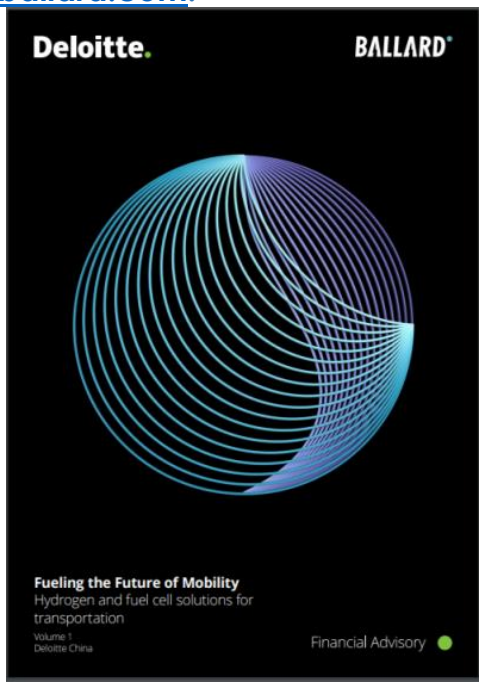
ALPHADIRECT MANAGEMENT SERIES

MARCH 24, 2020

PART II 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 II of this interview we continue with a review of the white paper *"Fueling the Future of Mobility: Hydrogen and fuel cell solutions for transportation"* with Dr. Kenneth DeWoskin, Senior Advisor to Deloitte. To read Part I of this interview, please click here. The white paper is available for download from Ballard's website at 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$7.83*
Market Cap: USD$1.85B*
Website: www.ballard.com
**As of March 23, 2020*

BALLARD

About *alpha*DIRECT EnergyTech Investor

alphaDIRECT Advisors is a Publishing and Investor Intelligence firm that creates and implements digital content and programs to help investors better understand a company's key drivers including industry dynamics, technology, strategy, outlook and risks as well as the impact they could have on the stock price. alphaDIRECT's expertise encompasses a variety of sectors including Clean Transportation, Emerging EnergyTech, Energy Services, Smart Buildings, Solar, Water Value Chain and Industrial. alphaDIRECT was founded by Wall Street veteran and research analyst, Shawn Severson, after seeing a significant shift in the investment industry that resulted in less fundamental research conducted on small cap companies and a significant decline in information available to all investors. alphaDIRECT's mission is to bridge that information gap and engage companies and investors in a way that opens information flow and analytical insights.

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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
***alpha*DIRECT Advisors**

Mr. Severson is the Founding Partner of *alpha*DIRECT 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 *alpha*DIRECT 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.

Dr. Kenneth J. DeWoskin, Ph.D
Founder China Research and Insight Center, and Senior Advisor to Deloitte
Source: www.ballard.com

Shawn Severson: Ken, let's talk a bit more about the total cost of ownership, or TCO. Clearly investors are familiar with internal combustion engines and to some degree also battery electric vehicles, but can you address the fuel infrastructure, maintenance, and other aspects of fuel cell electric vehicles?

Kenneth DeWoskin: Absolutely, Shawn. Let me start by saying that we have a long history of studying these issues. In our report we note that in the United States in 1974, a conference was convened at Miami University to look at the production and infrastructure issues related to the use of hydrogen. The study was not specifically for mobility, but rather for a broad number of energy applications.

"Of all the alternatives that have been considered for (energy) storage, renewable production of hydrogen with an electrolysis energy conversion rate of 80% is by far the most efficient."

The main operational issues with hydrogen are the production, storage, transport costs, and the facility cost associated with filling the vehicle storage tanks. Of course, hydrogen safety was also a topic to be better understood.

All of these issues in hydrogen production, transport, storage, and fueling are highly sensitive to scale and that is one reason why we are encouraged by the growth trends that underlie our white paper projections.

Right now, we have a 40% disadvantage with fuel cell electric vehicles, or FCEVs, compared to lithium battery electric vehicles, or BEVs, and about a 90% disadvantage compared to internal combustion engine, or ICE, vehicles. However, we expect the crossover point to occur within this decade. Current economic applications that minimize these costs do cluster around fleets and, what I would call closed system applications like warehouses and intercity logistics systems, where centralized storage and fueling facilities can serve a substantial and also predictable number of vehicles. This is already, in my view, a significant market opportunity globally and its continued growth will actually chart the way for broader applications with more open and infrastructure-intensive applications.

The costs of fuel cells themselves will come down and they are less bound by costly material requirements of lithium batteries, for example. This was an interesting thing to contemplate. Fuel cells will see significant cost reductions as manufacturing scales up and as the technology continues to develop.

This is because fuel cells, while they use platinum, that only represents a small percentage of the cost of a cell. When compared to lithium batteries, and their dependence on high material costs such as substantial quantities of lithium, cobalt, and other materials – these are all materials that are subject to finite supplies and they could see a significant cost appreciation due to limited availability.

Lithium mining, for example, is now experiencing tremendous environmental pushback and potential high environmental remediation costs and there are geopolitical risks that involve everything from embargoes to local instability in countries where lithium is acquired. Fuel cells avoid this and it's obvious that there is real potential for significant cost reduction as technology

continues to develop and as manufacturing scales up significantly.

It is almost common sense that lithium batteries are likely to become much more expensive as their deployment becomes broader in the world over the next three to five years period. Hydrogen production using modern electrolysis technology, can reach about an 80% conversion efficiency that is far higher than hydrogen produced by steam methane reforming from natural gas and other sources. Fossil fuel sources, for example, deliver around 60% efficiency. So, as high-tech production technology becomes more widely deployed for hydrogen, hydrogen itself will become very competitive in terms of its production costs.

In thinking about the entirety of the hydrogen market, the technologies that have been developed, such as electrolysis, lead to an inevitable conclusion that hydrogen itself is likely to be reduced significantly in cost as production scales up and as the latest technologies are disseminated around the world for production and usage. Other critically important points we plan to explore in the next two white paper volumes in this series are the role hydrogen plays in renewable energy storage and the distribution of benefits of offshore wind farms, for example. We will look at all of these issues and every one of them is a vector in the same direction, which is to reduce hydrogen cost for production, distribution, storage, and ultimately, application on a much broader scale.

Shawn Severson: To clarify, we are talking about renewables. Is that from a kind of stranded electron strategy where you have all of these renewables that could be used to produce hydrogen and basically as an energy storage system in the form of hydrogen?

"The costs of fuel cells themselves will come down and they are less bound by costly material requirements of lithium batteries, for example."

Kenneth DeWoskin: Yes, Shawn that's correct. Especially in countries like China where an enormous amount of investment has gone into wind farms and large solar photovoltaic systems. A lot of those ended up being stranded and they weren't commercially practical to hook up to the big China state grid because they simply are either too remote or for other political or commercial reasons it has not always worked out well.

Around the world, where a big investment has been made in renewables, one always has the supply-demand imbalance issue which leads to a quest for ways of storing energy where more is being produced than utilized. Of all the alternatives that have been considered for storage, renewable production of hydrogen with an electrolysis energy conversion rate of 80% is by far the most efficient. We expect as hydrogen becomes more widely utilized in things like mobility applications using fuel cells, more renewable energy producers will use hydrogen as a way of being productive during low demand periods of the day and as a way simply of storing energy which then could be used locally in fixed stationary fuel cell applications or even thermal generating applications producing electricity when demand is high.

In conclusion, hydrogen is going to play a central role in broader energy scenarios and in mobility. In this first white paper, we focus on mobility as a set of current

leading applications, but the remaining volumes in the series will use a broader lens and look beyond mobility. The broader role is going to be extremely important in reducing the cost of hydrogen availability for mobility applications.

"Fuel cells will see significant cost reductions as manufacturing scales up and as the technology continues to develop."

Shawn Severson: Thank you and I think we covered it a bit, but one thing I would like to understand is whether it's really just a question of scale or are there other key issues to drive the cost down over the next decade?

Kenneth DeWoskin: I think it's primarily scale. We've seen an incredible growth of the sector, starting from a very small scale where the R&D investment has to be recovered in a reasonable amount of time with what is still not an enormous market. I think scale is really the main issue and scale across the entire supply chain, which include things like transport, as well as the cost of fuel cells themselves at the current modest volume levels.

I mentioned the technology advances in electrolysis that pushed the conversion efficiency up to a very high level. Let me give you another example that's sort of relevant to a previous question and that has to do with the transport of hydrogen. Hydrogen molecules are small, and they are actually not well contained in existing pipelines that are designed for natural gas. Natural gas pipelines without further treatment will actually leak hydrogen because of the size of the hydrogen molecule. That's what leads to these gas mixtures where pure hydrogen is added to an existing natural gas or methane partner, so the combined gas flow doesn't leak through the pipe system.

That means that hydrogen is now primarily transported in individual containers and under high pressure; you need a container capable of handling about 2000 psi. Traditionally these containers have been made of metal which obviously weighs a lot and adds cost to the logistic side of things and additionally, there are safety issues.

We currently have technology developments in the production of hydrogen containers and these involve replacing metal containers with carbon fiber containers. We are moving away from metal tanks to lined carbon fiber tanks and more specifically polyester lined carbon fiber tanks. The reason why this is so important is because they are much cheaper to produce and they are much, much lighter. The difference between a medium sized FCEV, like a central city logistics delivery vehicle carrying a 150 pound steel tank, as opposed to carrying a 20 pound carbon fiber tank, is significant. This kind of technology application, once scale is reached, will be an important element in taking the transportation of hydrogen to the next level and scale.

The scale of production of these new kinds of tanks is relatively small but it is reasonable to expect that to increase, so further gains will be made in these technologies that are related both to pipe and container transport of hydrogen. As these things scale out, one of the major cost factors in using hydrogen broadly for mobility applications will potentially come down very quickly.

Shawn Severson: Can you discuss where the biggest challenges would be in that

cost reduction curve in regard to new improved electrolysis technology and tanks, but also discuss the easy ones versus the hard ones and the real impact it has on the overall cost?

Kenneth DeWoskin: I think through the commercial lens, the biggest challenge is getting through this period of time when the cost of FCEVs is higher for broad applications, not for the applications we studied. For broad applications, the cost is much higher than for BEVs and ICEs, notwithstanding the qualitative environmental advantages of hydrogen, which may or may not play much of a role in commercial decisions.

Through a commercial lens, I think the greatest challenge is the governments strong interest in making sure that hydrogen development continues in their marketplaces. Another challenge is how governments will participate along with facilitating the path to the scenarios we are going to begin seeing between 2024 and 2025 and eventually lead to independently commercial viability in 2026-27. I think it's that period of time that is challenging.

Beyond that, I see fairly clear pathways for every element of FCEV manufacturing and operational cost reductions. Again, the biggest challenge is where the resources will come from to support continued deployment, continued increase in scale, continued development of the technologies and the funds required for the R&D work, which gets more expensive as it gets more elevated and more refined. The challenge is solving where this will come from, how smartly it will be deployed and how effectively it will keep the process accelerating to the point where it escapes the gravitational pull of the competition.

Shawn Severson: Thanks, Ken. The white paper covers some of the current and future beneficial environmental impacts of fuel cell technology. As you can see today, people are very interested in ESG strategies and companies are taking that into account, not to mention the regulatory environments in Europe and so forth. How important and what impact do you think fuel cell electric vehicles will have on the cleaner and greener environment, especially relative to BEV and ICE vehicles?

"Not only the total cost of ownership, but the total environmental impact of these alternative systems is very much in FCEVs favor."

Kenneth DeWoskin: Let's talk about ICE vehicles first. Emissions from ICE vehicles have essentially pretty much reached their limits with the electrification of control systems, the computerization of control systems, and the incredibly subtle tuning of ICEs. Their efficiency has been raised significantly, but ultimately their energy conversion efficiency will always remain low and their emissions, with the very best catalytic converter technology, will never reach anything near what a hydrogen fuel cell electric vehicle can reach. With all these operational advantages of ICE fueling infrastructure around the world for diesel and gasoline powered vehicles, there is a limit to how much improvement can be made in that space.

Lithium batteries are particularly interesting because the actual total environmental impact of those vehicles is much higher than ICE. When you consider the impact of lithium mining on the environment with large open distillation pools that are part of lithium mining and the contamination that is created by that environmental degradation, the making of a lithium

battery is itself terribly energy-intensive and very polluting.

It's difficult to make lithium batteries in ways that don't essentially have a negative environmental impact and, I would add, that no one really has solved the lithium battery recycling issue. It's interesting to see China, as an example, being intense in granular regulation of BEVs that are lithium battery driven, has actually kind of sidestepped this particular issue. Nobody really knows whether the battery maker, the dealer or the automotive OEM is ultimately going to be responsible for recycling lithium batteries. In addition, they are not given any guidance on that and since there aren't that many in the marketplace currently. I believe this will become an issue and we have to think ahead and say, what's going to happen with all of these batteries once you have millions of BEVs on the road, and their batteries begin to reach, say 40% of their original amperage capability or power capability. What's going to happen to those batteries?

"In conclusion, hydrogen is going to play a central role in broader energy scenarios and in mobility."

These are problems that actually haven't even been addressed, much less quantified or solved. It's for those reasons that hydrogen fuel cells, which present none of those problems, are relatively inexpensive to build, even with current technologies. The lifespan of the active elements is much longer than a lithium battery and the erosion of conversion efficiency is much slower. What's left if you recycle a fuel cell, is much less impactful on the environment than recycling the lithium battery.

Not only the total cost of ownership, but the total environmental impact of these alternative systems is very much in FCEVs favor. Just to reiterate one more point, because the production of hydrogen is also environmentally very friendly compared to fossil fuels and transport compared to LNG, hydrogen utilization and production is going to integrate into renewable energy around the world, which itself is a very strong and rapidly scaling element of energy production.

Another point that seems to be kind of lost or not even referenced in a lot of the dialogue, is the fact that as battery electric vehicle penetration rises, there is going to be an impact on the electrical grid in terms of investment requirement, as well as potentially a big negative impact depending on where grid electricity is actually coming from, and that is something that is not addressed very often either.

The reality in countries like China is actually that you don't have enough load on the grid yet related to mobility. If electric mobility becomes a bigger issue in China, if they meet their goals of let's say 2 million vehicles on the road by 2021, then it's more likely than not that a lot of that demand is going to be fulfilled by thermally-generated electricity, that is coal fired.

That's a very big negative, but on the positive side, the reluctance on the part of consumers to adopt electric vehicles is beginning to melt away quickly with both luxury and other moderately high-end vehicle brands that are very attractive.

This expansion of lithium supported basic electric vehicles is very positive for the future of fuel cell vehicles because people who buy electric vehicles are kind of

agnostic with respect to where the electricity comes from and once they make that conversion, they will get comfortable with the range issue and certainly with the role of FCEVs as an alternative.

Shawn Severson: Thank you, Ken. We appreciate your time today.

Kenneth DeWoskin: You are most welcome, Shawn.

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SHAWN SEVERSON
FOUNDING PARTNER

Mr. Severson founded *alpha*DIRECT 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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