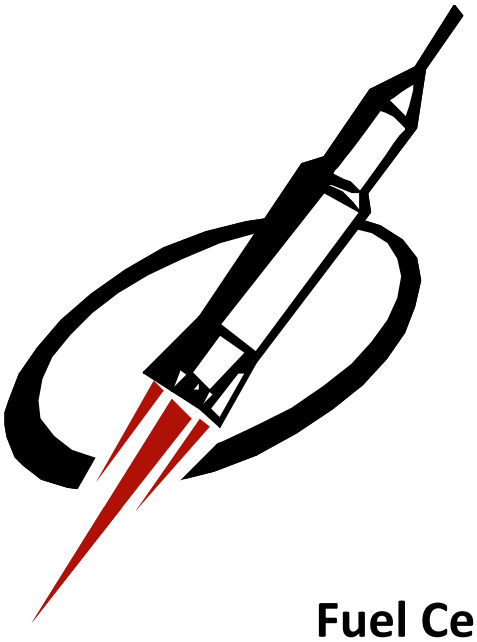

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Executive Summary:

Fuel Cell Technology Applications and Early Commercialization in the Construction Industry

Executive summary of key findings and recommendations of a market research study on go-to-market challenges and opportunities for Fuel Cells in the construction sector.

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AUTHOR INFORMATION

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BACKGROUND

The use of fuel cell technology in the construction industry is faced with many commercialization challenges ranging from product-market fit to barriers to adoption.

Although many potential applications for fuel cell technology have been researched in the past, this research project has examined the commercialization issues surrounding specific applications in the construction industry.

Fuel cell technology has potential as both an enabling technology for tools in the construction process and as a potential new component in new building developments. This project has focused on the potential for stationary units installed as part of building infrastructure.

RESEARCH APPROACH

The research was designed based on a number of assumptions. Rather than be overly consumed with questions of whether a particular system can work, we decided to assume that suitable systems could be made operational today and designed the research to focus on getting feedback on a "straw man model" we conceptualized based on case evidence of successful demonstration projects.

Secondary research was employed to validate our assumptions, examine geographic requirements and regulations, and to model market requirements. The majority of effort was applied to primary research that leveraged a broad range of stakeholders ranging from researchers, commercial vendors, investors, market analysts, utilities, systems integrators, construction specifiers, and building developers. These research interviews were designed to assess attitudes and seek specific opinions on market potential and market requirements while asking for feedback on the straw man model.

KEY FINDINGS

MARKET SITUATION

The construction industry has needs that can be fulfilled by fuel cells. The major applications for fuel cells in the construction industry are:

- On-site portable power during construction
- Stationary power as part of the infrastructure on the building
    - Retro-fit
    - New Construction

Greater integration into building infrastructure would be of great benefit to reduction of green house gas emissions. To date, only a small number of construction projects have featured fuel cell deployments. Examples of current market initiatives are the Ballard 1 KW units sold to individual home owners in Japan, the 10-30 KW units sold by Hydrogenics as back-up power units for Data Centres. Interviews with specifiers and developers revealed low awareness, unclear sales channels, too much perceived risk and complexity, and high perceived costs.

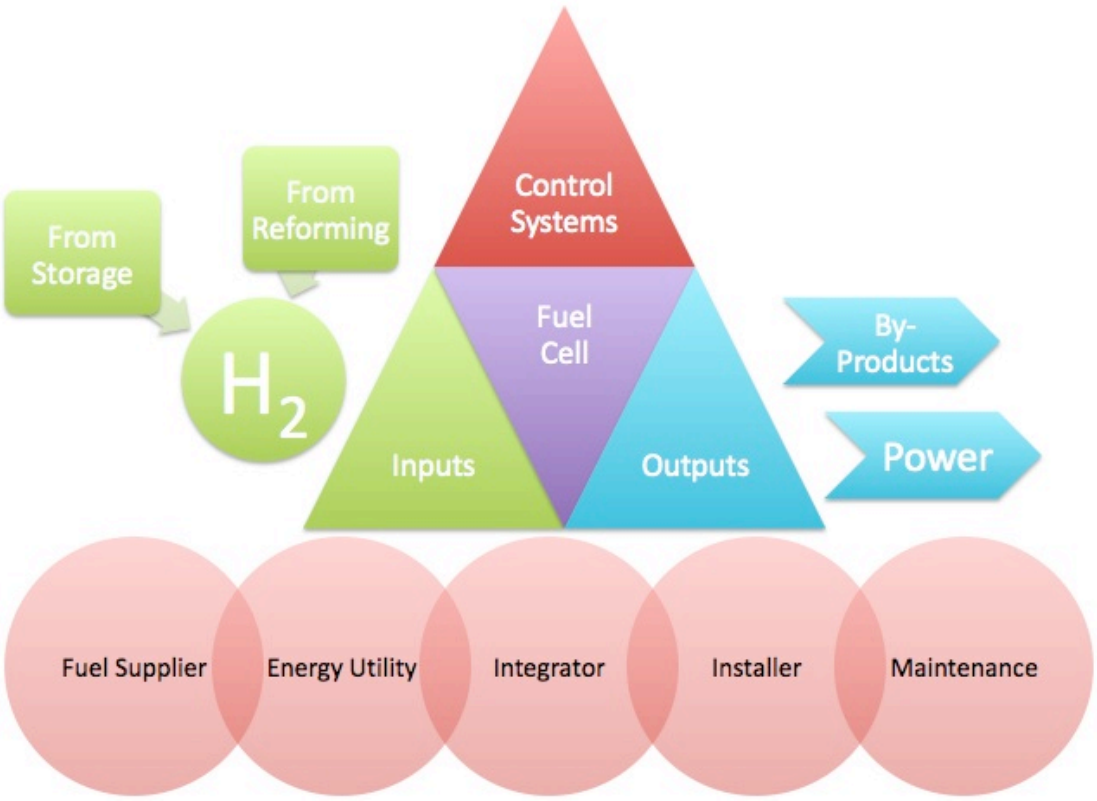
The fuel cell industry has followed a typical "hype cycle" pattern. The "hype cycle", popularized by analyst firm Gartner, is based on the premise that the benefits of emerging technologies are overestimated in the short term, that broad adoption takes much longer than expected, and that long term benefits and transformative impacts are underestimated.

Figure 2.0 Fuel Cell Attributes and Byproducts

	Power	Hot Water	CO2	Lower GHG	Carbon Credits	Energy Storage	Natural Gas	Smart Grid	Back-up	Low Cost
House	x									x
MUR	x	x							x	x
Swim Pool	x	x		x	x				x	P
Hockey Rink	x	x		x	x				x	P
Com Centre	x	x		x	x				x	P
Data Centre	x			x						P
Green House	x	x	x	x		M	x	x	x	P
Utility	x	x		x	x	x	M	x	x	x
Utility Remote	x	x		x		x		x	x	
Cell Towers	x					x			x	
Hybrid	x					x				x

M= May be desirable P = Partial – not the sole motivator

The whole product, meaning the complete offering a buyer will consume, can be defined by a model. Below is schematic desribing the key "conceptual" components of a "complete solution":



RECOMMENDATIONS

KEY RECOMMENDATIONS

Our key recommendations are as follows:

- Further study - more research needs to be done into precise market requirements and corresponding technical requirements for the commercialization roadmap described in this report
- Well defined assessment of business cases for fuel cell applications - by standardÉzing a method of defining the business case for a fuel cell application, we can greatly simplify go-to-market decision making and define benchmarks for commercialization or demonstration project funding
- Incentives to develop fully integrated products and services - to open up wider market opportunity for fuel cell applications, the market requires fully integrated products and services to overcome key adoption barriers
- Utility and government collaboration to define managed service business models for fuel cell applications and fuel cell hybrid applications - as proven by Solar solutions adoption, a well defined product-service bundle with business models supported by "managed services" subsidized by both utilities and government is required for wide adoption
- Budget for Demonstration Projects - market validation is the key commercialization step that can help facilitate adoption at this stage and can define the metrics that future business models require for mass market product-service bundles

gains from new technology when the off the shelf 'appliances' required by consumer markets are not yet available.

Initial opportunities require a motivated utility that has defined ROI criteria for deploying new technologies and access to customers. They are an integral part of any potential deployment.

The energy utilization context is an important consideration when defining key market segments. There are a number of applications that define specific segments for fuel cell adoption. Examples include:

1. Remote Communities – Grid disconnected or independence from the grid as fuel cells reduce utilization of high cost alternatives such as diesel fuel (Hydro NIA is an example)
2. Partial Grid Disconnect – Fuel Cells can increase total capacity, reduce demand on the grid and smooth demand during peak periods.
3. Energy Storage – Fuel Cells may be part of hybrid solutions that store hydrogen electrolyzed using energy from other intermittent green technologies such as wind, solar or run of river
4. Back-up Systems – Fuel cells meet back-up requirements and also contribute to partial grid independence

As discussed above, the key market segments for near term opportunities (aka. early adopters) are defined by large energy capacity requirements and ability to support integration and ongoing maintenance. These early adopters will have longer-term ROI criteria and the capability to assemble and integrate the required components. The scale of these deployments means any integration is easily offset by the returns of the larger scale deployment. The actual fuel cell stack is only a portion of the cost of the full installation as reformers, electrolyzers and micro grid control systems are also required. A 100 KW fuel cell costs marginally more than a 50 KW system. These early adopters are Utilities, Greeenhouse Operators and Municipal Facilities.

Utilities

Powertech is the major integrator for the Bella Coola installation and they run a fleet of fuel cell powered vehicles and have integrated solar power and other hybrid solutions in the past. They will use the Bella Coola demonstration project to prove that they can integrate fuel cells of up to 1 MW as they become available.

BC Hydro measures ROI for power generation using a twenty year calculation. This is far longer than the normal three to five years that most industries use for capital investment decisions.

Utilities are a top potential customer for deploying fuel cells and a strong and trusted partner for commercialization funding. Powertech is a key enabler for accelerating commercialization of fuel cells.

On April 9, 2009 the Connecticut Department of Public Utility Control (DPUC) issued its final decision approving 27.3 megawatts (MW) of projects incorporating FuelCell Energy Power Plants. The sales value of the projects will be $84 million when project developers finalize electricity purchase agreements and project financing for the nine FuelCell Energy DFC3000 power plants. FuelCell Energy has over 50 deployments of itó stationary fuel cell plants worldwide.

Greenhouse Operators

The greenhouse industry has a number of features that make it a prime market for fuel cell deployments. They use many of the byproducts from fuel cells. Both power and hot water are desirable so they can utilize the higher efficiency from the hot water generated. Many currently reform CO2 from Natural Gas or purchase it for growing plants so they can utilize the CO2 generated when H2 is reformed from Natural Gas for the fuel cell. The gas utility in BC, Terasen, currently supplies many greenhouse operators.

Many are located in urban environments so reducing emissions is important and fuel cells can replace other green house gas emitting energy sources. They also have emergency back-up power needs and infrastructure capability.

Greenhouses are a primary market as they meet many of the criteria for deployments and the BC Greenhouse Growers Association has been open to fuel cells in the past.

Municipal Facilities

Swimming Pools, hockey rinks, community centres and other portions of the municipal market are similar in size to many Greenhouse operations. Except for CO2 their requirements are similar. They have engineering and maintenance capability and are motivated by carbon credits and Leeds building certification programs.

Their infrastructure capability is less than the greenhouse operators but they are motivated to reduce greenhouse gas emissions and meet certification standards.

COMMERCIALIZATION ANALYSIS

Beyond the typical "early market" issues of knowledge and awareness, the fuel solutions in the construction industry face a number of barriers to adoption. These barriers can be summarized as high cost, complexity of integration, suitable energy capacity, practical and cost effective fuel supply, management of by-products, unclear regulatory approval processes and lack of regulatory incentives or requirements. Overcoming these barriers requires cooperation between industry and government and a clear roadmap to make these cooperative efforts effective at accelerating adoption.

The following diagram show potential accelerators of adoption relative to the barriers we identified:

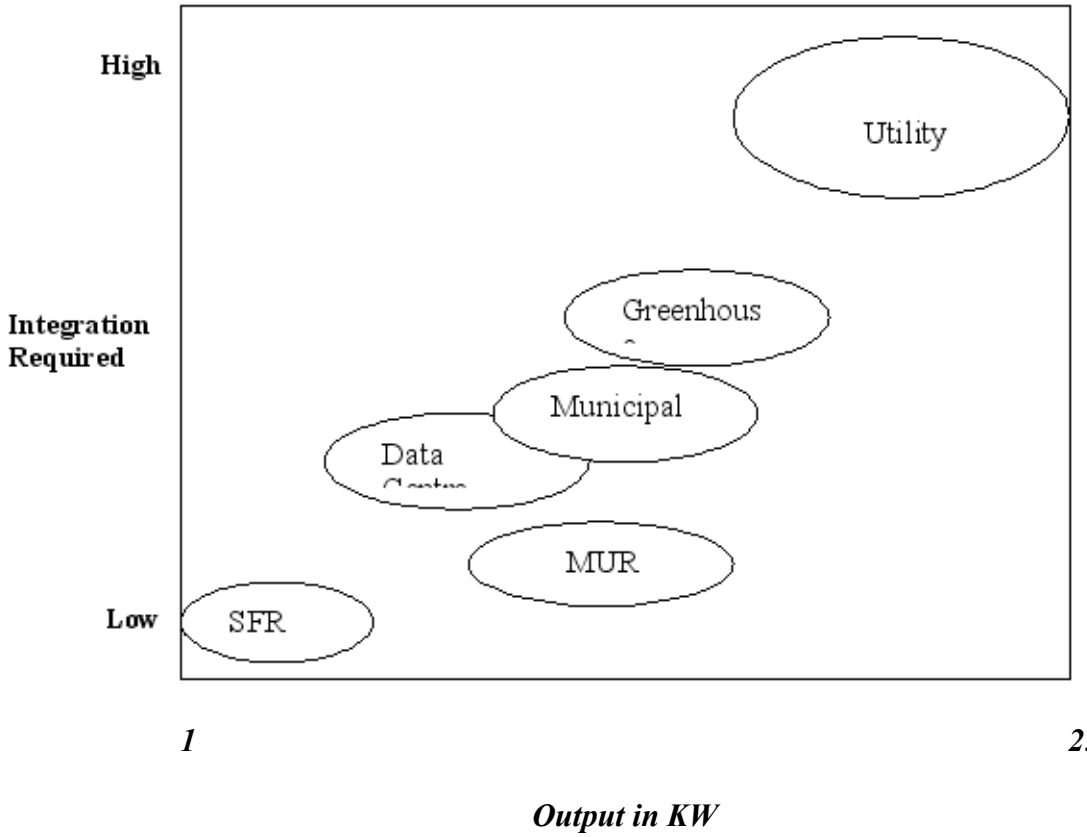
Table 1 – Barriers and Accelerators for Fuel Cell Commercialization

	Barriers	**Accelerators**
I	Cost - alternative costs (diesel) - business model	Offset Credits Demonstration Project Funding Monthly cost versus Capital cost
II	Integration - Lack of control systems	Experienced, capable integrators Scalability in demo projects Micro grid control systems Retrofit
III	Capacity	Integrated Products - retrofit Scalable Demonstration Projects
IV	Gas Supply	Utility participation in selected target markets

	- Natural Gas - Propane Hydrogen Fuel Costs	Hybrid Solutions Energy storage Retrofit
V	Byproduct non-utilization - Hot water - CO2	Byproduct Usage - Heat exchangers
VI	Low Carbon Trading	Greenhouse Gas emission reduction initiatives Carbon credit trading
VII	Regulatory Approval	Utility participation in Demonstration Projects
VIII	Hydrogen Storage	Hybrid Solutions

Understanding the product-market fit is an important pre-requisite to commercialization planning. Part of this "fit" is the energy required (output in kiloWatts) and another part is the integration required for "complete solution". The following schematic displays a number of potential markets on a graph comparing fuel cell size and infrastructure or integration capability. A key finding was that the market needs significantly more service integration than product integration at this time. It is important to note that as more integrated products come to market in the coming years, this schematic chart would change considerably.

Figure 1.0 Fuel Cell Size versus Infrastructure and Integration capability - 2009



Product features are a key aspect of commercialization as well. In addition to obvious needs for easy integration (especially in retrofit use cases) and other technical features, we identified several attributes and by-products as potential feature set contributors that could have significant impact on adoption.

Different attributes and by-products of fuel cells and features are valued by different markets.

- By-products
    - Power
    - Hot water
    - CO2
- Green House Gas Emission reduction
    - Carbon credits
- Energy Storage Capability (Hydrogen Gas)
- Natural Gas as the fuel source
- Smart Grid systems
- Emergency Back-up Power requirements
- Low Cost

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Data Centre	x			x						P
Green House	x	x	x	x		M	x	x	x	P
Utility	x	x		x	x	x	M	x	x	x
Utility Remote	x	x		x		x		x	x	
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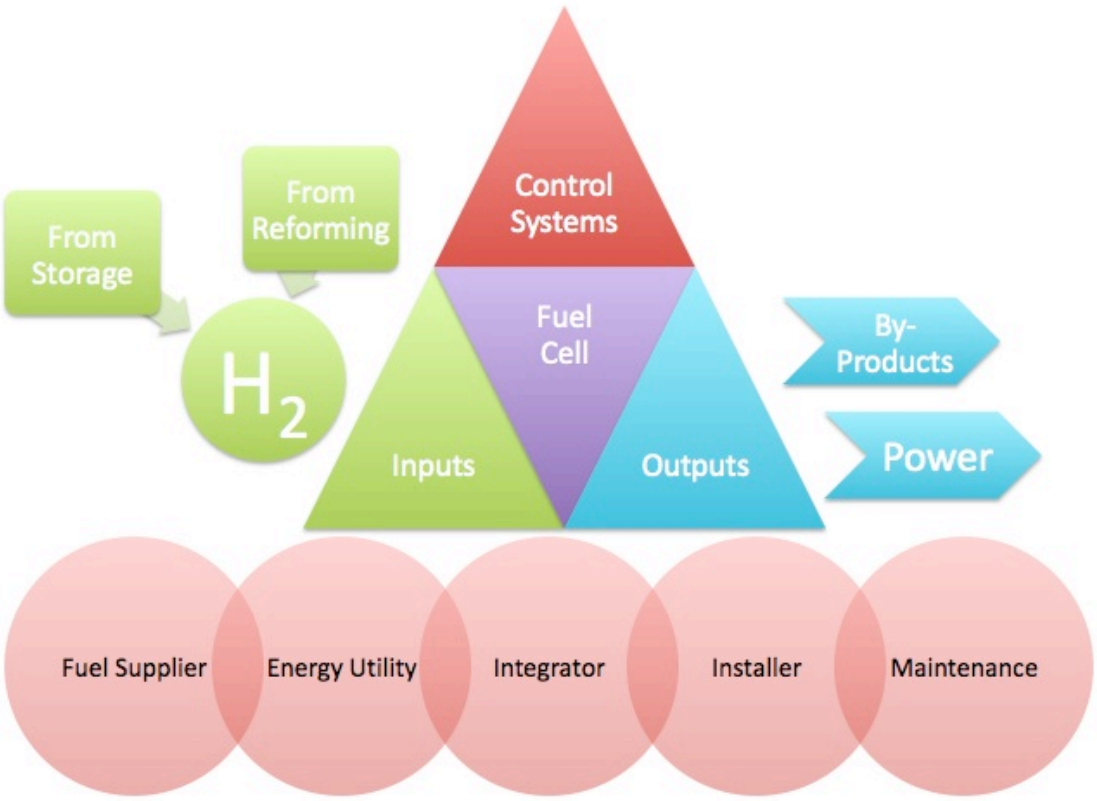

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NRC AS CATALYST FOR PARTNERSHIPS

NRC/IRAP and other partners can accelerate the commercialization of fuel cells. The largest impact would be from heavily subsidized demonstration projects supported by a number of important industry players.

Participants could include:

- End customer
- Utility – Terasen or BC Hydro
- ROI criteria from utilities such as Terasen and BC Hydro
- Powertech Labs – Integration and Micro grid technology
- Engineering Firms – Site survey and Leeds certification
- Municipal Government – Customer and carbon credit authentication
- SDTC & ICE Fund - Finance
- Fuel Cells Canada & IFCC – Lobbying
- Fuel Cell manufacturers – products and components

IMPORTANCE OF DEMONSTRATION PROJECTS

NRC/IRAP should initiate a series of demonstration projects. They should target proving the reliability and scalability of fuel cells in specific markets. Each successive deployment would feature greater fuel cell stack efficiency, lower integration requirements and reduced cost.

The commitment to the projects should mirror the commitment by the gas utility in Japan to the residential market. It needs to be for four to five years with potential for renewal if targets for deployments are met in the last three years of the program.

The demonstration projects should start with larger installations in the Utility market. Powertech is a key component in initiating a series of effective demonstration projects. They can leverage their expertise from fuel cell vehicles, the Bella Coola project and other alternative energy solutions. The GE micro grid software would initially be accessed through Powertech Labs.

The number of demonstration projects should increase each year as the cost for successive projects decreases. The Bella Coola project budget is estimated at $ 7 M and it is anticipated that a second similar project leveraging recent experience would close to halve the cost.

Deployments in Multi-Unit Residential and eventually in Single Family residential would follow after the commercial and municipal markets demonstrate that infrastructure requirements are manageable and reliable.

Many deployments should be positioned as partially grid disconnected where the fuel cell also meets back-up requirements and reduces demand on the grid.

Regulatory issues would be addressed via the demonstration projects. The projects will require integration and the partners will include competent engineering firms

and utilities that can meet and define code as the projects progress. Building code and regulatory frameworks will be an important byproduct of the demonstration projects.

CONCLUSIONS

This research report makes recommendations for improving the commercialization success for fuel cell technology in the construction industry. Among the many recommendations to overcome barriers to adoption, the largest commitment recommended is to support demonstration projects to provide needed market validation and to improve collaboration and cooperation between industry, Utilities and Government. A budget of 15M to 20M is necessary for the full support of this demonstration project initiative.

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Rocket Builders is a consulting group focused on helping technology companies identify and capitalize on market opportunities. Based on past success in driving the growth of technology companies, Rocket Builders are experts in market research and strategic planning and helps companies in building revenue through proven sales methodologies, building market capabilities through partnering programs, and building processes that lead to winning products. For more information, visit http://www.rocketbuilders.com.

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