STANDING COMMITTEE ON STATE DEVELOPMENT

DEVELOPMENT OF A HYDROGEN INDUSTRY IN NEW SOUTH WALES

At Macquarie Room, Parliament House, Sydney, on Monday 21 June 2021

Prepared by: Ty Christopher, Director Energy Futures Network at University of Wollongong

Questions On Notice:

The CHAIR: Can I just ask what countries is that technology currently accessible in?
Mr CHRISTOPHER: The technology that we have seen—and indeed at the meeting that was referred to last Thursday by my colleagues we saw an excellent presentation from a US-based company and they are manufacturing this equipment in the US and also in Europe. I am under evidence, so I am not 100 per cent on the exact country in Europe, but it is Western Europe and the United States.
The CHAIR: Would you mind taking that on notice, perhaps, and providing us with some further detail?
Mr CHRISTOPHER: I can provide a link and some further information. I am more than happy to.

AND:

Mr CHRISTOPHER: Thank you, Mr Shoebridge. You are very well informed and your German is actually better than mine, so thank you for enunciating that. The reality is everything you have said is correct and more, again. The challenge of course when we talk about hydrogen for heavy rail transport is, as I mentioned earlier, the extended life of the rolling stock. Much of the opportunity only arises when you are at those natural changeover points in the life cycle. Within Australia and within New South Wales in particular that can be a bit of a dice roll, if you like. Where we see that there is the greatest opportunity in the short term is repowering of existing fleets—and re-lifing of existing fleets, perhaps, but certainly letting existing heavy rolling stock reach the end of its economic life by repowering it with hydrogen power plants.
I have taken the question on notice and I am more than happy to provide to the Committee the information we have on these repowering units that are of the 200-plus kilowatt range, which is what you need to power a heavy, traditionally diesel locomotive. This is where we see an opportunity—with the infrastructure of the Illawarra and the expertise within the Illawarra and within the University of Wollongong—to undertake a program to research this repowering of existing diesel fleets using, as you have correctly pointed out, technology that is not pie in the sky but is in fact firm technology available globally now.
Answer:

Alstom

The world's first Hydrogen fuel cell powered train was developed by Alstom in Germany. Launched in 2016, Alstom describe the train as:

"The Coradia iLint is the world's first passenger train powered by a hydrogen fuel cell, which produces electrical power for traction. This zero-emission train emits low levels of noise, with exhaust being only steam and condensed water. The iLint is special for its combination of different innovative elements: clean energy conversion, flexible energy storage in batteries, and smart management of traction power and available energy. Specifically designed for operation on non-electrified lines, it enables clean, sustainable train operation while ensuring high levels of performance."

Further information can be found on the following web link:

https://www.alstom.com/solutions/rolling-stock/coradia-ilint-worlds-1st-hydrogen-powered-train

Hyzon/Horizon

A United States based company, Hyzon, are focussed on the production of Hydrogen fuel cell powered heavy vehicles.

Hyzon describe themselves thus:

"Hyzon was established as a new business of Horizon Fuel Cell. Hyzon is a global supplier of zero-emissions hydrogen fuel cell powered commercial vehicles, including heavy duty trucks, buses and coaches.
Headquartered in Rochester, NY and with operations in Europe, Singapore, Australia and China, the company is led by Hyzon co-founders George Gu, Craig Knight and Gary Robb and commercializes Horizon's 17 years of hydrogen technology development for the transport sector.
Hyzon was known as the Heavy Vehicle Business Unit (HVBU) of Horizon and was responsible for the development of fuel cell systems and the delivery of about 500 fuel cell-powered commercial vehicles during 2019 and 2020, leveraging the deep and extensive experience bolstered within the group.
Its establishment as a standalone entity was to focus on accelerating the energy transition through the manufacturing and supply of hydrogen fuel cell-powered commercial vehicles across the North American, European, and Australasian regions."

Further information can be found on the following web link:
https://hyzonmotors.com

Hyzon's parent company Horizon have announced a program to power trains in South Korea using Hydrogen fuel cell technology. The 400 kW fuel cell units are being incorporated into train rolling stock by the Korean Railroad research Institute (KRRI). Further information can be found on the following web links:

https://www.horizonfuelcell.com/mediacoverage

https://fuelcellsworks.com/news/south-korea-krri-to-deploy-hydrogen-fuel-cell-train-powered-by-horizon-fuel-cell-systems/

Siemens

Siemens AG are also developing hydrogen powered trains, stating:

“A climate-friendly transportation transition is essential for dealing with climate change. In a joint project, Deutsche Bahn and Siemens Mobility are testing a brand-new complete system consisting of a newly developed train and a newly designed filling station. Siemens Mobility is developing the next generation of hydrogen trains that are based on the proven, high-performance Mireo commuter train, which is also used in battery-powered operation. Equipped with a fuel cell drive and a lithium-ion battery, it provides local, emission-free mobility on non-electrified routes. Learn all about this project and join us when we bring the future of hydrogen technology on rails.”

Further information can be found on the following web link:

https://www.mobility.siemens.com/global/en/portfolio/rail/rolling-stock/commuter-and-regional-trains/hybrid-drive-systems/mireo-plus-h.html

Stadler

The Swiss train manufacturer Stadler have developed a hydrogen powered train for service in the San Bernardino County Transportation Authority (SBCTA) rail system in the United States. The train is planned for passenger service in 2024.

Further information can be found on the following web link:

https://www.stadlerrail.com/en/media/article/green-tech-for-the-us-stadler-signs-first-ever-contractfor-hydrogen-powered-train/649/

Hydroflex

The first hydrogen powered train has run on the UK mainline as part of a project being delivered by a partnership between the UK Department for Transport, the University of Birmingham and Porterbrook.

Reports state that the technology powering the train will also be available by 2023 to retrofit current in-service trains to hydrogen power.

Further information can be found on the following web link:

https://www.birmingham.ac.uk/research/railway/research/power-systems-and-energy-use/hydrogen-train-mainline.aspx

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Question On Notice:

The Hon. MARK BANASIAK: Mr Christopher, you spoke in your opening statement about developing your own road map for the hydrogen industry in Wollongong. Would you be able to perhaps table that or provide the Committee with a copy so we could include that as part of our deliberations?
Mr CHRISTOPHER: Yes, of course.

Answer:

The Recharge Illawarra Hydrogen Plan attached is comprised of three documents which are attached to this answer. In summary, the documents are:

Document 1: "Energy futures roadmap infographic.pdf"

This document details the overall delivery framework and the road map for building a sustainable hydrogen industry within the Illawarra Region. The roadmap specifically considers the areas of Hydrogen Demand, Hydrogen Supply, Regulation to facilitate Hydrogen technology, Technical development and workforce development through Skills and Training. The roadmap articulates the key milestones for each of these areas for the years 2021, 2024, 2027 and 2030.

Document 2: "210514 Recharge Illawarra Hydrogen Plan.pdf"

This document details the specific actions required to build a sustainable hydrogen industry in the Illawarra, including the initial funding required from the NSW Government to deliver the initial stages of the roadmap detailed in document 1. Specifically, this document proposes funding requirements to:

1. Manage the Illawarra Hydrogen program;
2. Immediately implement the first phase of heavy transport hydrogen use including refuelling, bus and heavy road transport hydrogen trucks;
3. Develop skills and training requirements for VET and tertiary courses in the hydrogen industry;
4. The Energy Future Communities initiative to prove at scale existing and newly developed hydrogen based energy technology, drive innovation and community involvement in building the energy future;
5. Land use planning to facilitate appropriate location of hydrogen based industry;

6. Hydrogen supply chain development to act as an attractant to new and emerging businesses.

Document 3: "UOW Energy Future Communities handout.pdf"

This document provides greater detail on the Energy Future Communities initiative. The Energy Future Communities initiative would build on the established Innovation Campus (IC) by providing a living laboratory comprising a range of residential, commercial and social centres. This unique location enables the implementation at scale of advanced and innovative energy technologies and policies and the comprehensive monitoring and studying of the behavioural and social effects of different technologies and different energy policies.

The Energy Future Communities initiative would be open to communities and industry (such as asset owners and managers and new technology companies), both as an engagement mechanism and as a 'sand pit' for new ideas and new technology implementation which can be further scaled up to involve communities across NSW and Australia.

The Energy Future Communities initiative would also operate as an energy outreach centre, engaging Industry and communities in the further development and implementation of the road map to an equitable energy future for NSW.

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Question On Notice:

The Hon. MICK VEITCH: I have a question which follows on from that line of questioning from Mr Pearson and Mr Shoebridge. With the various techniques of storage, what are the losses from going through that process—putting it into ammonia or whatever and then taking it back out of ammonia to hydrogen? What are the losses that are sustained in that process?
Mr CHRISTOPHER: The energy loss journey for hydrogen creation storage transport via ammonia, for instance, and then out of there can be quite significant. If I may, rather than quote numbers that do have, first, some variability and, second, interdependence around them, if possible, Madam Chair, I could present a brief, say, half-page summary on exactly that—
The CHAIR: That would be terrific.
Mr CHRISTOPHER: —as information to the Committee, and that would probably be the more fulsome way I could answer that question.

Answer:
The Commonwealth Scientific and Industrial Research Organization (CSIRO) research paper titled "Ammonia as a Renewable Energy Transportation Media" [1] states:

"Ammonia synthesized using hydrogen from renewable sources offers a vast potential for the storage as well as transportation of renewable energy from regions with high intensity to regions lean in renewable sources. Ammonia can be used as an energy vector for an emissionless energy cycle in a variety of ways. Ammonia at the point of end use can be converted to hydrogen for fuel cell vehicles or alternatively utilized directly in solid oxide fuel cells, in an internal combustion engine or a gas turbine. One ton of ammonia production requires 9–15 MWh of energy. However, its conversion back to useful form or direct utilization can lead to substantial energy losses. In this paper, we present an overview of the current processes and technologies for ammonia synthesis and its utilization as an energy carrier. We have performed an estimation of the round-trip efficiency of different routes for ammonia utilization at the point of end use along with some sensitivity analysis, and we discuss the outcomes resulting from the best and worst case scenarios."

The CSIRO are quite clear that, relative to making ammonia, using renewable electricity directly "would clearly be far more efficient" given the distribution losses of only "less than 10%" in most electrical grids. CSIRO makes a similar case for directly charging electric vehicles because "losses during charging … are typically significantly less than 20%." Therefore, CSIRO provides the argument for the use of ammonia as an energy vector:

“Conversion of renewable energy to a fuel would only be considered viable if the energy is to be transported over long distances by ship, the energy needs to be stored for extended (months) periods of time or there is another engineering constraint that precludes the direct use of the generated electricity.”[1]

The CSIRO study summarises three end-use scenarios for ammonia fuel, quantifying the round-trip efficiency of ammonia as:

1. a high-purity hydrogen carrier for fuel cell vehicles (PEMFC),
2. a hydrogen carrier for stationary fuel cells (SOFC), and
3. a direct fuel for internal combustion engines and gas turbines.

CSIRO has published these findings as ranges [1], taking into account both the best-case and worst-case assumptions for the energy performance of these various technologies in various applications, including both automotive and residential power (Combined Heat and Power (CHP) and electric).

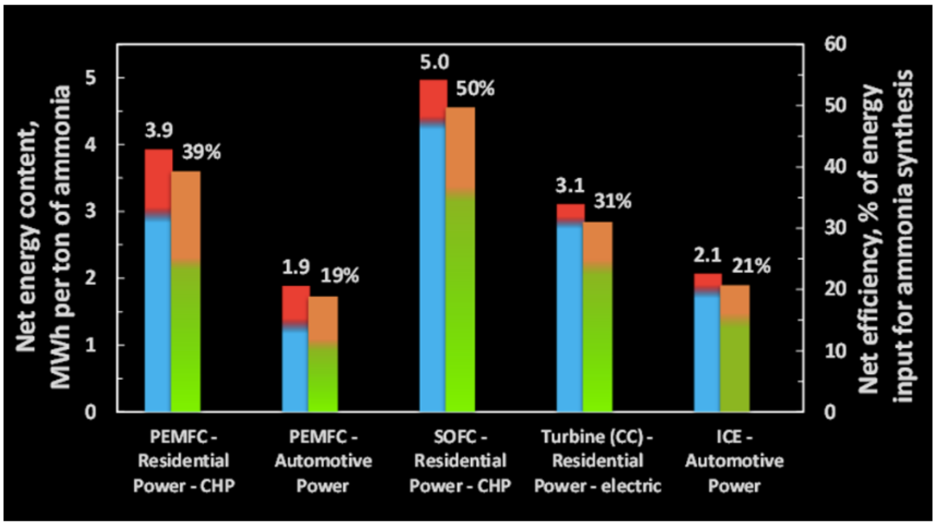

Figure 7. Comparison of net energy produced and the efficiency for different end-use applications of ammonia. The changing color shade in each column shows performance from the worst to the best case scenario as per data in Tables 1 and 2. The numbers at the top of each column are for the best case scenario.

Reference:

[1] **Ammonia as a Renewable Energy Transportation Media** S. Giddey, S. P. S. Badwal, C. Munnings, and M. Dolan *ACS Sustainable Chemistry & Engineering* **2017** *5* (11), 10231-10239 DOI: 10.1021/acssuschemeng.7b02219