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The Potential of BC's Waste and By-Product Hydrogen

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Issue

Hydrogen currently produced as waste or as an industrial by-product can be harnessed as a fuel for power generation and transportation. British Columbia is well situated to take advantage of this green energy opportunity by simply re-positioning the hydrogen that is already being produced without the need for expensive infrastructure investments. Currently, BC has three industrial plants (in Prince George, North Vancouver and Nanaimo) that could produce enough hydrogen to generate 22 to 25 megawatts (MW) of power, enough to support domestic demand in 18,000 – 20,400 homes[i] or significant fuel-cell powered transit fleets. On-site fleet fuelling or stationary power generation at these industrial plants would require minimal infrastructural investment, and would simultaneously help reduce conventional energy consumption, improve air quality and foster innovation in a resilient 'smart-grid'.

Background

As part of many industrial processes hydrogen is generated as a waste or by-product. The power to drive these industrial processes is most commonly supplied by BC Hydro whose electricity is approximately 93% clean[ii]. This ensures that emissions associated with the hydrogen generation are significantly lower than in locations where methane reformation or fossil-fuel powered electrolysis are used. Currently, hydrogen not required by the facilities is often disposed of through venting or flaring. However, it could instead be utilised as a transport fuel (in an internal combustion engine or fuel-cell) or to produce electricity (without combustion) in a stationary fuel-cell[iii].

Due to the extensive use of hydroelectric generation, greenhouse gas (GHG) emissions from electricity generation are small in both BC (~2% of the provincial total[iv]) and the City of Vancouver (~6%[v]). However, GHG gains can still be achieved with hydrogen-based power generation. Ballard Power Systems recently signed a sales agreement[iii] to use a 163 kilowatt PEM fuel-cell at a K2 Pure Solutions bleach plant in Pittsburgh. This technology is fully scalable and could be used, for example, at Erco's hydrogen-producing sodium chlorate facility in North Vancouver. In this instance, the waste hydrogen would generate 6-8 MW of power, offsetting facility base-load demand by approximately 10%. Alternatively, it could be sold to the grid as a cost offset.

In 2008, transportation accounted for approximately 37% of both British Columbia's[iv] and the City of Vancouver's[v] CO_2 emissions; this is significantly more than the national average of 27%[vi]. This means that there are disproportionately large emissions reductions to be made from tackling transport-generated GHGs. Transport fuels require high energy densities and should be easily transportable. Hydrogen provides a solution, either as a clean fuel for internal combustion engines or as a feedstock for fuel-cells. In both applications, the main by-product is water. From early 2011, the hydrogen produced by Erco's North Vancouver plant is to be liquefied and transported to Whistler for use in their fleet of 20 fuel-cell powered buses[vii]. The hydrogen required by the entire fleet for one day is produced in less than one hour by the North Vancouver plant.

The implications for the recovery of industrially-generated hydrogen in BC are extensive. The auto-manufacturers Daimler and Ford already have a joint venture, the Automotive Fuel Cell Co-operation Corp, in Burnaby which employs 200 people in Canada's largest auto R&D centre. Along with local leaders like Ballard Power Systems, HTEC, Quadrogen, and the National Research Canada Institute for Fuel Cell Innovation, BC is primed for the nascent fuel-cell market.

Recommendations

The integration into the grid of 'distributed power generation' (power generation at any location on the electrical grid and not just at major power stations) has the potential to help BC Hydro significantly through peak-shaving and fuel-switching and to improve power quality[viii]. The industrial facility that produces the hydrogen will save money on the cost of disposal while reducing its energy bill, though it must finance capture infrastructure. Typically, this will comprise: industrial compressors, scrubbers and cleaners (of varying degrees depending upon the intended end-use) and a fuel-cell to generate power, or a compression/liquefaction plant to prepare the hydrogen for distribution. Should sale to the grid be desired, the appropriate electrical switching equipment must also be installed. Despite these infrastructure demands, using by-product or waste hydrogen as a high-grade fuel to generate electricity at industrial sites still offers a ready opportunity for significant energy savings and cost recovery. Moreover, hydrogen consumers (if different from the plant operator) can gain a reliable fuel supply. Finally, but not least, the impacts upon the environment and human health from displaced fossil-fuel consumption cannot be under-stated.

The implications for using waste or by-product hydrogen as a fuel vary for stationary and mobile applications.

Application to Stationary Power Generation

The hydrogen produced is used to supply (possibly after storage, if not needed immediately) a fuel-cell that generates clean electricity without combustion, which may be used on-site or sold back to the grid. The benefits include:

- *Reduced overall power demand from BC Hydro*: The waste/by-product hydrogen stream, GHG and air-contaminant free, is now used to generate power, reducing demand on the grid.

- *Reduction of peak loads*: Electricity sales to BC Hydro at times of peak grid load can reduce required generating capacity and help with power management (peak-shaving).

- *Facilitate 'smart-grid' potential*: Compressed or liquefied hydrogen has essentially become a form of electricity storage, which is a central requirement of the 'smart-grid'. The smart-grid utilises distributed generation, energy storage and the ability to move energy in both directions along the grid (not just from source to consumer) in order to enhance the overall efficiency of the system. Distributed electricity generation from by-product hydrogen, with its potential for energy storage as a compressed gas or high-pressure liquid ensures that by-product hydrogen can play a key role in a resilient smart gird.

Application to Transportation.

The hydrogen produced is stored and shipped to locations where it can be used to fuel commercial fleets powered by fuel cells, or hydrogen-fuelled internal combustion engine vehicles. The benefits of this system are:

- *GHG reductions*: A significant reduction in emissions from the vehicle fleets through displacement of diesel engines.

- *Reduction of air contaminants:* Significant reductions in air contaminants like nitrogen oxides (NO_x), particulate matter (black carbon), carbon monoxide and hydrocarbons.

- *Fuel intrastructure and storage capacity in support of future public transit systems*.

Conclusion

By-product or waste hydrogen from industrial facilities throughout BC is currently under-utilised. Using BC-developed PEM fuel-cells, hydrogen could be used to offset plant power demand, or used as a storage medium to reduce peak demands on the grid. Furthermore, compressed or liquefied by-product hydrogen has the potential to fuel fleets of clean fuel-cell powered buses, and will be doing so in BC from 2011.

Sources

[i] Based on average per dwelling BC residential electricity consumption as listed in Natural Resources Canada *Comprehensive Energy Use Database 1990-2008*, Oct. 2010 http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/res_bc_1_e_4.cfm?attr=0

[ii] British Columbia Ministry of Energy, Mines & Petroleum Resources, Sept. 2008 www.empr.gov.bc.ca/EPD/Electricity/supply/Pages/default.aspx

[iii] *News Release*, Ballard Power Systems Inc., Aug. 2010, http://phx.corporate-ir.net/phoenix.zhtml?c=76046&p=irol-newsArticle&ID=1457222&highlight=

[iv] *British Columbia Greenhouse Gas Inventory Report* , Sept. 2010, www.env.gov.bc.ca/cas/mitigation/ghg_inventory/pdf/pir-2008-full-report.pdf

[v] *City of Vancouver Greenhouse Gas Emissions Inventory: Summary & Methodology*, Dec. 2009, www.vancouver.ca/sustainability/documents/2008GHGInventoryMethodologiesDocument20091210.pdf

[vi] Calculated from data in *National Inventory Report 1990-2008: Greenhouse Gas Sources & Sinks in Canada- Part 1*, Table S-1, http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=492D914C-2EAB-47AB-A045-C62B2CDACC29

[vii] *News Release*, British Columbia Ministry of Transportation & Infrastructure, Jan. 2010, www2.news.gov.bc.ca/news_releases_2009-2013/2010TRAN0001-000064.htm

[viii] BC Hydro, Distributed Energy Website entry, Mar. 2010 http://www.bchydro.com/powersmart/technology_tips/buying_guides/distributed_generation.html