Canadian Hydrogen and Fuel Cell Programs

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Canadian Hydrogen and Fuel Cell Programs

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1 Introduction

Canada has been participating in the development of hydrogen and fuel cell technologies for more than two decades. Canada is the largest country per capita producer of hydrogen in the world, producing approximately 3 million tonnes annually. Canada is an international leader in the development of hydrogen and fuel cell technology.

Hydrogen and fuel cell technologies also represent a unique opportunity for Canada to reduce the environmental footprint from many sectors, such as, Transportation, which accounts for approximately 30% of total energy use and 25% of all greenhouse gas emissions in Canada. It is Canada's plan to move towards low carbon fuels, as well as other technologies, using electricity and hydrogen produced from renewable energy sources.

Along with government and academia, the hydrogen and fuel cell community in Canada is comprised of highly innovative smaller companies, which are investing heavily in R&D to further commercialize hydrogen and fuel cell technology. Although many of the companies are spread out across the country in cities such as, Calgary, AB; Toronto, ON; and Montreal, QC, Vancouver, BC, is said to have the largest cluster of hydrogen and fuel cell companies in the world.

As of today, Canada is operating a variety of hydrogen fuelled vehicles and fuelling stations, ranging from transit buses and automobiles, to forklifts and wheelchairs. In total there are 70 vehicles of different make and model operating on hydrogen in Canada. Canada is also operating 10 hydrogen re-fuelling stations across the country from Charlottetown, PEI to Whistler, BC.

2 Hydrogen & Fuel Cells | Research & Development – CanmetENERGY

Since the early 1980s, much advancement in Canadian hydrogen and fuel cell technology has been made. Current efforts in research and development (R&D) are continuing to advance this alternative energy option so that it is affordable and available to consumers.

Natural Resources Canada/CanmetENERGY/Hydrogen, Fuel Cells and Transportation Energy (HyFATE) group, has a long and successful history of partnerships with industry, academia, associations and other government organizations which support innovative research development and demonstrations in transportation technologies and fuels. Partners are actively sought and involved at an early stage of project development to ensure that the R&D supported will have a high likelihood of adoption by Canadian and international markets. All stakeholders benefit from these partnerships as projects and initiatives are co-funded and/or are supported by "in-kind" contributions.

Some examples of HyFATE's activities are:

- Managing RD&D transportation energy technology programs

- Advising on innovative energy technology R&D
- Conducting in-house hydrogen and fuel cell research
- Supporting safety work and the development of codes and standards, as well as training and certificate programs
- Coordinating workshops, seminars and information exchanges with public and private sector organizations
- Facilitating international student automotive engineering competitions such as Challenge X and ecoCAR
- Providing input into policies, developing national strategies and facilitating energy technology road maps
- Participating in federal committees and international groups and tasks such as the Canadian Hydrogen and Fuel Cell Committee, the International Energy Agency and the International Partnership for the Hydrogen Economy

3 Program Structure

Canada’s program targets sustainable hydrogen production; hydrogen storage; fuel cells; and safety, codes and standards. Canada is also involved in several Demonstration projects.

3.1 Hydrogen production

Hydrogen’s value as an energy carrier stems from the wide base of primary energy sources which can be employed to produce it. These include both renewable sources such as hydro, wind, solar and biomass, and non-renewable sources such as natural gas, coal and nuclear energy, as well as from waste streams.

Historically, Canada’s main thrust of past investments has been electrolysis systems for hydrogen production from wind, hydrogen from low-value materials such as hydrogen sulphide and from coal or petroleum coke via the steam/iron process (a technology for centralized hydrogen production allowing easier carbon capture). Smaller program elements included purification and separation. Activities have steered away from technologies which are developed extensively in other countries and for which there was not a unique Canadian capability. Going forward, Canada’s activities in the short term will focus almost exclusively on electrolytic hydrogen production integrated to renewable energy sources and the purification of waste hydrogen.

Highlights:

3.1.1 Development of advanced PEM water electrolyser

Market interest in PEM water electrolysis is quickly growing for backup power, renewable energy storage and onsite hydrogen generation applications. These markets require increased stack durability, lower total system cost, higher delivery pressures and hydrogen production rates up to 10 Nm^3/hr. This project is addressing technology needs for membrane durability improvements, bipolar plate manufacturing and coating, cost reductions and higher pressure stack design.

3.1.2 Materials for improved, durable electrocatalysts for hydrogen/oxygen alkaline electrolyzer systems

Alkaline electrolysis offers significant potential in two ways. First, it offers a method for large scale hydrogen production, which would expedite the transition to hydrogen. Second, if utilizing renewable electricity, alkaline electrolysis offers emissions free hydrogen production.

3.2 Hydrogen storage

Hydrogen storage is a key enabling technology for the deployment of fuel cell technologies in stationary, portable, and transportation applications. The challenge for all end-uses is reversible, lower cost, lighter weight, and higher-density hydrogen storage systems. For transportation, the overarching technical challenge for hydrogen storage is how to store the amount of hydrogen required for a conventional driving range (>300 miles) within the vehicular constraints of weight, volume, efficiency, safety, and cost. Durability over the performance lifetime of these systems must also be verified and validated, and acceptable refuelling times must be achieved.

Going forward, Canada will pursue the development and optimization of new hydrogen storage materials and systems. Gravimetric and volumetric densities, as well as cost, will be the key parameters addressed.

Highlights:

3.2.1 Materials for off-board hydrogen storage

Work is aimed at developing materials and technologies to store energy in a safe, solid hydride media. The stored energy can be used to power transportation, mobile and stationary fuel cell energy systems – as needed. These materials and technologies will improve Canada's ability to store excess/off-peak energy from the grid and from renewable energy technologies – particularly in remote community applications.

3.2.2 Development of lightweight hydrogen storage systems

Canada is working on enhancing hydrogen storage and generation for portable, long run time applications. A prototype developed offers hydrogen and fuel cell energy pack which can be utilised as a replacement for D-Cell battery packs in a variety of portable applications. The major benefit of this technology is that it has a higher energy density and can run continuously at a 5W steady state for a minimum of 26 hours, which is an improvement of almost 50% over the incumbent D-cell battery technology.

3.3 Fuel cells

Canada is working to improve fuel cell technologies. For transportation, small-scale stationary generation (e.g. back-up power), and portable devices, the focus is on proton exchange membrane (PEM) fuel cells, due to their low temperature operation and capability for fast start-up. For larger-scale distributed energy generation, the focus is on the high temperature solid oxide fuel cell (SOFC), which can directly use natural gas or other hydrocarbon fuels.

Highlights:

3.3.1 High temperature fuel cell cogeneration systems

The residual heat generated by a high temperature PEM fuel cell co-generation system can be channelled into a heat exchanger to produce domestic hot water. This CHP process reduces water heating costs, while also providing very efficient electricity generation. Co-generation systems present a viable option to reduce natural gas use and decrease air pollutants and CO^2 footprints.

3.3.2 Development of fuel cell humidifiers

Humidification is one of the key components in fuel cell systems, affecting performance, durability, size, cost and ultimately commercialization. This project is optimizing fuel cell humidifiers for better performance, reliability and integration with customers, in order to make systems ready for manufacturing and commercialization.

3.4 Codes, standards and safety

The successful global commercialization of hydrogen and fuel cells depends on internationally accepted codes and standards. These will help to increase the experience, knowledge and confidence of local, regional, and national officials in the use of hydrogen and fuel cell technology, and facilitate the development of smart regulations. R&D supports the development of performance-based, rather than product-specific, codes and standards. International collaboration in this area is essential.

Highlights:

3.4.1 ISO Technical Committee 197

Canada plays a leading role as chair of the ISO Technical Committee 197 (Hydrogen Technologies) and is a key contributor to the IEA Hydrogen Implementing Agreement Task 19. Task 19 participants have been working to identify the physical properties of hydrogen which impact the issue of safety.

3.4.2 Canadian Hydrogen Installation Code

Published by the Bureau de normalisation du Québec (BNQ) as a National Standard of Canada, the Canadian Hydrogen Installation Code (CHIC) [CAN/BNQ 1784-000] will help pave the way for a greater use of hydrogen as an energy carrier by guiding safe design and facilitating the approval process of hydrogen installations across Canada. This code has also been used as a guide for other countries and jurisdictions, to develop their own codes.

3.5 Demonstrations

Complementing the aforementioned R&D, HyFATE supports projects that demonstrate and deploy hydrogen and fuel cell technologies in Canada. These projects are building and evaluating fuelling options for a variety of on-road and off-road hydrogen-fuelled vehicles, as well as hydrogen infrastructure.

Highlights:

3.5.1 Hydrogen highway demonstration

By coordinating and promoting a network of demonstration projects, the BC Hydrogen Highway will advance commercialization of hydrogen fuel cell technologies for vehicles and fuelling systems as well as micro, portable and stationary power applications. It is also the background for the world's largest hybrid electric fuel cell bus fleet. These buses were a part of Canada's demonstration of sustainable transportation technologies for the 2010 Olympic and Paralympic Games. The BC Hydrogen Highway was also recognized by the Vancouver Olympic Committee's (VANOC) Sustainability Star program, a program that recognizes innovative environmental technology efforts in and surrounding the Vancouver 2010 Olympic and Paralympic Games.

3.5.2 Vancouver Fuel Cell Vehicle Program

The Vancouver Fuel Cell Vehicle Program (VFCVP) is a demonstration aimed to increase public awareness of hydrogen and fuel cell vehicles, and to test and evaluate the performance, durability and reliability of five Ford Focus fuel cell vehicles in Vancouver and Victoria, British Columbia.

The VFCVP is putting FCVs and hydrogen refueling systems to work in real-world applications to enable the evaluation and improvement of system performance. It is also helping facilitate international codes and standards development and other activities critical to preparing the market for a clean-energy future. The five Ford Focus vehicles will re-fuel at hydrogen fuelling stations located throughout B.C., such as the Victoria and Pacific Spirit Hydrogen Fuelling Stations.

3.5.3 Prince Edward Island Wind-Hydrogen Village

The Wind-Hydrogen Village project will develop and demonstrate a wind-hydrogen energy system to provide a reliable, grid-independent power source that is sufficient to electrify a small village and provide hydrogen fuel for vehicles.

Located on the North Cape of Prince Edward Island, the project will demonstrate, evaluate and refine hydrogen technologies while developing innovative and fully-operational wind-hydrogen control software and interface components, with potential applications both within Canada and abroad. There are two major operational components of the Wind-Hydrogen Village: village electrification; and hydrogen fuel to be used in vehicles for transportation in Charlottetown.

4 Summary

Canada continues to conduct research, development and demonstrations. Engineers and scientists will continue their work on developing, demonstrating and deploying hydrogen technologies that minimize environmental impact, increase economic growth and improve energy-efficiency.

The aforementioned achievements mentioned in this paper, illustrate the commitment Canada has made to become a global leader in the development of hydrogen technologies and infrastructure to benefit both the present and future generations.

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