Briefing Note

Purpose

The purpose of this briefing note is to provide information on PNWTS' vision to undertake a diesel double-decker to hydrogen fuel-cell conversion project. This project will determine the feasibility of a full fleet conversion from an environmental, viability, and cost-benefit perspective along with the future goal of developing a hydrogen conversion hub, further solidifying BC's position as a leader in the hydrogen marketplace.

At this stage, adequate funding is needed from a combination of government and private enterprise to complete a double-decker and single coach trial conversion. It is also imperative to determine whether the conversion will take place in the UK or Canada. Over time, PNWTS and BMT Group Services, a Western Group joint venture partner, are looking to develop an additional revenue stream as Canada's 'go-to' source for all bus conversions.

Introduction

Across the world, hydrogen fuel-cell powered electric buses (FCEB) provide a smooth and quiet passenger experience with zero emissions at the tailpipe. As governments and cities take the lead in placing increasingly strict regulations and restrictions on internal combustion engines, transportation operators are looking to FCEB as the best option to transition their fleets to zero-emissions without affecting service levels.

Fuel-cell electric buses hold a significant economic value for Canada, compared to their zero-emission counterparts, battery-electric buses. Canada is already a leader in hydrogen production as an energy carrier and has many competitive advantages to grow this sector with the world seeking low carbon intensity fuel options. On the technology side, Canada is already home to world-leading hydrogen and fuel-cell companies that cover all elements of the supply chain— including hydrogen production, distribution, dispensing and utilization, fuel-cell vehicle engineering, and manufacturing.

Background

Climate change is one of the most significant issues of our times, demanding action today. Governments around the world are doing their part; Canada has committed to achieving net-zero emissions by 2050. There are significant opportunities for zero-emission vehicles to play a critical role in Canada's carbon neutrality mandate. In 2017, the transportation sector was the second-largest source of GHG emissions, accounting for 24% (174 megatons of carbon dioxide equivalent) of total national emissions. Between 1990 and 2017, GHG emissions from the transportation sector grew by 43%.[1]

Current Status

Canada's Federal Government Environment Policy now centers on greenhouse gas (GHG) emission reductions, technology innovation, and clean growth as the pillars for a low carbon future. All three areas are relevant to

[1] https://info.ballard.com/hubfs/Premium%20Content/An%20Attractive%20Value%20Proposition%20for%20Fuel%20Cell%20Buses%20in%20Canada/WP%20Ballard%20Fuel%20Cell%20Buses%20for%20Canada.pdf?hsCtaTracking=92e9f17a-bbd2-4e7b-a3b3-f8ce682cfe45%7C053dc2a0-beb5-4e55-a53a-aec7e12fc155

greater hydrogen and fuel cell use across the economy. Six specific actions identified in the Pan-Canadian Framework can support greater hydrogen use in transportation and stationary applications. Natural Resources Canada's (NRCan's) Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) is also helping remove barriers to the availability of hydrogen fueling stations for public use. Additionally, Budget 2019 included $130 million in funding over five years for ZEV-related infrastructure.[2]

The Global Hydrogen Landscape

Several governments worldwide have adopted hydrogen transportation strategies and have committed significant funding for comprehensive hydrogen technology.[3]

Jurisdiction		Plan	Funds Committed	Jurisdiction		Plan	Funds Committed
	EU	Y	Backed by COVID-19 stimulus package earmarked $830.3 B for climate change		Australia	Y	$273.2 M
	South Korea	Y	Included in clean stimulus plan of $128.6 B		Denmark		$151.7 M
	Germany	Y	$13.7 B		Netherlands	Y	$53.1 M
	France	Y	$10.9 B		Spain	Draft	$37.9 M
	Portugal	Y	$10.6 B		Lithuania		$33.4 M
	UK		$602.2 M clean stimulus package and Scotland's $106.7 M energy recovery fund		New Zealand	Y	$17.2 M
	Norway	Y	Included in clean stimulus plan of $510.5 M		USA		TBD

Considerations

FCEBs are the only zero-emission solution that can meet the performance demands of transit operators without compromise. With tens of millions of kilometers in commercial services and more than fifteen years on the road in different environments, FCEBs have proven to meet bus operators' operational requirements. Fuel Cell Electric Buses offer a one-to-one replacement for diesel with no compromise in service. Critical attributes of FCEB include:

- Zero-emission at the tailpipe
- Range of up to 300 miles/450 km between refueling
- Consistent power delivery during the duty cycle, in heat and cold

[2] https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/resource-library/hydrogen-and-fuel-cells-sector-status-and-vehicle-use-canada/21959

[3] https://cleanenergycanada.org/wp-content/uploads/2020/10/CEC_Report_Hydrogen2020.pdf

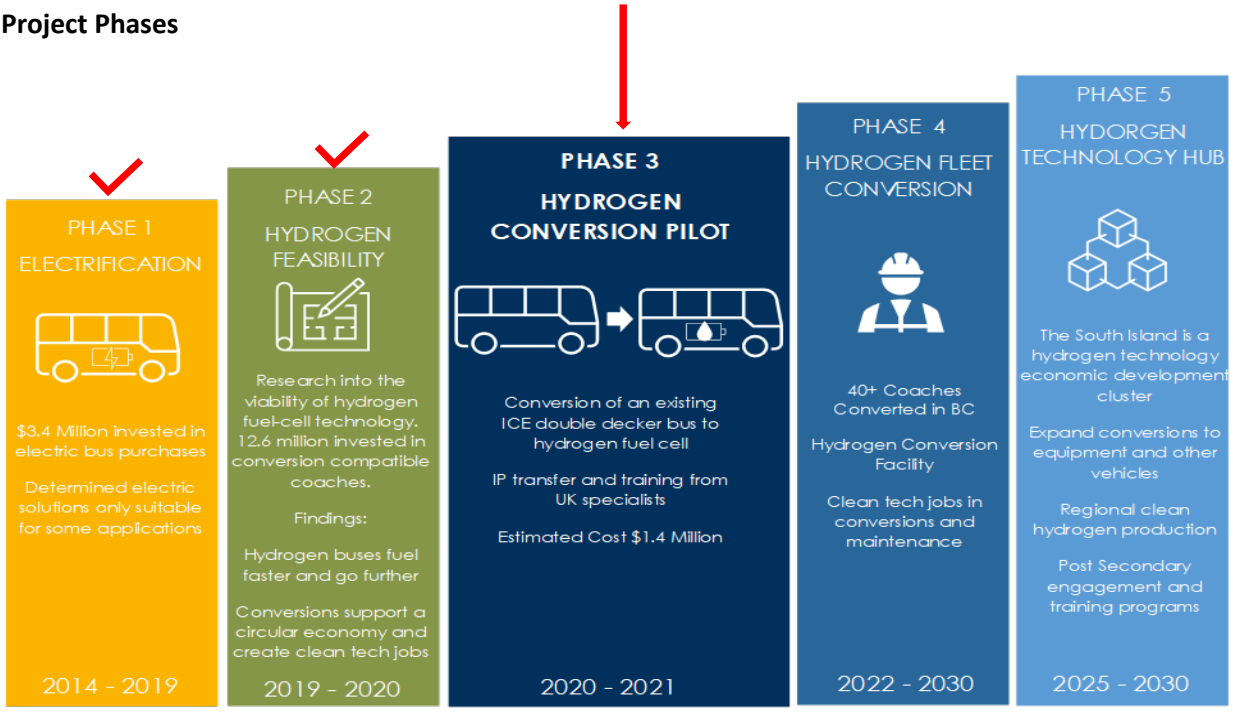
- Compact depot gas refueling, eliminating the need for roadside charging infrastructure with a total refueling time of fewer than 10 minutes
- Proven durability, with fuel cell lifetime of more than 30,000 hours[4]

Several companies have conducted hydrogen fuel-cell research and experimental fuel-cell bus trials with *new builds*. These include:

- Daimler AG, with thirty-six experimental units powered by Ballard Power Systems fuel cells completing a three-year trial, in eleven cities, in 2007.[1][2]
- Thor Industries, based on UTC Power fuel cell technology
- Irisbus, based on UTC Power fuel cell technology
- TATA Motors and Indian Oil Corporation (Starbus, fuel cell)
- Van Hool, and Ballard, which have had commercial fleets in passenger service in Aberdeen, Scotland
- Wrightbus, which has had a fleet in London, England

At present, Innervated Vehicle engineering (IVe) in Scotland is the first to *convert* a diesel double-decker bus to hydrogen fuel-cell successfully. As a result, PNWTS has selected IVe to complete the trial double-decker conversion with the provision of transferring the IP for future conversions to BMT Group Services.

Project Phases



4 https://info.ballard.com/hubfs/Premium%20Content/An%20Attractive%20Value%20Proposition%20for%20Fuel%20Cell%20Buses%20in%20Canada/WP%20Ballard%20Fuel%20Cell%20Buses%20for%20Canada.pdf?hsCtaTracking=92e9f17a-bbd2-4e7b-a3b3-f8ce682cfe45%7C053dc2a0-beb5-4e55-a53a-aec7e12fc155

Next Steps

1. Finalize business case, determine available funding sources, and complete applications. Confirm total funding available for trial.

Program	What it will Fund	Potential Funding	Timeline
Sustainable Development Technology Canada	33% of eligible costs	Avg. $2 million	Avg. 5 months for approval
National Research Council of Canada (NRCAN) Industrial Research Assistance Program	"Shared cost of R&D project activities."	Est. $500,000 – $1 million	3 months
NRCAN Innovation and Clean Growth Programs	R&D, including first commercial installations	TBD	TBD
Eureka Network	International collaboration on innovative ideas	Multiple funding options	Open call
Government of Canada Strategic Innovation Fund	Funds $10 million (min), 50% of total	$10 million+	~6 months

2. Finalize location for trials—transport equipment, as necessary.
3. Complete trials and assess outcomes. Determine feasibility for full fleet conversion.
4. Create a conversion hub at BMT.

Outcomes

1. The project will provide a chance to influence and support local community concerns relative to the cruise industry's sustainability and the Ogden Point Terminal viability.
2. An opportunity exists to build a hydrogen fuelling station at Ogden Point, highlighting our commitment to the City of Victoria community in supporting green jobs growth.
3. BMT stands to become THE Canadian experts in FCEB technology and conversion. The unique IP transfer will increase the clean fuel transition speed, reduce the number of gas and diesel vehicles on the road, and create new clean-tech jobs, all while helping BC and Canada meet our emission reduction targets.
4. This project will include developing partnerships with post-secondary institutions, other transportation industry members, and various clean-technology funding programs.

Conclusion

As a proven application with a high technology readiness level, fuel cell electric buses can be particularly important to Canada's economy as we transition to a more sustainable transportation future. In terms of infrastructure investment, bus fleets can provide early, reliable, and strategic loads as new blue and green hydrogen production and liquefaction capital are deployed strategically around the country.

Pacific Northwest Transportation Services, along with parent company Western Stevedoring, is committed to sustainability and the environment and is dedicated to supporting Canada's Climate Action Plan goals to reduce emissions, spark innovation, and create jobs.