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The case for hydrogen – motivations for an increasing focus on hydrogen

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Thinking about the challenges for today's meeting, I could not help but reflect on the dreams of the last 150 years. Dreams full of promise, not yet delivered.

Why is today's dream different from all the earlier dreams?

In 1874, Jules Verne wrote a science-fiction novel called The Mysterious Island, in which the hero, Cyrus Harding, waxed lyrical about hydrogen.

> *"Yes, but water decomposed into its primitive elements," replied Cyrus Harding, "and decomposed doubtless, by electricity, which will then have become a powerful and manageable force… Yes, my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable. Someday the coal-rooms of steamers and the tenders of locomotives will, instead of coal, be stored with these two condensed gases, which will burn in the furnaces with enormous calorific power."*

In 1923, British biologist JBS Haldane painted his vision for a renewable energy economy powered by "rows of metallic windmills" producing electricity for "electrolytic decomposition of water into oxygen and hydrogen" that would be stored, then recombined in "oxidation cells" to produce electricity when needed.

We were there again in the 1970s, when the oil shock helped to popularise the hitherto fringe ideas of John Bockris, an American academic based at Flinders University in South Australia. It was Bockris who coined the term "hydrogen economy", and Bockris who brought the concept into the academic mainstream at the first-ever global Hydrogen Energy conference in 1974.

You remember the story of the boy who cried wolf. Why should the politicians, businesses and consumers believe the message this time round?

Because a lot has changed.

It is up to us to explain it, to take the fiction out of 'science fiction' and focus on the science. And we have to do so based on a mix of proven achievement and yet to be fulfilled ambition.

The importance of the energy transition that we will be part of cannot be overstated. Nothing is more essential to civilisation than energy.

In 2003, Richard Smalley, who in 1996 won the Nobel Prize in Chemistry for discovering a spherical form of carbon called Buckminsterfullerene, published his list of the top ten problems facing humanity. Top of his list was *energy*, followed by water and food.

But energy production and energy use contribute massively to carbon dioxide emissions and thus climate change. For example, in Australia, more than 75% of our emissions are in the energy-intensive sectors: electricity, transport, heating and fugitive releases. Thus, for the best return on effort, it makes great sense to focus on decarbonising these sectors.

Ultimately, we can get all our primary energy from zero emissions electricity through solar, wind, hydro and perhaps nuclear. However, although electrons are versatile, they are not *always* the best way to use that energy. We need storage, and we need a transportable fuel to replace oil and gas.

Nothing could be simpler, more capable or cleaner than hydrogen to deliver these capabilities.

So, what has changed since the dreams of Jules Verne, JBS Haldane and John Bockris? Why has the Japanese Government asked the IEA to prepare a comprehensive study on hydrogen energy and economics as a key input to the G20 Ministerial Meeting in June this year?

Three things have changed and converged to make the dream achievable.

First, we are in the midst of a growing determination to decarbonise our societies. It is a determination shared by most countries, many represented here today. But Japan gets a special mention: 94% of all its energy is imported coal, oil and natural gas. Japan needs a breakthrough solution, and by using hydrogen as an alternative fuel Japan will go a long way to decarbonising its economy.

Second, plummeting production costs, especially solar and wind to generate the electricity for electrolysis.

Third, plummeting utilisation costs, especially in fuel cells. The price to produce fuel cells dropped by a factor of 20 between 2008 and 2015, and has continued to fall since then.

Making it work will require international partnerships. Every country has different needs and unique offerings to contribute. Take Japan and Australia: Japan is interested in importing hydrogen. Its first domestic uses will be for electricity generation and transport. Australia is interested in becoming a hydrogen exporting nation. Our first domestic uses will be for heating and transport.

In all cases, countries must consider:

- Safety in everything we do.
- The costs of production and utilisation.
- The smartest means of shipping sunshine internationally.
- Minimising the impact on our land and water supplies.
- Economic growth. Hydrogen utilisation can provide new jobs and new industries – Japan and the Republic of Korea have recognised this explicitly in their national hydrogen plans.

And, of course, for hydrogen to be a low emissions fuel, the production must also be associated with low net emissions.

We cannot simply shift the emissions from the consumers to the producers.

To avoid that, we need an internationally agreed threshold for the amount of carbon dioxide that can be emitted during production and still qualify to be called 'carbon-free' hydrogen.

There are three things about the hydrogen economy that keep me awake at night:

First, safety. But then I reflect on our decades of safe industrial use of hydrogen and I am confident we can manage this.

Second, costs. But then I reflect on the stunning rate of cost reduction in solar and wind electricity generation and I am confident we can manage this.

Third, the transition from demonstration projects to commercial projects. I reflect on the large and growing number of demonstration projects but the paucity of commercial projects and I toss and turn thinking about how to traverse the valley. It is our biggest challenge, and I am pleased it will be discussed extensively today.

Assuming we can make the leap to commercial scale, to meet the global future needs the volume to be produced is huge.

The Hydrogen Council is predicting a hydrogen market of more than $2 trillion per year by 2050.

Can we make enough? Cheaply enough?

Yes, by scaling up, reducing the input costs for production, and adopting internationally agreed standards.

But we will also need research and development to deliver further efficiency improvements.

Given the role of fuel cells in electricity generation and transport, every 1% improvement in fuel-cell efficiency will save tens of billions of dollars.

Every 1% improvement in electrolysis efficiency will save tens of billions of dollars.

Ongoing investment in research and development will pay back the investment many times over.

We've done this in other industries. Many of you will have followed the stunning improvements in the efficiency of light emitting diodes, which have gone from being less efficient than a candle when I started Electrical Engineering more than forty years ago to outshining every other form of lighting today.

Lastly, as we decarbonise our economies, we need to move past the false dichotomy of low prices or low emissions – our unrelenting ambition should be to have both.

We need to embrace change for economic advantage and environmental advantage.

By embracing change and new technologies we can have our cake and eat it too.

Buckminster Fuller, the famous architect, inventor and futurist, after whom buckminsterfullerene was named, said it best:

> *"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."*

Let's build that new model, through vision, determination and international cooperation.

Thank you.