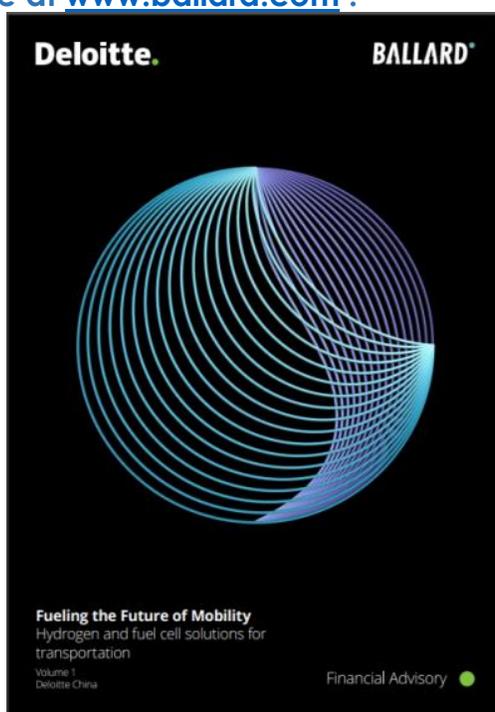


# ALPHADIRECT MANAGEMENT SERIES

MARCH 17, 2020

**PART I INTERVIEW – REGARDING THE DELOITTE CHINA & BALLARD POWER SYSTEMS JOINT WHITE PAPER “FUELING THE FUTURE OF MOBILITY: HYDROGEN AND FUEL CELL SOLUTIONS FOR TRANSPORTATION”.**

In Part I of this interview we review the white paper “*Fueling the Future of Mobility: Hydrogen and fuel cell solutions for transportation*” with Dr. Kenneth DeWoskin, Senior Advisor to Deloitte. The white paper is available for download from Ballard’s website at [www.ballard.com](http://www.ballard.com).



## THE ALPHADIRECT INSIGHT

The Deloitte China-Ballard joint white paper, published in 01.2020, focuses on TCO analysis of mobility applications. The white paper encompasses various transportation use cases in different parts of the globe, providing detailed cost comparisons between fuel cell electric, battery electric and internal combustion engine solutions. The white paper concludes that fuel cells will be the lowest-cost solution available within this decade, and sooner than previously expected. In this interview we review the implications for Ballard and the overall fuel cell sector. As with most technology, cost reduction is a significant factor in driving wide scale commercial adoption, with fuel cell technology already having been proven highly efficient and effective for certain transportation use cases.

## BLDP Business Snapshot

**Founded:** 1979  
**Headquarters:** Burnaby, Canada  
**Ticker:** BLDP (NASDAQ/TSX)  
**Stock Price:** USD\$7.85\*  
**Market Cap:** USD\$1.85B\*  
**Website:** [www.ballard.com](http://www.ballard.com)  
\*As of March 16, 2020



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## Participants

### **Dr. Kenneth J. DeWoskin, Ph.D** **Founder, China Research and Insight Center and Senior Advisor to Deloitte**

Dr. DeWoskin is a former partner for China Strategy and Business Development at one of the Big Four, founder of Deloitte's China Research and Insight Centre, and now serves as a Senior Advisor and Eminence Fellow to Deloitte for China research and insight. He concurrently serves as Senior Advisor to The Conference Board China Center for Economics and Business, is a former professor of International Business and chairman & professor of Asian Cultures at the University of Michigan. Dr. DeWoskin has been involved with China for over 50 years and has lived and worked extensively in both China and Japan. Dr. DeWoskin received his B.A. from Columbia College in 1965 and his Ph.D. from Columbia University in 1974. He has also studied at National Taiwan University and Kyoto University, and is fluent in Mandarin Chinese and Japanese.

### **Mr. Shawn Severson** **Founding Partner** **alphaDIRECT Advisors**

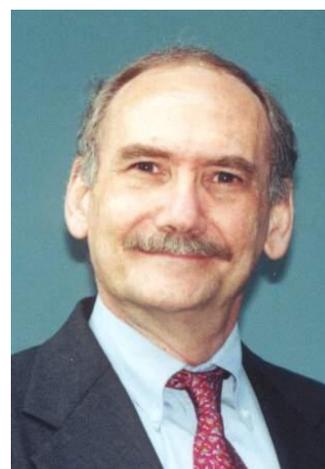
Mr. Severson is the Founding Partner of alphaDIRECT Advisors (ADA), a division of EnergyTech Investor, LLC (ETI). He has over 20 years of experience as a senior research analyst covering the technology and cleantech industries. Prior to founding alphaDIRECT Advisors, he led the Energy, Environmental and Industrial Technologies practice at the Blueshirt Group. Mr. Severson was frequently ranked as a top research analyst including one of the Wall Street Journal's "Best on the Street" stock pickers and multiple awards as Starmine's top three stock pickers.

## ABOUT BALLARD POWER SYSTEMS

Ballard a Canadian public company headquartered in Vancouver, British Columbia and is listed on both NASDAQ and the Toronto Stock Exchange under the ticker BLDP.

The Company's vision is to deliver fuel cell power for a sustainable planet. Ballard zero-emission PEM fuel cells are enabling electrification of mobility, including buses, commercial trucks, trains, marine vessels, passenger cars, forklift trucks and UAVs.

For further information please visit [www.ballard.com](http://www.ballard.com).



*Dr. Kenneth J. DeWoskin, Ph.D*  
*Founder China Research and Insight Center*  
*and Senior Advisor to Deloitte*  
Source: [www.ballard.com](http://www.ballard.com)

**Shawn Severson:** First, I would like to thank you, Ken for taking time to speak with us today. Last time that we spoke with Ballard Power Systems, we discussed Ballard's manufacturing capabilities and production facilities. Today our focus will be on the total cost of ownership (TCO) analysis for fuel cell electric vehicles (FCEVs) versus battery electric vehicles (BEVs) and internal combustion engine (ICE) vehicles. But, before we get started, could you give us a brief introduction of yourself and your position at the Deloitte Asia Pacific?

**Kenneth DeWoskin:** Sure, Shawn. My name is Ken DeWoskin and I am a lifetime student of China and have worked extensively in the Chinese energy and mobility spaces. Even before the reforms began, I went to the Mainland in 1977, and prior to that, I was attending school in Taiwan in the 1960s.

I've had the pleasure to work in this industry for a long time and I watched East Asia, the Asia Pacific region and many economies grow and develop in their own unique ways to become major players in the world. This is especially true in terms of the auto sector, energy consumption, crude oil consumption, other material consumption patterns and similar sectors. I currently work for Deloitte as a senior advisor and consultant and I'm a former partner of PWC, having started their management consulting business in China in 1993 in Shanghai.

A lot has changed since then. China was still eight years away from joining the World Trade Organization in 1993, but countries around the world, including high tech players like Ballard, were becoming interested in China because of the population size, the very organized form of society and the potential market growth. I

am personally particularly interested in the solutions that are emerging from Europe, the United States and Asia Pacific, for some of the world's energy and environmental issues and am delighted to be talking about it today.

**Shawn Severson:** Great, thank you Ken. You recently published a white paper jointly with Ballard Power Systems – can you briefly summarize the report and its main conclusions?

**Kenneth DeWoskin:** Sure, Shawn. The report actually came from discussions we have had with Ballard and other people in this space for many, many years. I have known Ballard now for 5 or 6 years and I was actually interested in Ballard way back when they first started. I have been visiting Vancouver and talking to senior executives and the Ballard board for a number of years now. With this being said, I was very happy to discuss the possibility of working on this white paper.

The volume we just published with Ballard was launched at the Consumer Electronics Show in January 2020 and is the first in a series. This first white paper focuses on mobility applications and the total cost of ownership, or TCO, related to mobility applications. The other white papers are going to expand the framework a little bit, talk about hydrogen more broadly in the context of renewable energy and other applications and advanced societies with strong technological platforms as well as interest in continued sustainable growth and the energy needed to facilitate that growth.

The focus on mobility in this white paper looks at a number of models for understanding TCO, what contributes to it, both in terms of manufacturing the capital

assets involved in hydrogen-fueled mobility compared to lithium battery based electric vehicles and internal combustion engines, including enhanced and modernized internal combustion engines.

The paper looks at the current situation in 2019 in terms of TCO. We are using a very detailed and sophisticated model when looking at the future cost of ownership including crossover lines, with the critical years being 2026 and 2027. The report projects that FCEVs will become the most cost efficient, both in terms of manufacturing and operation in that timeframe. That's really the main conclusion of the report and I think in our discussion, subsequently, we'll get into some of the details.

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***“The report projects that FCEVs (Fuel Cell Electric Vehicles) will become the most cost efficient, both in terms of manufacturing and operation in that (2026-27) timeframe.”***

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**Shawn Severson:** What would you identify as the main benefits of FCEVs relative to conventional gasoline and diesel fuels and have those technologies reached limitations in fuel efficiency and emissions reduction?

**Kenneth DeWoskin:** The first and foremost benefit with hydrogen is that it is the most common element in the world and, in fact, probably in the universe as well if you consider the sun and space beyond our solar system. That's a lot of hydrogen and it is essentially an inexhaustible source of energy.

Based on the detailed case studies available today, we expect the cost to decrease very quickly and significantly as its utilization scales up in various markets around the world. We expect this cost

decrease to affect all players and the entire supply chain in hydrogen, from production to storage to transport to applications to fueling stations.

The main benefits are spread over a set of commercial issues and a set of environmental issues. Nothing else ultimately can compete with hydrogen as a source of energy because the only emission from hydrogen when it oxidizes and is used for production of electricity is water.

Hydrogen is not only extremely abundant, but it is extraordinarily clean, is essentially inexhaustible without any sort of geopolitical risks associated with it like those with crude oil or lithium, chromium, and cobalt and other things that are implicated in alternative models. These benefits are significant and very sustainable. Hydrogen is not going to cease being the most common element in the world and we see that as a fundamental advantage.

The report is very focused on quantitative information that can be distilled from current cases, government policy, current costs of everything along the entire supply chain, but we do make reference in the report to what I would call qualitative issues, which have to do with the environmentally friendly aspects of manufacturing and operating. But again, the quantitative issues, I should say, are the real heart of the report.

**Shawn Severson:** Thanks, Ken. How do you think the various markets will develop for fuel cell electric vehicles regarding commercial medium- and heavy-duty and the passenger vehicle market?

**Kenneth DeWoskin:** In the report we look very specifically at China, Europe with

focus on England, the United States, and Japan. Our focus was on what those countries have done over the last decade and what they propose to do in the future to develop their markets for continued expansion of fuel cell electric vehicles and in a wide range of applications.

When you're talking about various markets there are sort of two ways to parse that. One is looking at the geographies and what's going on country by country in terms of the particular features of their markets, their indigenous energy resources, the current state of technology, the level of government policy and support for the development of FCEVs. In addition, there is the issue of commercial market sectors, passenger vehicles versus commercial vehicles versus special use vehicles, and so on. Our report actually parses all of those issues into various discussions and analytic sections.

Beginning of course with what the central government is doing in terms of promoting and supporting the technology and regulating incentives for mobility applications. In countries like China, of course, central government plays a very strong role in policy development, even at the local level. This is a particularly important model to study because we can see exactly how the planners intend to develop FCEVs in a very visible and explicit way and there is nothing secretive about it. We can anticipate favorable developments in a market like that, driven by the very strong and explicit commitment of the government.

I would say China in particular has some of the leading voices in mobility, including the recently retired Minister of Science and Technology, Wan Gang. Wan Gang has for two decades advocated a focus on

hydrogen as the key energy source of the future. Europe, especially Northern Europe, are also likely to be very strong leaders together with parts of the United States, where they have also addressed energy issues and they will probably be pioneering markets in the continued development and application of FCEVs.

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***“Based on the detailed case studies...we expect the cost (of hydrogen) to decrease very quickly and significantly as its utilization scales up in various markets around the world.”***

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**Shawn Severson:** Let's discuss the total cost of ownership for fuel cell electric vehicles when compared to battery electric and internal combustion. Can you explain the basics of your TCO analysis for the U.S., China, and Europe using the white paper published in January?

**Kenneth DeWoskin:** First we went to look at use cases in various countries. This report was led by a research team in Shanghai. We made this selection because they are deeply involved in what is going on in China in terms of FCEV over in Shanghai and we felt that they were the most informed. However, we wanted to look at cases around the world in various countries to make sure that the report had a global perspective and relevance. Secondly, we wanted to look at cases where there was both a sufficient history and sufficient scale to make the data meaningful and to ensure the projections are well based. Finally, we wanted to look at cases where usage and innovation address some of the early stage challenges, like distribution of hydrogen transport and fueling infrastructure.

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***“So, the crossover point, in terms of the TCO model where FCEVs become less expensive than battery electric vehicles, or BEVs, is going to be in 2026 according to our analysis and fuel cell vehicles will become less expensive... than internal combustion engine, or ICE, vehicles in 2027.”***

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As already mentioned, we believe that these kinds of use cases are and will continue to be pioneering. In 2019, fuel cell electric vehicles run about 40% more expensive than equivalent lithium battery and 90% more expensive than ICEs on a 100 kilometer analysis basis. This is primarily related to the early stage of development of the FCEV vehicles and the rather limited scale at which they're being manufactured and deployed, as well as the long-term infrastructure investment requirements.

So, the crossover point, in terms of the TCO model where FCEVs become less expensive than battery electric vehicles, or BEVs, is going to be in 2026 according to our analysis and fuel cell vehicles will become less expensive on a TCO basis than internal combustion engine, or ICE, vehicles in 2027.

I know that projection may seem aggressive, but we are talking less than a decade away and we feel confident in our predictions.

We believe that this is dependent on commercial dimensions of manufacturing. The importance of this is that it is not something that's going to be driven primarily by government policy, although policy is going to play an important part. There are commercial imperatives that are going to shape and enable these 2026 and 2027 crossover points and I think that's

very important in thinking about TCO scenarios in the future.

The report looks very specifically at TCO issues in China, the U.S., and in Europe and these calculations provide a model that is very detailed with respect to vehicle types and includes purchase costs and of course operating costs based on real operations. We then apply this model to create a current and a future TCO comparison, encompassing FCEVs, BEVs and ICEs for buses in the U.S., China and Europe, for special use vehicles like warehouse forklifts and things of that sort. That is how we arrived at the TCO information, which is the basis for the detailed analysis in the report.

**Shawn Severson:** If we dig into that a little bit and get more granular, can you talk about the use cases that you modelled and studied in each of the geographies, U.S., China and Europe?

**Kenneth DeWoskin:** Of course. Firstly, hydrogen has a very long history as an energy source and not just on the sun, but down here on earth as well. It has a long history as a fuel for mobility, even in aerospace from relatively low-tech applications like dirigibles, for example, to very high-tech applications like space vehicles. The idea that hydrogen is critically important and also a technology-driven energy opportunity is not something that is new but to analyze the applications, we chose three geographies where governments and enterprises have been particularly active, and where they have a very clear, accessible public record of accomplishments and plans.

This led us to the U.S., China and England. We began by looking at the history of hydrogen in these three countries and we also added Japan as well. The U.S. was the

first country in the world to establish hydrogen as a national strategic energy priority and in spite of what's going on today and the current administration, the U.S. continues to be a leader in pursuing these technologies. And, I really should say North America since I would certainly include Ballard as a very important player in this space.

When we thought about these geographies and vehicle applications, we wanted to make sure that we talked about the global relevance and applicability on a global basis. We looked country-by-country over about a two-decade history of discussions, meetings, technological accomplishments, government policy changes and commercial applications and we followed that with kind of a technical discussion of propulsion systems. Although this is not a major focus of the report, we did this as a basis for selecting and analyzing our cases. The relevance of specific use cases really must be related back to the fundamental technology, meaning how the propulsion systems work, how they're likely to be improved in the future, and what the critical issues of cost and scale and safety are. We explored the broad categories of passenger vehicles, commercial vehicles, mass transit applications, and special use vehicles like forklifts and other warehouse conveyance systems.

Worth mentioning is that we don't have a detailed application case for Japan, but they are focused on hydrogen, which again has been very public and well financed, enabling us to include the Japanese data in many of these analyses. Following the discussions based on vehicle types and application, we looked at TCO, as it manifests in specific cases. We choose

three cases, starting with logistics vehicles in Shanghai, China, knowing that e-commerce in China and the delivery of purchases constitutes a very fast-growing portion of total retail in the area. Of course, the fulfilment and delivery capability is a huge driver of mobility expansion and non-passenger mobility expansion. In a city like Shanghai, Beijing or Shenzhen, where e-commerce is huge, the logistic challenges of these enormous cities are particularly interesting to study, because the imperatives to improve logistics are extremely strong.

Then we looked at port-related drayage trucks in Los Angeles and we also looked at transit buses in London, England. It's important that all of the cases studied are commercially viable today. There are special cases with respect to some of the operating costs that drive current FCEV applications to a higher cost level than the competing alternatives, and that are somewhat closed systems. This means that all of them enable concentrated infrastructure investment to be used very efficiently.

Cases like a municipal bus system that can have one or two fueling stations for a fleet, where the storage and transportation of hydrogen is possible, or logistic vehicles operating in a fairly limited municipal space, were selected because they represent very distributed geographies. They represent different economic models, in comparison to China and London, which represents cases that are commercially viable today with a lot of very reliable data available.

**Please click [here](#) to read Part II of this interview  
(available March 24<sup>th</sup>, 2020)**

## SHAWN SEVERSON FOUNDING PARTNER

Mr. Severson founded *alphaDIRECT* Advisors, a division of EnergyTech Investor, LLC in 2016 after seeing a significant communication and information gap developing between small and micro-cap companies and the financial community. Mr. Severson has over 20 years of experience as a senior research analyst covering the technology and cleantech industries. Previously, he was Managing Director at the Blueshirt Group where he was the head of the Energy, Environmental and Industrial Technologies practice. Prior to the Blueshirt Group, Mr. Severson was at JMP Securities where he was a Senior Equity Research Analyst and Managing Director of the firm's Energy, Environmental & Industrial Technologies research team. Before joining JMP, he held senior positions at ThinkEquity, Robert W. Baird (London) and Raymond James. He began his career as an Equity Research Associate at Kemper Securities. He was frequently ranked as a top research analyst including one of the Wall Street Journal's "Best on the Street" stock pickers and multiple awards as Starmine's top three stock pickers.



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