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UCD-ITS-RR-01-07

July 18, 2001

Delivered at a dinner in his honor hosted by the Institute of Transportation Studies University of California, Davis

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Remarks by Dr. Geoffrey E.H. Ballard
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July 18, 2001

In a conversation that I had with Bob Moore, he suggested that I might do a retrospective — sort of a look at what has happened since 1985 with respect to Ballard Power Systems — and discuss how I see the events that unfolded.

One question that keeps cropping up is:

"Why has Ballard been successful in introducing a new technology to a very established and conservative industry, when one might hazard the guess that this industry did not really want the change."

I think it is now apparent that even if Ballard the company is not successful economically in the long run, Ballard, by putting a fuel cell vehicle on the road, has changed the way the world thinks about power, and the world will not go back to where it was.

I think the overriding factors were that the technology was timely and legitimate, and by legitimate I mean the technology conformed to recognized principles and accepted standards of society.

I will come back to this point in a few minutes.

First I would like to make a point about the technology. To produce a working fuel cell engine the technology has to be frozen at a point in time and the configuration, power density, etcetera, of that time is turned over to the systems engineers to produce an engine, which takes several years of development in itself.

The plate and frame technology that Ballard developed using commercially available materials with power characteristics that met the ICE power envelope, was frozen back in the early 90s.

It seems to me that it would be the height of arrogance to assume that this first attempt at a configuration is the best possible geometry that could be developed. I suspect that there are geometries and configurations that are very superior to this plate and frame technology.

These geometries I think will begin to appear in the next few years as the full force of the automotive industrial development is focused on the fuel cell.

Returning to Ballard and its business development. Ballard had essentially two paths open to it, for the manufacturing, marketing, and sales of its fuel cell product: a narrow niche market approach, or an all-out assault on fossil fuel combustion in air.

The first possible path was to explore narrow market niches where the technology would be mission-enabling and other niches where some feature of the fuel cell such as reliability, instant on, silence, etcetera, would justify the very high price that would be associated with small production runs.

Following this first path, the company would slowly introduce the new technology to the marketplace and essentially rely on market pull to identify gradually increasing and diversified markets. Public awareness would come slowly. Industry would not be threatened.

The capital requirements of this approach are not large. Investors would need to be patient. The original owners and founders would maintain controlling interest for the foreseeable future. The company could remain a private corporation.

Technology progress would still be significant but funded mainly by gifts and grants from governments and in some cases industry when a unique application was to be considered.

The drawbacks to this approach were several:

- there would be no ready liquidity option to attract investors;
- patent protection would have to be minimal, and what protection was financed would run out in the long run;
- know-how could not be protected when the units were in the public domain;
- when the world finally caught on to the value of the fuel cell, big industry would step in and there would be no way that Ballard could compete for these larger markets.

The second possible path was to go all out to change the way the world thought about power, to tackle the power industry on all fronts — stationary, portable, transportation, space — to introduce distributive power as a viable alternative to the power grid and centralized production.

This approach would require significant amounts of money, liquidity for the investors, and superb patent protection, with accompanying rapid market development and penetration. Ballard would need strategic partners in every major market sector and would have to give up a great deal of autonomy to bring these partners on board.

Estimates of the dollar requirements to move forward on these multiple fronts dictated that markets must be addressed that justified the investments.

As a small aside: The general thinking that embraced us all in these times was that the automobile would be the last fuel cell frontier, not one of the early conquests. The privately owned and garaged family auto, with its entrenched infrastructure, is the toughest technological mountain imaginable — not even considering industrial reluctance to change and the incredibly low price per kilowatt that the ICE has achieved.

Perhaps the real question is really: why did the automotive market move to centre stage in 1997 so much ahead of our estimates?

Referring to our belief at the time that the automotive market was technologically the most difficult, sociologically the most complex, and competitively the most dangerous, one had little choice but to focus on the stationary power market if they wished to follow the path of "let's change the way the world thinks about power."

Essentially Ballard made the decision to follow the second path; to change the way the world thinks about power on all fronts where fossil fuels are being burned in air to produce energy. Ballard, therefore, focused its marketing and fuel cell designs for the distributive, stationary power market.

This, of course, did not mean that Ballard focused exclusively on the utility power market. Ballard moved forward on all fronts where fossil fuels were being burned in air; submarine projects, military needs, space applications, and of course, buses, trucks, locomotives, and cars for the future.

Business decisions are rarely totally altruistic. The owners, of which I was one, had to weigh the benefits of being controlling players in a slowly developing company that could lead, with some luck, to a real financial empire; or to be bit players in a rapidly developing world movement, with modest but more sure financial returns. It was a tough call, but we made the call in favour of the second path.

To recap a bit: the automotive market was seen to be the last conquest on the time line and the bus, truck, and locomotive markets were far too small to justify much internal investment.

Therefore, the corporate resources went into the utility market development, and submarines, cars, buses, locomotives were forced to seek funding from interested outside parties. The project teams were very successful in finding funding for everything except the truck and the locomotive.

We found funding for the bus, but not for the locomotive, which incidentally, is by an order of magnitude, the easiest application of the PEM fuel cell.

Marketing teams pursued the automotive industry with some remarkable successes. The DaimlerChrysler and Ford relationships are now history, or to be more precise, the relationships have emerged to be a major part of the future for Ballard.

I think perhaps the bus that we built was the single most significant marketing event in our rapid acceptance. It is so hard to ignore a freewheeling zero emission example of what the future can look like. And as the late Minister for Energy for the Province of British Columbia said, "give me a significant, green, photo op for the Premier and I will get you the funding."

We have come full circle to the original question, "Why was Ballard, against all odds, able to bring a new technology to an established industry." The answer I said was to be found in legitimacy and I would like to develop that theme for a few minutes.

Legitimacy originates in ideology and flows through to our social institutions to define at any point in time what is considered good and acceptable, both in technology and in human behaviour. Ideology is the vehicle for legitimacy and serves as a means by which a community translates timeless universal values such as survival, justice, self-fulfilment into real world applications. It is the framework of ideas that integrate and synthesize all aspects of a community's being – political, social, economic, cultural, ecological and others.

To encapsulate this idea: something is legitimate when it satisfies the community's ideology.

I know these are not new thoughts to you, but what might be a little more thought-provoking is the idea that we have been undergoing a significant ideological shift since some time in the sixties, and this ideological shift has made much of our

standard everyday business behaviour illegitimate, and the community recognizes this illegitimate behaviour in all aspects of our culture.

Most of us grew up with an ideology of the open frontier: self-reliance and the rugged individualism that explored, settled, and civilized this great nation. Indigenous to this ideology was the right of contract and the right of property. This is often typified by John Wayne, born in a Lockean crib, growing into a rugged individual to dispense frontier justice, and then riding into the western sunset to pounding hearts and applause.

I do not think that old ideology works anymore. I think it has been replaced by a much more communitarian idea, where corporate freedom is constrained by the public good, where freedom to exploit natural resources is constrained by ecological considerations, where contracts are held invalid if the right of minorities are infringed, where politicians are thrown out of office or impeached if they don't keep their campaign promises, or if they infringe on ever more restrictive ethical codes of conduct.

The public, I think, is operational on this new communitarian ideology and much of our established institutions and businesses are operational on the old traditional system of individualism, property rights, competition, limited state and scientific specialization.

For a moment, reflect back 50 years on the esteem and deference that was paid to politicians, clergy, policemen, revenue agents, business leaders, lawyers,

schoolteachers, and almost all authority figures. Compare that to today and the disdain we find in the conversations of our colleagues and friends for this same group of community leaders. They no longer have our confidence and respect.

Well what has this to do with Ballard's apparent success at introducing the concept of fuel cell power into the field of transportation? I think the new ideology that is manifesting itself in our society has reached out and taken zero polluting transportation and a clean inner city as a requirement of the new era. The technology not only fits their ideology, the concept of a small company bringing in a solution fits their emotional stance.

I do not think that Ballard could have been successful 50 years ago by following what we called the second path, to change the way the world thinks about power. We would have had to follow the niche market growth path. I think 30 years ago the public was not tuned to expect successful ideas from small companies. We would have been illegitimate; the new ideology was still at the academic stage.

I think there are a number of major businesses, politicians, and institutions who either understand this new ideology or who are just very aware of public perception. These companies and institutions have helped to bring the PEM technology forward. California has certainly been in there helping and has contributed to the acceptance of PEM technology for the automotive sector. California seems to be in tune with this new ideology. I have had dozens of shareholders come up to me and say, "I have never bought stock before but I own some Ballard shares. I want to help, or I want to be part of this new idea."

Earlier I identified to you the belief at Ballard that the automobile would be the last fuel cell frontier, that many other market sectors would adopt and move forward with the fuel cell option before the family car became feasible. Yet what we have seen in the past few years is many major automobile companies, world wide, pulling out almost all stops to be first to the market with the affordable family fuel cell car.

Certainly I think we did a lot of the right thinks to make this happen. A proof of concept bus touring transportation conferences helped get the idea out there. Following that bus with a full-scale heavy-duty transit bus said the first bus was not a fluke and that the technology was moving quickly forward, telling the average voter, you don't have to put up with inner city pollution anymore. Your air can be clean and you don't have to give up your car. This will continue to have considerable political impact.

Apart from what Ballard as a company did, the nature of PEM technology itself is important. Everyone that works with PEM comes to feel, "Proton Exchange Membrane fuel cells seem to be a very forgiving technology." Whereas an unforgiving technology forces an ever more complex system, fuel cell systems get simpler and more reliable with time.

We were greatly concerned at first that they would not be rugged enough, or they would falter when they were actually on the city streets. None of these things seemed to happen. When we made a mistake and a problem arose, there seemed

to be a fairly simple fix that fit right in.

Fuel cells are following in the tradition of the internal combustion engine – they get better and better with time.

To summarize, I think Ballard did a number of things that were right:

- they chose to introduce the PEM technology on all fronts where fossil fuels were being burned in air to produce energy; and
- they chose a very public demonstration which everyone could understand, the ZEV Bus.

And there were a number of mainstream forces in motion that carried Ballard forward:

- the PEM fuel cell technology and Ballard were legitimate in the modern world perception of what technology and business should really be doing; and
- the technology is amazingly forgiving, the more you work with it the simpler your systems become.

I think we were very lucky and I suspect a lot of Ballard's success was being at the right place at the right time.

In conclusion, I want to repeat something that I do not think can be said too often:

the developed world is hooked on electricity.

In the 17 years after the oil crisis of 1973 — from 1973 to 1990 — as conservation kicked in, there was a per capita decrease in the consumption of total energy in North America. During the same 17 years there was a 28 percent increase in the per capita consumption of electricity.

But common as electricity was, no good storage mechanism for electricity had been developed.

But, when the fuel cell entered the power envelope of the internal combustion engine, hydrogen became viable as the storage mechanism for electricity.

Up until that time the most common storage mechanism for electricity was the battery, but the battery is not commercially viable for storing large amounts of energy, apart from the fact that any given battery does not allow us to scale power and energy separately.

Hydrogen, and the hydrogen conversion device — the fuel cell — allow us to store vast amounts of electricity. It allows us to peak shave, and it scales easily in both power and energy.

Electricity and hydrogen will become so interchangeable that we will think of them as a composite energy currency. Already the term HYDRICITY has entered our vocabulary to express this common currency.

We are practitioners at the dawn of a new energy age, the age of HYDROGEN, or again in the common language that David Scott has taught us; we are on the threshold of the HYDROGEN ECONOMY and the currency is HYDRICITY.

Companies and political organizations that understand this new hydrogen age and are prepared to align their thinking and marketing with this new ideology of the consumer, stand an above average chance of being successful.

It is encouraging to me that my colleagues and I have recently formed a strategic relationship between General Motors and General Hydrogen. I choose to believe that this tells me the largest automotive company in the world understands the hydrogen imperative, "take the automobile out of the environmental equation."

For those of us with responsibilities to our stockholders, understanding all aspects of HYDROGEN takes on a new urgency; storage, safety, and education are the endeavors; implementation strategies and their economic and social implications have become paramount.

Hydrogen for transportation is an exciting subject and worthy of our attention.