEL CELLS	FOCUS ON 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	N/A, 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	No
Tax Reduction for Efficient Vehicles	Fuel Cell	Cost	No, applies to vehicles that meet efficiency standards	No

Germany

Name of policy: Munich Airport Hydrogen Project
Type of fiscal policy: Procurement
Jurisdiction: State (Bavaria)

Description: In addition to the on-site production and storage of gaseous hydrogen, the project will test the fully automatic refueling 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 were borne by the project partners and the Free State of Bavaria, which provided 50% of the finances from public funds.
Year of implementation/time span: Public filling station opened in 1999
Objective of policy: To gain insights into the routine use and economic feasibility of hydrogen as a fuel.

Name of policy: Clean Energy Partnership (CEP)
Type of fiscal policy: 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/time span: 2002 and projected for a five-year period
Objective of policy: The goal of the CEP is to demonstrate that hydrogen is a viable fuel for everyday life. In Berlin, an Aral fueling station will be established where hydrogen will be produced on site.

Name of policy: Future Technology Fuel Cell Rhineland Palatinate
Type of fiscal policy: 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/time span: 2002
Objective of policy: To encourage the transition to a hydrogen economy on the basis of renewable energies.

Name of policy: Hydrogen and Fuel Cell Initiative in Hesse
Type of fiscal policy: Direct expenditure
Jurisdiction: State (Hesse)
Description: Provides fund 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/time span: 2002
Objective of policy: 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 policy: Fuel Cells for Telephone and Internet Services
Type of fiscal policy: 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/time span: 2002 and ongoing
Objective of policy: 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 policy: Production Incentive
Type of fiscal policy: 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 as long as the output is below 2 MW. The funds will be provided by a general rise in power prices.
Year of implementation/time span: 2001
Objective of policy: To facilitate the entry of fuel cells into the stationary energy market while costs are above those for competing technologies.

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

Name of policy: Biogenous Gases for Fuel Cells
Type of fiscal policy: 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/time span: 2002 and ongoing
Objective of policy: To investigate the possibility of using biogenous gases for fuel cells.

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

Summary of German Policies:

POLICY	TYPE OF POLICY	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 range 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 in Germany related to hydrogen and fuel cells have targeted infrastructure, fuel cell technologies and hydrogen fuels. Several hydrogen fueling 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 in Germany. Also noteworthy is that two policies are explicitly geared to developing hydrogen from renewable sources.

Evaluation of German Policies:

POLICY	SECTOR FOCUS	BARRIERS ADDRESSED	FOCUS ON HYDROGEN AND FUEL CELLS	FOCUS ON RENEWABLE ENERGY SOURCES
Munich Airport Hydrogen Project	Infrastructure	Infrastructure	Yes	No
Clean Energy Partnership	Hydrogen and fuel cells	Cost and technical	No, applies more broadly to alternative fuels in road transportation	Yes, focus is on renewable energy sources
Future Technology Fuel Cell Rhineland Palatinate	Fuel cells	Cost and technical	Yes	No, focus is on low emissions but not necessarily renewables
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	No
Fuel Cells for Telephone and Internet Services	Fuel cells	Cost	Yes	No
Production Incentive	Fuel cells	Cost	No, applies to cogeneration units in general	No
ZIP Program	Fuel cells	Technical	No, focus is on environmentally friendly technologies generally	No
Biogenous Gases for Fuel Cells	Fuel cells	Technical	Yes	Yes

European Union

Name of policy: Framework Programs
Type of fiscal policy: Direct expenditure
Jurisdiction: International
Description: Funding for research, development and demonstration work in the EU is channelled through periodic Framework Programs with an average budget of Euro 3 to 4 billion managed by the Directorate of Research of the EU Commission. The 5th Framework Program (1998–2002) awarded Euro 150 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 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 project (CUTE) is one component of the 5th Framework Program. Through the CUTE program, the European Union Commission awarded 18.5 million Euro to nine European cities to introduce hydrogen into their public transport system. The European cities awarded the funds are Amsterdam, Barcelona, Hamburg, London, Luxembourg, Madrid, Porto, Stockholm and Stuttgart.

Year of implementation/time span: The 5th Framework Program will be completed in 2002 and the 6th Framework Program is currently under development.

Objective of policy: 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. Here, major policy drivers are air quality and climate change, security of energy supply and noise pollution from transport.

The main fiscal policy 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.

While not a fiscal policy and so not included in the summary above, it is 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 fueled road vehicles. Procedures for periodic vehicle inspections will be developed. Requirements for new draft standards, refueling procedures and periodic inspections for hydrogen refueling infrastructure components and systems will be developed. EIHP2 will furthermore undertake actions to validate the EIHP1 draft regulations by developing and realizing hydrogen components and vehicles according to these drafts and getting them approved by selected authorities.

Canadian New Economy Policies

Fiscal policies related to new economy industries that have been implemented in Canada can help inform the direction of policy development for a hydrogen economy in the country. Such policies, where successful in increasing new economy industries in Canada, can be extended or replicated for the fuel cell and hydrogen industry. Existing policies related to new economy developments (but not necessarily tied to fuel cells or hydrogen development) in Canada are briefly summarized below.

NEW ECONOMY POLICY	DESCRIPTION
Industry Canada's Advanced Technology Innovative Fund	Provides financial support to BC-based companies in the multimedia, computer telephony and health, and informatics sectors for technology development leading to commercialization of products and services. Financial support is available for up to 75% of eligible project costs to a maximum of $100,000 for technology development. Funding is provided on a repayable basis through equity or royalties based on sales. Firms have to demonstrate that there is some form of innovation to their project. This fund addresses the difficulties small businesses encounter when trying to raise capital for technology development where projects are too large to finance through equity and too risky for the banks.
Canadian Foundation for Innovation (CFI)	This is an independent corporation established by the government of Canada in 1997. By investing in research infrastructure projects, the CFI supports research and helps strengthen research training at institutions in Canada. The CFI is responsible for a budget of $3.15 billion. These funds are invested in partnerships with the institutions and their funding partners from the public, private and voluntary sectors.
Connecting Canadians	Connecting Canadians is a vision and plan to make Canada the most connected country in the world and a world leader in the development and use of advanced information and communications technologies. It focuses on a number of sectors including schools, libraries, the voluntary sector, and community computer and Internet access in general.
Networks of Centers of Excellence (NCE)	NCE stimulates internationally competitive, leading-edge fundamental and applied research in areas critical to Canadian economic and social development. The total current annual budget is $77.4 million and there are 22 networks in Canada. This program is jointly administered by NSERC, Canadian Institute of Health Research and the Social Sciences and Humanities Research Council (SSHRC) in partnership with Industry Canada.
FedNor's Innovation Fund	FedNor is committed to supporting technological innovation, research and development and the commercialization of new products and processes in Northern Ontario. The innovation fund targets four types of projects: applied research and development; capacity building non-capital; capacity building capital; and general innovation-related.
Innovative and Community Investment Program (ICIP)	Over four years, $5.66 million will be invested in BC to help diversify the economy and support the development of innovative technologies. ICIP will foster the growth of knowledge-based jobs and industries; accelerate the commercialization and adoption of innovative processes and products; and encourage the diversification of local economies.

Funding to TRLabs	Funding of $17.5 million has been granted to TRLabs, Canada's largest and most successful not–for-profit information and communications technology research consortium. Western Diversification will contribute $10 million over the next four years to the research consortium while the government of Alberta will provide $7.5 million over 5 years.
High Technology Strategy and the BC Scientific Research and Experimental Development Tax Credit	The British Columbia government announced a three-year $90 million commitment to a new high technology provincial strategy. The strategy included a 10% research and development tax credit for BC companies, 2,000 new high technology post secondary spaces and 4,800 more high technology co-op placements. The tax credit is available to companies doing research and development in BC in such fields as communications technology, energy technology and bio-medical products plus forest, mining and environmental technologies.

4 Comparative Analysis and Evaluation:

This section of the report highlights fiscal policy trends in developing fuel cell technologies and hydrogen fuel and infrastructure in Germany, Japan and the United States. Here, factors that have contributed to the success of these leading countries in developing the hydrogen economy are identified and Canada's progress in incorporating those 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, the implementation of fiscal policies designed to support the hydrogen and fuel cell industries. Policies have generally focused on direct expenditure for research and development related to fuel cell technologies. 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, with the United States housing two of the largest stationary fuel cells in the world. Japan and Germany are leaders in infrastructure development for hydrogen fueling stations, having built several such stations in recent years.

Substantial evidence of the success of individual policies in influencing the growth of the hydrogen economy is unfortunately somewhat limited due to several factors. First, countries supporting hydrogen and fuel cells through fiscal policies 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 undocumented.

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.[20] Recent estimates presented by PricewaterhouseCoopers[21] indicate that between 2007 and 2011 the fuel cell industry[22] will grow at a compounded average annual rate of 75%. Specific examples of the growth in the industry indicate the effectiveness of fiscal policies in influencing hydrogen and fuel cell market penetration. A number of such examples are provided below:

- In 2001, Japan completed it's 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 refueling stations are currently able to handle 24 to 30 fueling operations per day. July 2002 saw a third station completed and five more are planned by 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 delivery 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.
- The United States will be home to the two of the largest fuel cell installations in the world. 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. Alaska is also 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).
- The United States government owns and operates 30 fuel cell cogeneration units, the largest fleet of fuel cells in the world.
- 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.

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[20] www.fuelcells.org

[21] PricewaterhouseCoopers. 2002. Fuel Cells: The Opportunity for Canada. PricewaterhouseCoopers.

[22] 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.

- Plug power, a fuel cell technology company in the United States, delivered 132 fuel cell systems in 2001, 81 of those units were delivered in the fourth quarter.
- 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 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. 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, these jurisdictions have been able to target and overcome a range of economic and technical barriers.
2. Fiscal policies 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 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 in Japan, Germany and the United States.
4. Policies have been implemented at both federal and state level 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 developed and implemented 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 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 that should be implemented in Canada, it is appropriate to consider how well the factors described above are applicable to current fiscal policies in Canada. As the table below reveals, Canada appears have focused more on transportation fuel cell applications as opposed to power generation (stationary and portable) applications. As well, fiscal policies 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. Canada provides very little support for demonstration programs and infrastructure development. Canada lacks a federally coordinated, long-term national commitment and methodology for developing a hydrogen economy in Canada.

FACTOR CONTRIBUTING TO SUCCESS	PROGRESS IN CANADA
Implement various types of fiscal policies	Canada has focused largely on direct expenditure. There is a significant gap in use of tax measures.
Focus on both power generation (stationary and portable) and transportation applications	Historically, Canada has placed greater emphasis on transportation applications of fuel cells than on power generation applications.
Focus on implementation	Canada lags behind other countries with respect to implementing technologies and infrastructure.
Implement state and federal level policies	With the exception of British Columbia, there are limited fiscal policies explicitly geared towards fuel cells and hydrogen at the provincial level.
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.[23]

[23] PricewaterhouseCoopers. 2002. Fuel Cells: The Opportunity for Canada. PricewaterhouseCoopers.

5 Developing a Hydrogen Economy in Canada:

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

1. The Canadian government should employ a **mix of fiscal policy instruments** specifically targeted at current barriers[24].

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. Procurement policies are important in the short term while cost remains a significant barrier to widespread adoption of fuel cells and hydrogen. Governments are well positioned to act as catalysts for market creation through procurement policies. Such policies serve to demonstrate the viability and commercialization of fuel cells and have been employed in the United States, Germany and Japan.

Tax measures are especially important to help overcome cost barriers and increase market penetration in the long term, once technical barriers have been largely addressed. Tax measures can be implemented by all levels of government in Canada to adjust the cost of producing and consuming 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 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 $200 million (CDN$307 million), and for fuel cell motor vehicles will be worth $750 million (CDN$1,150 million).[25]

Historically, the majority of funding in Canada has been on transportation fuel cell applications. This has substantial implications for developing the hydrogen infrastructure needed to support the mobile fuel cell sector. One strategy for addressing some of the barriers associated with infrastructure development

[24] 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.
[25] www.fuelcells.org

needs in the short term is to use existing infrastructure to the extent that is possible. A similar strategy has been used by the federal government in its quest to make Canada the most connected country in the world. To accomplish this goal, the federal government has implemented a package of policies (some of which are described in this report) 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 fueling infrastructure including facilities and other feedstock supplies to make it accessible and to minimize new infrastructure requirements in the short term. In the 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. Also, focusing on stationary fuel cell applications avoids the barriers associated with developing the hydrogen infrastructure needed to support the mobile fuel cell market.

It is also important to implement fiscal policies 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 hydrogen economies. Canada is lagging behind these leading countries in this area. The environmental benefits of pursuing fuel cells are diminished if policies do not focus on developing a sustainable energy source for the hydrogen. Furthermore, environmental improvements are one of the main drivers for fuel cells and hydrogen development. This implies that overtime 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 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 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 fueling infrastructures. Real life applications of the technologies are needed to demonstrate product viability and move towards widespread commercialization.

4. **Incent provincial governments to implement complimentary fiscal policies** to substantially increase the attractiveness of Canada as a place to do business related to fuel cell technologies.

Provinces should also pursue a mix of fiscal policy instruments targeted at both transportation and power generation fuel cell applications. The federal government can facilitate the introduction of such policies 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 for a hydrogen economy. This is especially true for Ontario and Québec, which are centers 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 economy** in Canada.

The long-term strategy should include specific plans, actions 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 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 in Canada need to be at least as aggressive as the policies implemented in other jurisdictions.