

# HYDROGEN FUEL CELL BUS EXPANSION STRATEGY

by

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## **Abstract**

Ballard Power Systems Inc. is the world leader in the development of Proton Exchange Membrane (PEM) fuel cells. Ballard's current strategy is focused on pursuing near-term commercial markets for fuel cell products. One of these, the hydrogen fuel cell bus market, provides a zero-emission alternative for urban public transit applications.

Hydrogen fuel cells provide a highly efficient source of electricity generation. The only reaction by-products are heat and water vapour. In an urban transit bus application they provide true zero emission propulsion capability with complete route flexibility. Ballard has been developing fuel cells for transit bus applications since 1991. To date, sales have been concentrated in Europe and North America.

This paper examines market conditions for hydrogen fuel cell buses in the USA, Mexico and Brazil and recommends the preferred markets for Ballard. In addition, a high level manufacturing plan is included that will facilitate local government support and market entry.

**Keywords:** bus; zero-emission; fuel cell

## **Executive Summary**

Ballard Power Systems Inc. is a recognized global leader in the design, manufacturing, distribution and support of clean energy Proton Exchange Membrane (PEM). Ballard develops and manufactures PEM fuel cell stacks and systems for telecommunications back-up power markets, material handling markets, distributed power generation markets and urban transit bus markets.

A Situation Analysis was conducted to study Ballard from both an internal as well as an external market perspective to establish the Key Success Factors necessary for its success in the fuel cell bus market segment.

Solution Analysis tools were employed to evaluate each of the primary Americas regions (i.e. Canada, USA, Mexico, Brazil) as potential markets for Ballard's fuel cell bus technology. From this the regions were priority ranked in terms of their potential for fuel cell bus market entry.

The results of the analyses and further synthesis indicate that Ballard should capitalize on the significant growth opportunities in the USA and Brazil while monitoring government commitment in Mexico. To improve profitability and maintain industry leadership, Ballard will need to address five key success factors:

- Product cost / pricing
- Support for zero emission transit bus fleets
- Local Partnerships
- Hydrogen Fuel Availability
- Government Support

Based on both CAGE and PESTEL analysis it was determined that Ballard should focus on US and Brazilian markets but not Mexico for its near-term expansion strategy. Ballard should enhance fuel cell durability and lower manufacturing costs by increasing synergies in product lines, standardizing manufacturing and lowering labor and component costs. For successful

market entry, Ballard should form partnerships with recommended strategic local players within the value chain. Ballard should implement a five phase manufacturing plan that will generate highest ROI while building local capability and increasing local content.

## **Dedication**

This paper is dedicated to my family who have endured the solitude of being EMBA orphans for the past two years. As always, they have provided me with the love, support and inspiration to persevere through the sometimes overwhelming workload and stress associated with achieving my MBA. I could not have done it without them.

## **Acknowledgements**

I would like to express my sincere gratitude to Dr. Daniela Blettner for her mentorship and guidance throughout the development of this project and my final paper. My gratitude goes out as well to Dr. Jeff Smiley for his review and final approval of my team's presentation. I am indebted to Paul Cass for his commitment to this project and to my development. His encouragement and advice has given me the motivation to achieve my goals.

I would also like to thank all of the other professors at SFU that pushed me to learn and my classmates for making the whole experience interesting and allowing me to get to know them. Lastly, my completion of the EMBA program would not have been possible without the friendship and support of Team Novo Auctus; Vanessa Dipe, Michelle Grinberg, Collin Mothupi, Rogerio Salvaia and Carlos Suarez. It was an honour to be a part of their team.

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## **Glossary**

PEM Proton Exchange Membrane. Ballard's fundamental fuel cell technology

R&D Research and Development

IP Intellectual Property

KSF Key Success Factor

BRIC Brazil, Russia, India and China. Emerging market economies

## **Introduction**

Ballard Power Systems Inc. is a recognized global leader in the design, manufacturing, distribution and support of clean energy Proton Exchange Membrane (PEM). With revenues of \$76M in 2011 and 420 employees located in Canada, US and Denmark, Ballard is the largest 'pure play' PEM fuel cell company in the world. Ballard has been in operation for over 30 years. Initially focused on developing fuel cells for automotive applications, in 2007 Ballard shifted its business to concentrate on nearer term commercial markets for their PEM fuel cell technology. Ballard develops and manufactures PEM fuel cell stacks and systems for telecommunications back-up power markets, material handling markets, distributed power generation markets and urban transit bus markets.

### **1.2 Competitive Advantage**

Ballard's competitive advantage derived from efficient use of its resources positions it to be successful for the long run.

- \$1.2B invested in state of the art R&D and manufacturing facilities
- Over 900 patents and exclusive design of equipment
- Lowest cost/KW
- Qualified skilled labor
- Reliability testing capability
- Brand equity – technology leadership
- Extensive experience with Fuel cells(IP)
- Employees – culture (part of pioneers) as evidenced by retention rate over 95%

An analysis of Ballard's competitive advantage highlights that their Research and Development (R&D) facilities need to stay in Vancouver due to proximity to tangible resources such as hydrogen infrastructure, reliability testing capability and a highly skilled workforce in R&D and prototype manufacturing. Intangible resources such as brand equity, extensive

experience in fuel cells and Intellectual Property (IP) will help Ballard in their quest to gain support from key industry players and Governments. It will also help in attracting alliances.

Ballard’s comparative advantages are summarized in the following:

*Table 1: Comparative Advantage Analysis*

	Helpful to achieve objective	Harmful to achieve objective
<b>Internal Origin (Attributes of the Organization)</b>	<p><b><u>Strengths</u></b></p> <ul style="list-style-type: none"> <li>• Product leadership</li> <li>• Reduced product development costs</li> <li>• Increased efficiency</li> </ul>	<p><b><u>Weakness</u></b></p> <ul style="list-style-type: none"> <li>• Limited liquidity</li> <li>• Negative net profits</li> </ul>
<b>External Origin (Attributes of the Environment)</b>	<p><b><u>Opportunities</u></b></p> <ul style="list-style-type: none"> <li>• Strategic Agreement</li> <li>• IdaTech Backup Power System</li> <li>• Efficiencies and Non-dependence on Natural Resources</li> <li>• Growing environmental concerns</li> </ul>	<p><b><u>Threats</u></b></p> <ul style="list-style-type: none"> <li>• Lack of infrastructure</li> <li>• High manufacturing and material costs</li> <li>• competition</li> </ul>

### 1.3 Financial Summary

Ballard has experienced consistent sales growth as evidenced in the following:

*Table 2: Financial Performance*

<b>Key Figures</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012E</b>
<b>Sales (\$m)</b>	<b>46.7</b>	<b>65.0</b>	<b>76.0</b>	<b>74.5E</b>
<b>EPS (\$m)</b>	<b>(0.05)</b>	<b>(0.39)</b>	<b>(0.40)</b>	<b>(0.22)E</b>
Cash per Share (\$)	0.97	0.88	0.55	0.37
<b>Free Cash Flow (\$m)</b>	<b>(33.7)</b>	<b>(32.8)</b>	<b>(37.3)</b>	<b>(19.6)</b>

Ballard recorded \$76M in revenue during 2011 from 4 regions and 4 product segments. Based on that, Ballard's financial performance ratios as compared to industry are as follows:

*Table 3: Financial Performance Ratio Analysis*

<b>Ratio</b>	<b>Ballard</b>	<b>Industry</b>
<b>Current ratio</b>	<b>1.53</b>	<b>2.32</b>
<b>Debt to Equity</b>	<b>0.33</b>	<b>0.56</b>
<b>Sales 5yr growth</b>	<b>8.81</b>	<b>8.07</b>
<b>Net Margin</b>	<b>-54.18</b>	<b>6.72</b>
<b>Return on Assets</b>	<b>-20.09</b>	<b>5.54</b>

## **1.4 Current Strategy**

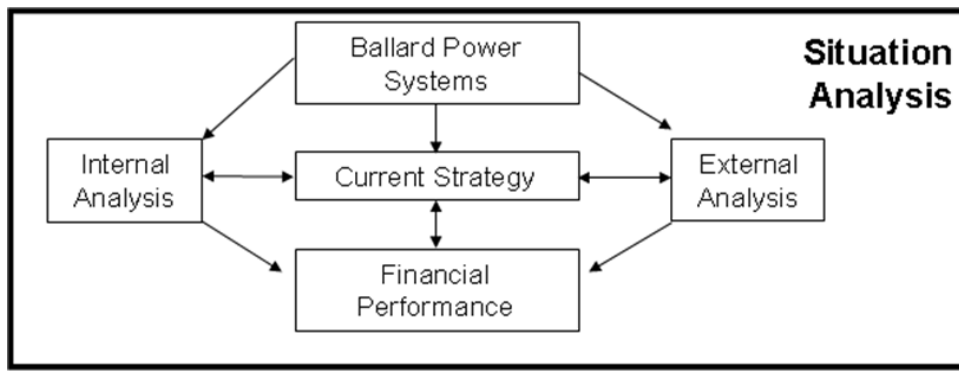
Ballard has decided to leverage its existing fuel cell products in current and new markets. This move allows Ballard to make current technology more efficient and eliminates the need for large R&D investment. Ballard has expanded into related markets by acquiring different fuel cell system integrators that use Ballard's stacks. This allows access to new customers and builds its system integration strength.

Ballard's growth strategy is to harmonize fuel cell component manufacturing between product platforms to create economies of scale between Bus and Material Handling product manufacturing while continuing to develop new fuel cell bus markets in Brazil, India, China and Europe. Ballard has acquired key customer assets to grow its product portfolio and fill the gap in system integration.

## 2.0: Situation Analysis

A Situation Analysis is necessary to understand Ballard's competitive advantage based on its internal factors, strategic direction and external environment. This provides the Key Success Factors necessary for Ballard's success in this market.

Figure 1: Situation Analysis Framework



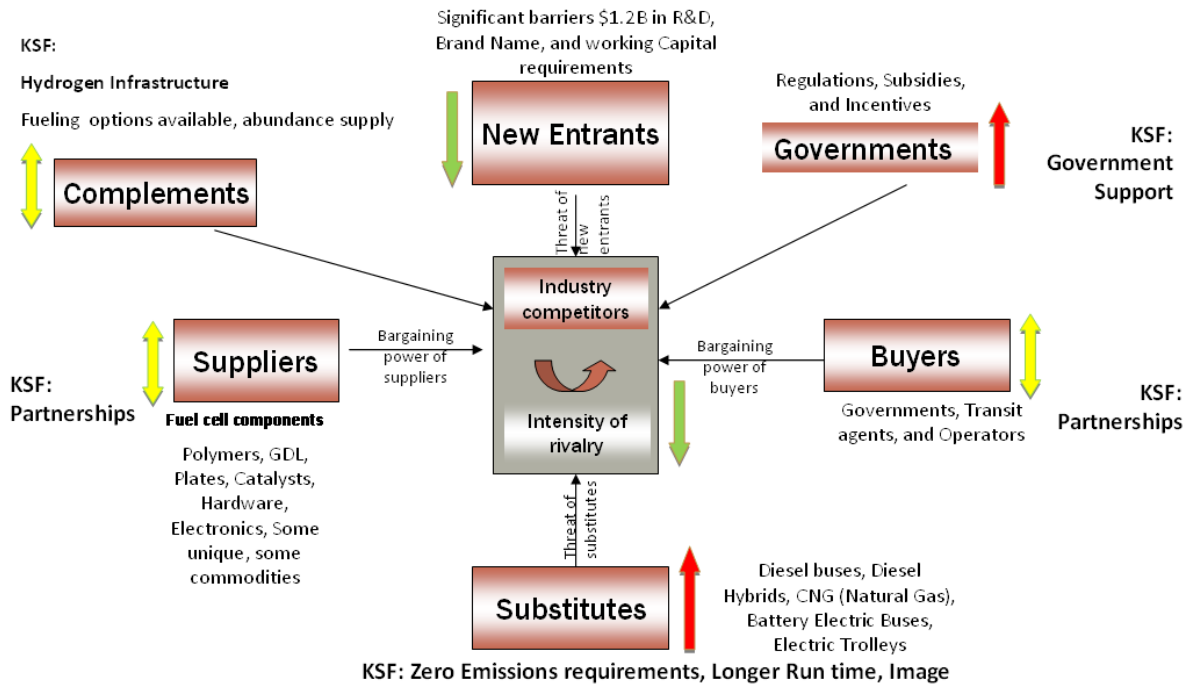
Using Porter's 7 Force Competitive Framework<sup>1</sup> the external competitive landscape is evaluated for Ballard's FC Velocity HD6™ product and the Key Success Factors are derived. For Ballard to be successful in fuel cell bus markets, they must focus on product pricing, supporting the establishment of zero emission transit bus regulations, strategic partnerships, affordable and available hydrogen fuel and government support.

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<sup>1</sup> The Five Competitive Forces that shape Strategy by Michael E. Porter



Figure 2: Porter's 7 Force Competitive Framework



**New Entrants:** Due to high R& D investment the barriers to market entry are significant; therefore it is very difficult for new competitors to enter the market.

**Suppliers:** Some of the expensive raw materials used in the manufacture of Ballard's fuel cells, such as platinum are commodities and are subject to market volatility, not controlled by suppliers. Suppliers that provide materials into other larger market sectors will have their pricing dictated by those other markets, so they can't raise prices arbitrarily. However, there are some suppliers who only supply customized components to Ballard. With Ballard "locked in" they typically can demand the price they want. A Key Success Factor (KSF) to overcome this issue is to partner with these custom component suppliers as it will provide Ballard with better control of its Supply Chain and the suppliers will feel more motivated to look for more cost-effective solutions.

**Substitutes:** There are direct substitutes that are less expensive than fuel cells and they have been in the industry for a longtime. However, due to rising costs of fossil fuels and environmental impact concerns they are becoming less attractive. Electric Trolleys are the only viable zero-emission substitute but they are very expensive and the need to install overhead catenary wire infrastructure is both costly and unsightly.

**Buyers:** Governments are generally the purchaser of transit bus fleets. As such, they have tremendous purchasing power. Governments are motivated in bus purchases by factors beyond

basic economics, such as passenger comfort, environmental sustainability or aesthetic appeal. In jurisdictions where government subsidizes the purchase of transit buses, transit operators will purchase more expensive buses providing government will offset the incremental cost of the more expensive alternatives. Operator and Technician training, spare parts inventories and enhanced service expectations by riders create high switching costs for buyers once they have converted to fuel cell bus fleets.

Industry Competitors: There are only 2 viable fuel cell bus competitors (United Technologies Corporation, Hydrogenics) both of whom have much smaller market share than Ballard.

Governments: Government support is a Key Success Factor for this segment to be successful. The influence can come from Zero emission regulations, incentives to run clean energy products and the provision of subsidies for technology research and transit bus fleet deployments.

Complements: The existence of a hydrogen fueling infrastructure is a Key Success Factor. Hydrogen can be produced through steam reformation of natural gas or in a completely renewable fashion through the electrolysis of water using either hydro-electric, wind or solar generated electricity. Hydrogen can be converted to liquid form to increase its energy density for cost-effective fuel transport.

From Porter's analysis of the competitive landscape the most significant market pressures facing Ballard come from substitutes and governments. Substitutes represent the incumbent technology solutions currently used to provide propulsion power for transit buses. Governments provide purchasing and operating subsidies as well as regulations that may restrict transit operators' future choices to enable the introduction of zero emission fuel cell buses in transit fleets.

## **2.1 Key Success Factors**

Ballard's success in the fuel cell bus market segment is dependent on five Key Success Factors:

1. Price: Ballard will have to reduce the cost and improve the durability of fuel cells to compete with incumbent technologies, absent of government regulation or subsidies.
2. Zero Emissions: Zero emission regulations for urban transit bus fleets are critical.
3. Partnerships: Ballard will need to form strategic partnerships with manufactures and operators and create joint ventures to ensure market penetration.

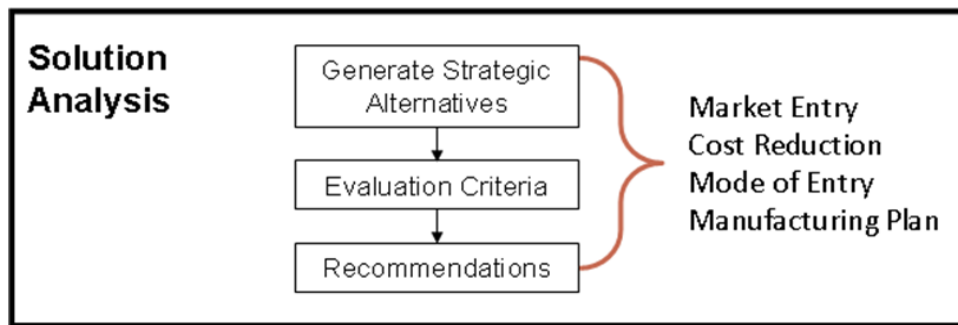
4. Hydrogen Availability: Ballard's expansion strategy should focus on areas where it hydrogen is readily available, cost-effective and can be safely transported.
5. Government Support: Environmental awareness and focus by governments is critical to support early deployments of fuel cell bus fleets.

These Key Success Factors should be used by Ballard to focus their resources and efforts in the most effective way to support the development of fuel cell bus markets. They should form the basis of both short-term tactical and long-term strategic marketing plans.

### 3.0: Solution Analysis

A Solution Analysis is necessary to understand the regional market challenges that Ballard must overcome in each of the Americas regions (i.e. Canada, USA, Mexico and Brazil) covered in this study. The regional differences will be compared and contrasted to develop a prioritized regional market entry plan.

Figure 3: Solution Analysis Framework



### 3.1 Market Entry

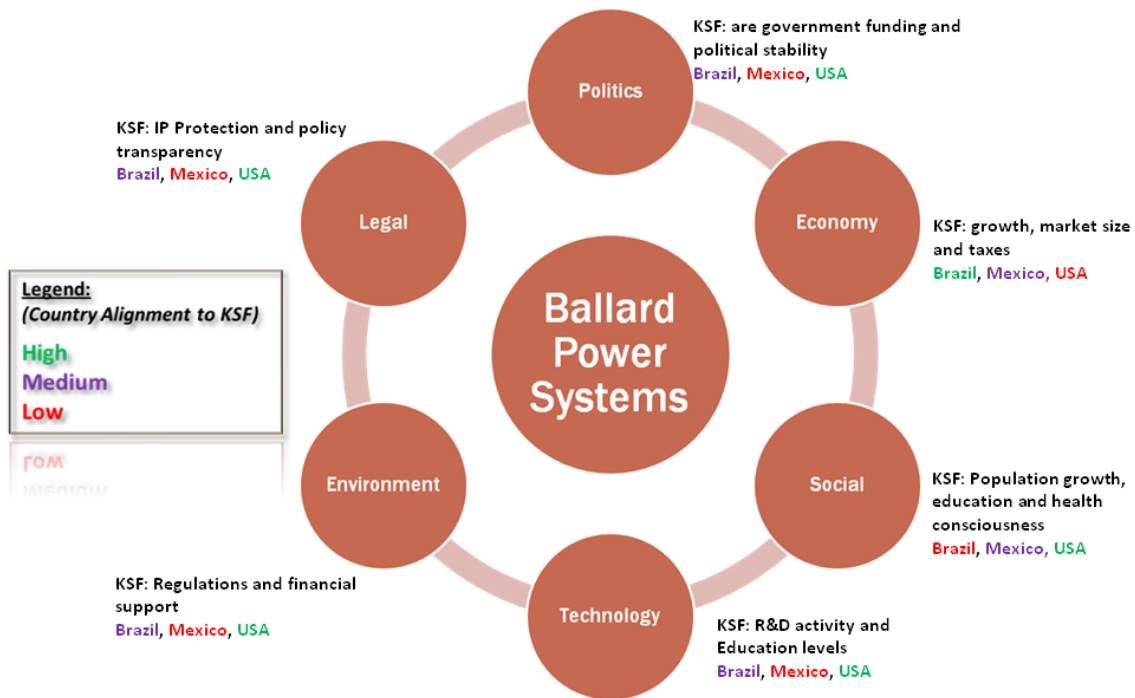
PESTEL Analysis<sup>2</sup> was utilized to evaluate the differences within the Americas regions to determine which environments would be most conducive to Ballard’s fuel cell bus marketing efforts. For each region the following criteria were examined and compared:

- **P**olitical: Government commitment for fuel cell technology exists in USA and Brazil as demonstrated by existing subsidies, regulations and pilot programs.
- **E**conomic: All of the countries studied have a large economy with similar projected GDP growth of 1% except Brazil whose projected GDP growth is 4%, however, Brazil has the worst ranking in regard to the ease of doing business.
- **S**ociocultural: There are significant differences amongst all of the countries studied ranging from cultural influences to economic measures of social mobility.

<sup>2</sup>PESTEL –analysis.com and The Global Competitiveness report 2011

- **T**echnological: Technical readiness and innovation are more prominent in the US and Canada, with Mexico lagging.
- **E**nvironmental: All of the countries studied demonstrate environmental commitment through various regulations but Mexico lags in adoption of alternative energy use.
- **L**egal: Legal infrastructure in Canada and USA allows for protection of intellectual property, while all countries have laws to promote environmental protection.

Figure 4: PESTEL Analysis Summary



Based on the PESTEL Analysis it was determined that Ballard should expand to the USA, then Brazil due to its GDP growth, political and legal aspects.

CAGE Analysis<sup>3</sup> was also used to supplement the findings from the PESTEL Analysis. CAGE evaluates the different regions by examining their Cultural, Aministrative, Geographic and Economic distances from Ballard situated in Canada.

Table 4: CAGE Analysis Summary

	USA	Mexico	Brazil
<b>Cultural distance</b>			
Language: English	English	Spanish	Portuguese
<b>Administrative Distance</b>			
Trade Bloc: NAFTA	NAFTA	NAFTA	MERCOSUL/BRICS
Government Support			
Currency: CAD	USD	MXN	BRL
Colony/Colonizer: UK	UK	Spain	Portugal
Corruption: 5.22 <sup>*</sup>	4.5	1.98	2.22
Legal Origin: UK	UK	France	France
<b>Geographical Distance</b>			
Distance	548	3,267	8,191
Land Area (9,984,000 sq. km)	9,826,675	1,964,375	8,514,877
Population (34 Million)	311	110	192
<b>Economical Distance - 2009</b>			
GDP Per Capita (46,215)	47,287	9,566	10,816
Real GDP Growth Rate: 1%	1%	1%	4%

\* Corruption Index indicates Transparency International Corruption Perceptions Index Score (Higher Score Indicates Less Corruption)

Favourable

Unfavourable

From the CAGE Analysis it was determined that Ballard should expand to the USA due to its CAGE proximity, then Brazil due to its growth rate & BRIC membership. Based on both PESTEL and CAGE analysis each of the Key Success Factors was evaluated to determine its ranking within each region.

<sup>3</sup>CAGE - Strategy and the Business Landscape – Pankaj Ghemawat - Third Edition

Table 5: KSF Regional Ranking Summary

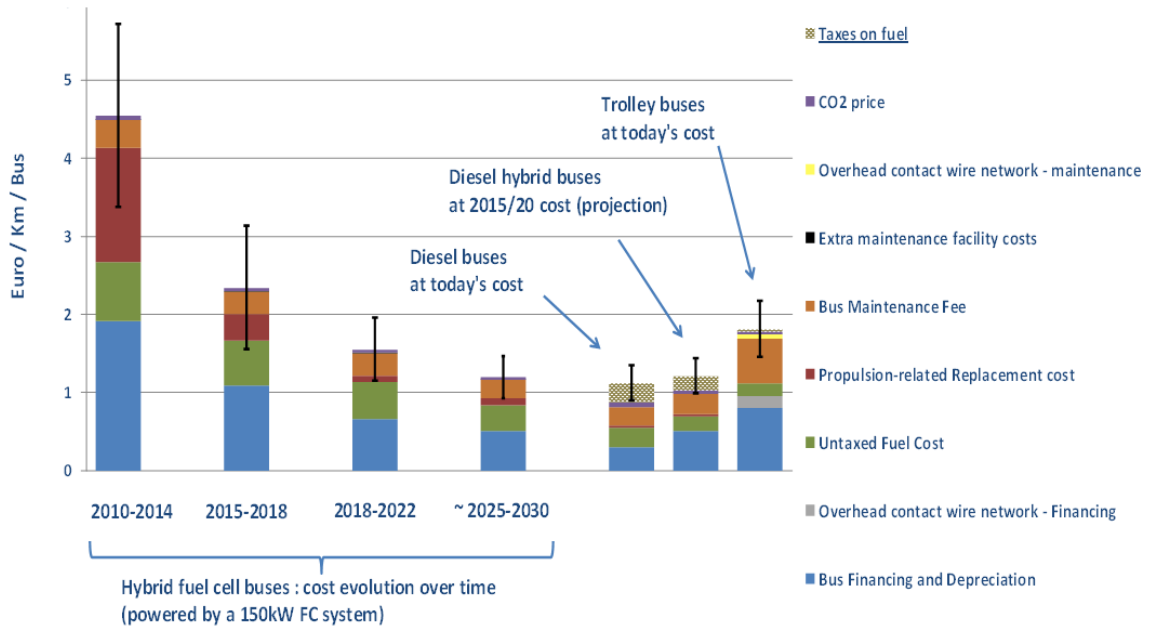
Key Success Factors			
FACTORS	USA	BRAZIL	MEXICO
HYDROGEN AVAILABILITY	√	√	X
PARTNERSHIPS	√	√	√
PRICE/GDP	√	√	√
GOVERNMENT SUPPORT	√	√	X
ZERO EMISSIONS REQUIRMENTS	√	√	X

Based on the results derived from both the PESTEL and CAGE analyses, it is clear that Ballard should focus its fuel cell bus marketing efforts on the US and Brazilian transit bus markets. At this time Mexico should not be included near-term fuel cell bus market expansion strategy.

### 3.2 Cost Reduction

To achieve commercialization Hydrogen Fuel Cell Buses need to be financially competitive with incumbent drive train technologies such as diesel hybrid buses. Today, Ballard directly influences only 25% of cost of the entire fuel cell bus. In the near term the Total Cost of Ownership (TCO) is projected to decrease through fuel cell cost reduction, improvements in durability and access to equipment purchase financing.

Figure 5: Total Cost of Ownership Projections<sup>4</sup>



Currently raw materials used in the production of fuel cells are manufactured in very small quantities using specialized production processes. This results in high direct material costs until market adoption volumes can create sufficient demand to realize true economies of scale and associated cost reductions.

Access to affordable hydrogen is a key success factor. Los Angeles and São Paulo are both sites of significant market adoption opportunities with both cities planning significant fuel cell bus fleet deployments in the near future. Both cities also have existing hydrogen infrastructures that will support local market adoption.

Ballard should focus its development efforts on enhancing fuel cell durability and lowering manufacturing costs. This can be accomplished by implementing simpler standardized manufacturing processes, increasing synergies in fuel cell stack product platforms/applications, lowering labour costs and lowering component costs through strategic sourcing and alliances.

### 3.3 Mode of Entry

Ballard's comparative advantage lies in the manufacture of fuel cells, therefore, to be successful in the current business model alliances and potentially joint ventures will be necessary

<sup>4</sup>Hydrogen Fuel cell Bus technology (NEXTHY LIGHTS, Feb 2011)



for market penetration. To successfully deploy fuel cell bus fleets Ballard partners with System Integrators, Bus Manufacturers (OEMs) and Transit Operators. Since each of these value chain partners gains financially from the deployment of fuel cell buses, they also represent good prospects for strategic alliances.

*Figure 6: Fuel Cell Bus Market Value Chain*



Strategic alliances may take the form of formalized partnerships or joint ventures. These alliances will enable Ballard to overcome market entry barriers, assist in securing government support and gain access to local supply chain resources.

Local partners in geographic markets will be more persuasive in lobbying local governments for support. They will have better access to government-sponsored local tax incentives that will help to lower overall fuel cell bus costs. Trade tariffs can often be reduced by increasing local content in products. Government agencies become more supportive if they see the potential for increased political capital associated with localized projects that improve the environment, create jobs and transfer technology into the region.

For successful market entry, Ballard should form strategic alliances with key local value chain partners such as:

USA:

- BAE Systems for hybrid drive system integration
- New Flyer Industries for bus coach manufacturing

Brazil:

- Tuttotransporti for hybrid drive system integration
- WEG Power Train for hybrid drive component supply
- MAN for bus chassis manufacturing
- Marcopolo for bus coach manufacturing

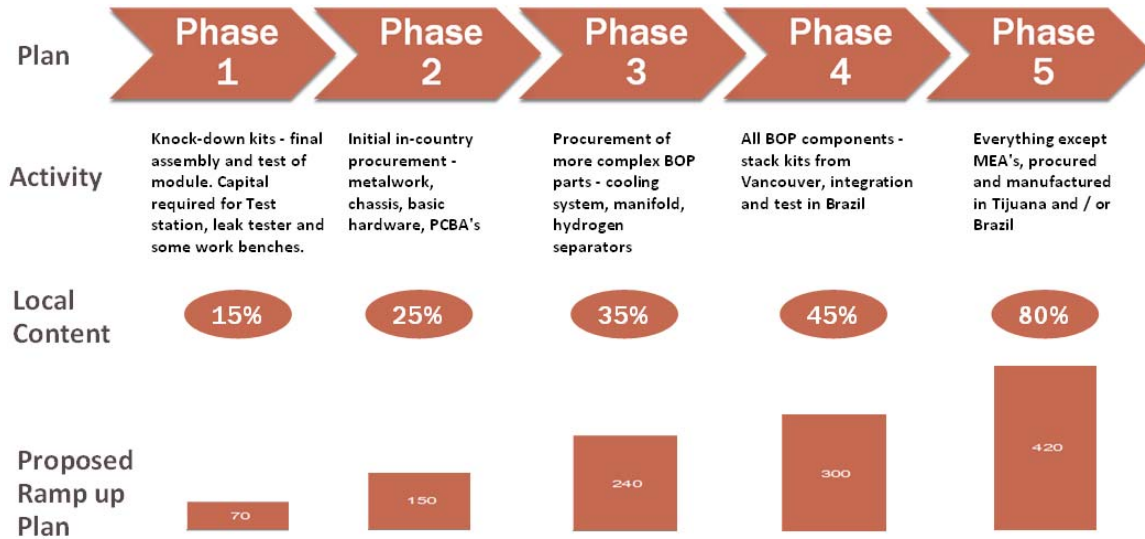
### 3.4 Manufacturing Plan

The correct manufacturing plan must:

- Meet product local content requirements to avoid costly trade tariffs
- Develop a local supply chain to reduce component and shipping costs
- Gain government support through the creation of local jobs

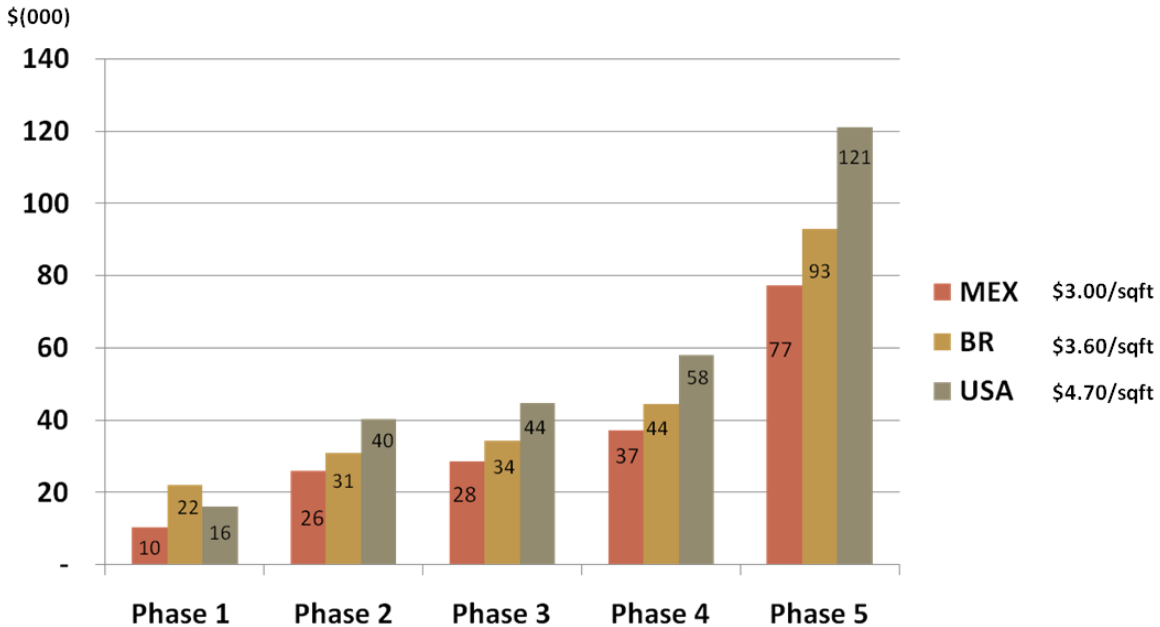
Simultaneously, the manufacturing plan must minimize Ballard’s financial exposure if the market does not develop as expected. A phased approach to the introduction of local manufacturing can provide the desired outcomes while minimizing Ballard’s financial risk.

Figure 7: 5-Phase Manufacturing Plan



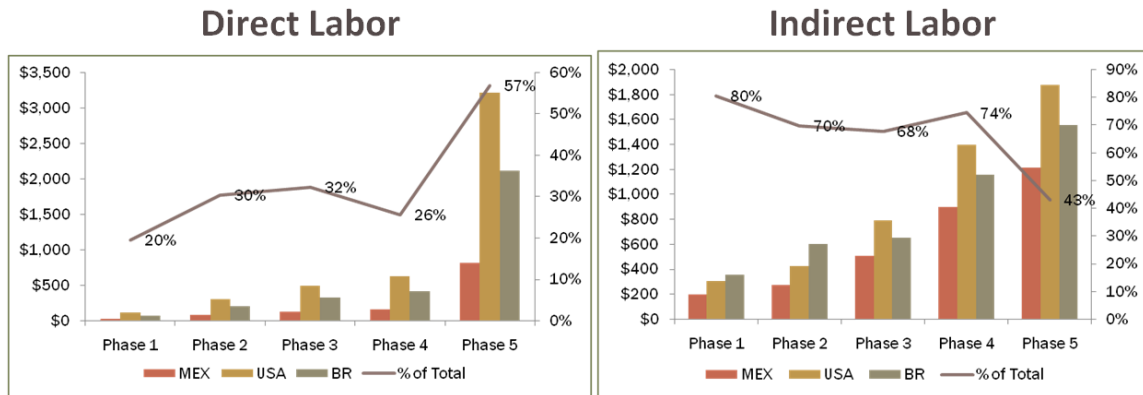
Comparative manufacturing costs have been evaluated for each of the primary regions being considered. Based on proposed space needs for each manufacturing phase, Mexico’s lower real estate cost would be favorable for Ballard.

Figure 8: Manufacturing Facility Cost Comparison



Of the three locations, USA has the highest labour costs and indirect cost is on average 75% of total cost for all the countries.

Figure 9: Manufacturing Labour Cost Comparison



Country	Direct Annual Salary (Hourly Rate)	Indirect Annual Salary
Mexico	\$8,256 (4.00/hr)	\$39,052
USA	\$27,000 (15.00/hr)	60,500
Brazil	\$17,712 (10.39/hr)	50,143

Mexico has a higher return on investment due to its favorable labor and real estate investments costs. As a result, it is in Ballard's best interest to manufacture its fuel cell products in Mexico unless there is a need to localize manufacturing in Brazil in order to gain local government support, access to local financing or to avoid trade barriers.

## **4.0: Conclusions & Recommendations**

To improve profit margins and maintain its market leadership position, Ballard should pursue the significant growth opportunities in the USA and Brazil while monitoring government commitment in Mexico.

To improve profitability and maintain industry leadership, Ballard will need to address five key success factors:

1. Fuel Cell Bus Price
2. Zero Emissions
3. Strategic Partnerships
4. Hydrogen Availability
5. Government Support

Both PESTEL and CAGE analysis indicated Ballard should focus its fuel cell bus marketing efforts on the US and Brazil but not Mexico for its near-term expansion strategy. Ballard should enhance fuel cell durability and lower manufacturing costs by increasing synergies in product lines, standardizing manufacturing and lowering labor and component costs. For successful market entry, Ballard should form partnerships with strategic local players within the value chain. Ballard should implement a five phase manufacturing plan that will generate highest ROI while building local capability and increasing local content.

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