U.S. Department of Energy – Quadrennial Energy Review

Comments Provided by Canadian Hydrogen Fuel Cell Association

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Summary

The Canadian Hydrogen and Fuel Cell Association (CHFCA) was pleased to participate in the September 18th special dialogue on the Quadrennial Energy Review (QER) that was held in Ottawa, Ontario, Canada. We understand the QER seeks to provide a multiyear roadmap that focuses on energy infrastructure with specific attention on the transmission, storage and distribution (TS&D) systems that make up North America's oil, gas and electricity infrastructure.

As part of the stakeholder process, the CHFCA is pleased to offer insight into the emergent role of hydrogen and fuel cell technologies as they scale up to offer utility and refining-scale infrastructure solutions. Hydrogen and fuel cell technologies are not new to the U.S. Department of Energy (DoE), but new applications of the technologies are emerging to enable large-scale, bulk energy storage under a concept known as Power-to-Gas (PtG).

Long-duration, bulk energy storage with hydrogen offers new-found flexibility, and resiliency, when integrating increasing supplies of intermittent renewable energy into the electricity networks. Additionally, PtG hydrogen energy storage offers new transmission and distribution pathways for the delivery of this renewable energy to alternative end-uses via North America's existing natural gas pipeline networks and the substantial fuel refining infrastructure. As this new hydrogen infrastructure grows it will offer diversity to the applications that incorporate hydrogen energy solutions into the existing TS&D bulk energy system. This in turn offers an opportunity to increase North America's access to more efficient, and environmentally sustainable, end-use of energy with the market adoption of fuel cell technologies that are being commercialized for stationary and transportation applications.

The QER is expected to define specific actions over a four year period that support a long-term (2030) vision for energy infrastructure renewal. Hydrogen and fuel cell solutions are demonstrating applicability in the utility-scale deployments today. The near-term relevance of hydrogen, in the renewal of continental TS&D infrastructure, can be advanced through innovative energy policies, targeted DoE programs, technology funding and incentives that drive technology adoption by large

energy infrastructure stakeholders. This would include utilities, electricity grid system operators (ISO), pipeline companies and refiners.

Furthermore, the United States and Canada both have substantial capacity to drive new technology innovation that can support the integration of hydrogen technologies in the TS&D infrastructure and the end-use adoption of fuel cells in stationary and emerging transportation applications. Bi-lateral planning and collaboration on research, development and demonstration priorities could accelerate the pace of technology commercialization and the economic competitiveness of the technologies. Identifying opportunities for collaborative R&D, and demonstrations, could be advanced under the U.S – Canada Clean Energy Dialogue.

The remainder of this submission highlights some of the potential priorities that could advance hydrogen technology commercialization that would be supportive of QER objectives. At a high-level, they include:

- ***Power-to-Gas (PtG) Energy Storage***
  - hydrogen energy storage for affordable renewable integration and improved grid resiliency

- ***Low-carbon / Renewable Hydrogen in Oil Refining***
  - support low-carbon fuel standards (LCFS) and renewable fuel standards (RFS) by diversifying renewable content beyond ethanol and bio-diesel

- ***Smart Energy Grid Development***
  - use of PtG technologies to interconnect electricity grids, natural gas pipelines/storage and refineries for increased TS&D flexibility and expanded pathways for renewable energy delivery

- ***Refueling Infrastructure for Fuel Cell Electric Vehicles (FCEV)***
  - leveraging an expanded portfolio of hydrogen technology use in the bulk TS&D infrastructure for more affordable vehicle refueling

- ***Expanded Energy Efficiency and Electricity Conservation Strategies***
  - accelerate the adoption of hydrogen end-uses, such as fuel cell fork lifts and material handling equipment as a demand management and demand reduction strategy.

Proposed Priorities for Hydrogen Integration with TS&D Infrastructure

Power to Gas (PtG) Energy Storage;The importance of energy storage is increasing as regional power system integrates increasingly larger amounts of intermittent renewable power generation into the electricity networks. When supply and demand imbalances occur, this can lead to periods of surplus power, curtailment of generation, negative power pool pricing and reduced resiliency of the power grid.

A portfolio of energy storage solutions will emerge to address these operational power grid challenges; however, PtG Hydrogen energy storage offers unique flexibility. This technology uses high-efficiency water electrolysis to convert surplus renewable electricity into renewable hydrogen gas. It has the ability to provide fast-acting, dynamic response that helps electricity gird operators stabilize their second-by-second imbalances. It also offers simultaneous bulk (terawatt-hour range) long duration storage capabilities.

The storage solution offers the flexibility to then draw the stored energy back as green power, green heating fuel or green transportation fuel. As the carbon intensity of the continental electricity system is reduced the environmental benefits are expected to be more significant if this stored energy is used for a variety of energy end-uses that are not linked to electricity needs.

Early commercialization activity, supporting the next-generation PEM electrolysis technology, underscores the shift to utility-scale hydrogen storage technologies. With scale, the potential exists for a significant step-change in costs reductions for the future production of renewable hydrogen. Recently, the Independent Electricity System Operator, in Ontario, Canada, awarded an electricity energy storage contract for a 2 MW Power-to-Gas project. This selection process involved a competitive RFP for energy storage technologies, and the enclosed web link provides additional insights.

http://www.hydrogenics.com/about-the-company/news-updates/2014/07/25/hydrogenics-selected-for-2-megawatt-energy-storage-facility-in-ontario

Market adoption of PtG hydrogen energy storage would be facilitated through demonstrations of utility-scale operations to provide electricity grid operators, and energy policy makers, with the insights needed to understand the unique value offered with this fast-acting, bulk, long-duration storage solution. Stakeholders need to understand the value for more cost-effective renewable energy integration and the added flexibility for the use of storage energy in end-uses other that electricity.

Low-carbon / Renewable Hydrogen in Oil Refining; With a shift to utility-scale, renewable hydrogen production, it is reasonable to consider further scale-up of renewable hydrogen infrastructure for transportation fuel refining over the medium-term (2020-2030). As a general rule of thumb, 2 kg of hydrogen will be used in the refining of a barrel of light oil. For refineries that processes heavier crude oil – such as many gulf-coast refineries – the hydrogen demands can double.

Most hydrogen use in oil refining is derived from steam methane reforming (SMR) of natural gas. A unique path for decarbonizing transportation fuels exists with the supply of renewable hydrogen, from PtG, into oil refining markets. Current U.S. Refinery Distillation Capacity exceeds 17 million barrels of oil per day.[1]

Assuming 2 kg of hydrogen is used per barrel of refined oil, the potential hydrogen demand for this application exceeds 34 million kg of hydrogen a day. If this hydrogen were sourced from surplus renewable generation using power-to-gas technologies it would offer renewable power generators an expanded market that could consume in excess of 500 TWh/year of electricity. In effect, this offers a type of renewable relief value during times of surplus or low-priced renewable generation.

Even with the scale-up of PtG technology to a refining scale, and the subsequent cost reductions, it is questionable if this renewable hydrogen could compete with SMR derived hydrogen from natural gas that is using existing legacy infrastructure that is already well depreciated. What is entirely credible is adjusting the policies that support LCFS and RFS such that renewable hydrogen has equivalency alongside ethanol and bio-diesel mandates on an energy equivalency basis.

To put this potential into perspective, a kilogram of hydrogen would offer similar renewable energy content to a gallon of bio-diesel. On an economic basis, the renewable hydrogen is believed to be competitive with ethanol and bio-diesel. A change to LCFS / RFS policy, to establish equivalency for renewable hydrogen eligibility, would offer the refining industry more flexibility to meet renewable energy blending mandates. When measured against other renewable feedstock, the potential exists to achieve this flexibility with improved energy affordability. Furthermore, this policy approach would offer a path to increase intermittent renewable power generation on the electricity grids without destabilizing the power system during times of surplus power generation. When renewable generation exceeds market demand the refining industry acts like a large renewable sponge. In effect, this is an alternative means of increasing renewable power generation used in the transportation system.

As an additional benefit, this strategy would stimulate the build-out of a diverse renewable hydrogen infrastructure over the near-to-medium term. This could help establish a cost-effective, renewable hydrogen infrastructure for the subsequent mass-market adoption of the fuel cell electric vehicle over the medium to long-term.

It is worth noting that variations on the PtG derived hydrogen are also emerging. Some of these low-carbon hydrogen solutions process readily available, cost-effective natural gas in a power reactor that consumes small amounts of renewable electricity. The subsequent output from the reactor is low-carbon hydrogen gas and solid industrial carbon that can be used in the manufacturing of various materials such as foundry steel and rubber goods like tires. The enclosed web-link offers insights into a pilot project that is scheduled for commissioning in 2015 near a refinery in Saint John, New Brunswick, Canada. The technology deployed in this pilot project is approximately ½-scale for what is envisioned as a starting point for future refinery interests.

Footnote 1; IEA, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=8_NA_8D0_NUS_4&f=A

http://www.atlantichydrogen.com/news/province-nb-invests-carbonsaver-clean-energy-technology

Smart Energy Grid Development; Significant policy, R&D and program focus has been aligned with smart electricity grid developments over the past several years. What is not readily acknowledged is this is just one segment of the energy end-use pie. The current focus has created a silo that limits the potential for innovation that might otherwise cut-across the entire energy infrastructure chain of wires, pipelines and fuel processing.

Hydrogen and fuel cell technology offers some of the most promising potential to unlock a true Smart Energy Grid where the electricity grids, natural gas networks and refineries are physically interacting with one another for multi-directional energy flows. As just one example, the common perception is that natural gas power generation aligns well with firming intermittent renewables; however, this is a one-way energy flow from pipelines to wires. With utility-scale hydrogen energy storage bi-directional energy flow is enabled so surplus renewable generation can flow from the electricity network into natural gas pipeline networks as an alternative to curtailing renewable generation.

Current smart grid planning places an emphasis on energy storage with batteries, flywheels and pumped hydro technologies. While valuable to the reliable operation of the power system, all these technologies are limited to storing renewable generation for a period of minutes, hours or a few days. With hydrogen energy storage, the potential exists for the natural gas pipeline network to operate as a large, continental, distributed battery by tapping into approximately 4 trillion cubic feet (Tcf) of underground gas storage. Small but increasing quantities of hydrogen can be injected into the natural gas pipeline networks using Power-to-Gas energy storage.

When considering how to maintain affordability of the TS&D infrastructure, North America already has extensive and cost-effective energy storage, we just need to convert the renewable energy into a renewable gas to match the consumer need with the energy infrastructure we already have. Hydrogen-based solutions offer one means of accessing this existing storage infrastructure.

The scale of this storage resource is unmatched. The existing U.S. natural gas storage network is estimated to provide over 1,100 terawatt hours in equivalent energy storage. This is approximately 30% of the total 2011 electricity consumption in the United States. As a renewable gas in pipelines, energy planners can consider seasonal energy storage of renewable energy as a credible alternative, and the flexibility exists to bring this energy back to consumers as green power, green heat, and low-carbon transportation fuels. As more dedicated hydrogen end-uses are adopted, like fuel cells, the existence of a hydrogen-based energy storage industry simplifies the future transition to a dedicated hydrogen fuel supply infrastructure over a realistic transition period.

Utility-scale hydrogen energy storage can form the foundation for hydrogen's role in supporting a true smart energy grid. The resulting scale, cost-efficiencies, and accessibility of hydrogen can subsequently accelerate the current, but early, commercialization activity of fuel cells and other hydrogen applications that are aimed at cleaner and more efficient energy use in the stationary, material handling and transportation sectors. Accelerated market adoption of these hydrogen and fuel cell technologies can further support the smart energy grid developments since these technologies can contribute to a reduction in the environmental footprint of our energy infrastructure, and energy use, in the electricity, natural gas pipeline and transportation sectors.

Today's policy, R&D and program environment tends to be segmented into silos by energy end-use. It is therefore not well aligned with the development of a smart energy grid than spans wire, pipeline and refinery infrastructure. For hydrogen and fuel cell technologies that cut-across this TS&D infrastructure, as well as the related energy end-uses, this creates additional barriers to market adoption.

Opportunities exist to foster an improved environment for the emergency of a smart energy grid and the related role of hydrogen and fuel cell technologies. These could include:

1. The development of a road map that better defines the opportunities for how hydrogen technologies can be integrated in the larger TS&D infrastructure, and how this might subsequently improve the end-user adoption and affordability of consumer-based hydrogen solutions. Historical efforts to create a road map for hydrogen and fuel cell systems have generally been aimed only at the end-use applications rather than the upstream energy infrastructure applications.

2. Establishing program support, R&D and legislation aimed at increasing the flexibility of the continental natural gas pipeline network in accepting small but increasing quantities of hydrogen blending. The establishment of gas quality standards that include hydrogen blending can provide a catalyst for an expanded role for hydrogen in smart energy grids. The National Renewable Energy Lab (NREL) has initiated early technical reports that assess the technical capabilities for hydrogen injection in the existing natural gas networks.[2]

3. Ensuring the long-range planning environment for TS&D includes hydrogen-based solutions. This is particularly important when assessing any future wholesale electricity export needs at a regional grid level. The assessment of least-cost solutions, for renewable energy integration, should include the potential to export wholesale renewable power into alternative wholesale energy markets such as natural gas pipeline networks, refinery operations and future hydrogen networks.

4. Seeking collaborative and bi-lateral opportunities, with Canada, for next-generation R&D and demonstration activities involving hydrogen and fuel cell technology deployments. This would be linked to TS&D infrastructure and new supply-side energy solutions. Examples could include the use of hydrogen and fuel cells in micro grids, remote communities and supply-side energy developments like methanation technologies that upgrade captured CO_2 and renewable hydrogen to supply a high-quality syngas or renewable natural gas (RNG).

Footnote 2; NREL Technical Report, NREL/TP-5600-51995, March 2013, Contract No. DE-AC36-08GO28308

5. Consideration for federal programs that help electricity utilities consider customer-use of hydrogen and fuel cell technologies as energy conservation, demand management, or demand shifting initiatives.

Refueling Infrastructure for Fuel Cell Electric Vehicles (FCEV); Hydrogen powered Fuel Cell Electric Vehicles will become commercially available from 2015 from Toyota, Hyundai, Honda, Mercedes. Nearly all major car makers consider FCEVs as a significant part of their vehicle portfolio to deliver zero-emission and long-range mobility with short refueling times. The market penetration of FCEVs will depend on competitive performance and pricing for the vehicles as well as the widespread availability of hydrogen at a price competitive to the use of gasoline in conventional vehicles.

Substantial efforts have been made in California to establish a hydrogen station network which allows the initial rollout of FCEVs. It has to be noted, however, that the existing station concepts require a high level of government funding, due to the still relatively small number of vehicles to be filled and due to the high station cost. Long-term, station concepts which are financially feasible without government funding need to be developed. This could include:

1. Dramatically reduced hydrogen station equipment cost through modular design, standardized high-volume manufacturing

2. Simplified station implementation through “drop-in” design, standardized locations (e.g. a big box stores), simplified permitting processes

3. Increase station usage through specific vehicle programs (e.g. FCEV public fleets, combination with Fuel Cell Bus applications)

   It will be possible to leverage an expanded portfolio of hydrogen technology use in the bulk TS&D infrastructure for more affordable vehicle refueling which will be key to support the rollout of zero-emission transportation in larger numbers.

While an early leader in FCV fueling stations, much of Canada 'a fueling infrastructure is now dated or inappropriate for the required fast-fill FCVs.

Canada needs a renewed Hydrogen Road Map that identifies the timing, cost, geographic and other requirements to update our fueling infrastructure to integrate with the US vehicle roll out.

Expanded Energy Efficiency and Electricity Conservation Strategies; The commercialization of hydrogen and fuel cell technologies in the backup power, stationary power and material handling markets offers energy planners an opportunity to reassess the role that these technologies can play in shaping the renewal of upstream energy infrastructure.

As an example, today’s backup power systems that use fuel cells are demonstrating high reliability for telecommunication companies and critical data management needs when upstream energy infrastructure is lost due to weather or other interruptions. As an aggregated resource (backup power and prime-power, stationary fuel cells), future energy planning could consider these zero emission resources as a demand management tool for the electricity networks where these systems could be remotely dispatched during times of peak demand or demand shifting. This would build resiliency into the electricity networks while also creating a need more robust and flexible hydrogen supply infrastructure.

On a continental basis, the material handling requirements for our manufacturing industries is significant. Recent fuel cell deployments in the lift truck markets are demonstrating significant reductions in electricity consumption using a zero-emission energy supply. This represents an opportunity to expand on energy efficiency and energy conservation programs offered by utilities.

As just one example, a recent deployment of fuel cell forklifts at an auto manufacture reduced electricity consumption by over 1.8 million kilowatt-hours per year.[3] Across the entire material handling sector, this aggregate market potential represents a new opportunity for energy conservation. This is particularly true if we consider that the future TS&D infrastructure might evolve to capture curtailed renewable power using power-to-gas hydrogen energy storage. The potential exists for an entirely different means of applying electricity conservation when the power used in the forklifts, on the factory floor, could originate from surplus renewable energy that would have otherwise been curtailed. Additionally, the renewable energy can be transported to the end-user by a means other than conventional electricity networks.

This is just the start of a transformation involving how we plan, operate and renew our future energy infrastructure. As the FCEV is fully commercialized the true potential to transform the upstream TS&D infrastructure with hydrogen technologies can be realized. This will occur in both the physical upstream infrastructure space (e.g. power-to-gas hydrogen energy storage) and at the energy end-use level where a diverse portfolio of hydrogen supplies can fuel an increasing array of consumer needs thereby allowing different planning considerations for upstream TS&D infrastructure.

Footnote 3; http://www.ballard.com/files/PDF/Material_Handling/Material_Handling_Case_Study_041911.pdf

Conclusion

The hydrogen and fuel cell industry is demonstrating the potential for solving many challenges related to the TS&D infrastructure planning and renewal. This is particularly true as the hydrogen-based energy solutions scale to a utility-level today and the technology's promise for expanded support of new wholesale energy services in electricity, pipeline and refinery industries.

The technology offers new opportunities to address the continental challenges related energy affordability, improved flexibility of energy infrastructure, reduced environmental footprint, and strengthening the resiliency of the energy networks. The CHFCA therefore encourages the U.S. Department of Energy to seriously consider the role of hydrogen and fuel cell technologies in the development of its multiyear roadmap that results from the current Quadrennial Energy Review process.

The CHFCA has appreciated the opportunity to participate in the process and would be pleased to address any questions related to its submission by contacting the undersigned.

Yours truly,

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About the CHFCA

The Canadian Hydrogen and Fuel Cell Association (CHFCA) is a national, non-profit association that supports Canadian corporations, governments and educational institutions that are developing, demonstrating and deploying hydrogen and fuel cell products and services in Canada and abroad. It also supports companies, research agencies and start-up/pre-commercialization ventures in the hydrogen and fuel cell space.

Our members work on hydrogen and fuel cell technologies, components, systems supply and integration, fuelling systems, fuel storage, and engineering and financial services.

Globally, hydrogen and fuel cell products are moving towards commercialization. The Canadian sector is a global leader as a result of pioneering technologies, world-renown expertise, and a 25-year history of partnerships between industry, academia and Canadian governments. The CHFCA is playing a key role in this leadership.

The CHFCA was formed in January 2009 when the Canadian Hydrogen Association (CHA) and Hydrogen & Fuel Cells Canada (H2FCC) merged together. The merge united all of the members of the former groups to create a vibrant, influential association.