roads australia

POLICY WEBINAR proudly sponsored by Advisian Worley Group

Katy Taylor
The Go-Ahead Group plc

James Hetherington
Department of Industry, Science, Energy and Resources

International Insights:
The future role of hydrogen fuel cell technology in our public transport system

Dr Fiona Simon
Australian Hydrogen Council

Phil O'Neil
Advisian

Becky Wood
Aurecon and Roads Australia

TUESDAY 8 DECEMBER 2020

ABOUT ROADS AUSTRALIA

Roads Australia (RA) is the peak body for roads within an integrated transport system, representing an industry that contributes $207 billion annually to the economy and supports 1.3 million jobs.

RA brings industry, government and communities together to lead the evolution of Australia's roads, integrated transport and mobility.

The nation's only roads champion, RA's 150+ members include all of Australia's road agencies, major contractors and consultants, motoring clubs, service providers and other relevant industry groups.

RA's current policy focus extends across five activity streams: Safety; Capacity; Transport Reform; Journey Reliability; and Sustainability with Diversity and Inclusion an underlying commitment across each stream.

Visit our website for upcoming policy events.

BACKGROUND

Presented as part of RA's ongoing policy focus on the impact of new technology on the transport sector, the event followed on from an International Insights webinar in September 2020, where RA facilitated a discussion on the transition from Internal Combustion Engines (ICE) to Electric Vehicles (EVs).

The impact of these technologies were also covered in RA's two most recent study visits in 2018 (Cities for the Future) and 2019 (Future Transport: Smart Cities).

This latest session explored the role hydrogen is expected to play in the electrification of buses and whether hydrogen fuel cell buses will be embraced in Australia. The session also considered the importance of looking beyond just tailpipe emissions, and using renewables to generate green hydrogen to achieve low / zero emissions. Panellists were also asked to provide their view as to whether Australia is likely to use hydrogen in other forms of public transport.

EVENT SUMMARY

Over 90 attendees joined RA's webinar on 08 December 2020 to hear from the following speakers:

- **James Hetherington**, Manager of Hydrogen Strategy, International Climate and Technology Division, Department of Industry, Science, Energy and Resources
- **Dr Fiona Simon**, Chief Executive Officer, Australian Hydrogen Council
- **Katy Taylor**, Chief Strategy and Customer Officer, The Go-Ahead Group plc (UK)
- **Phil O'Neil**, Senior Associate – New Energy, Advisian

Several of the speakers' presentations are available on the RA website.

The webinar was moderated by **Becky Wood**, former Transport Reform Policy Stream Deputy Chair, RA, and former Managing Director - Transportation ANZ, Aurecon, and was proudly sponsored by Advisian.

POLICY INSIGHTS

The webinar brought together leading experts from across Europe and Australia.

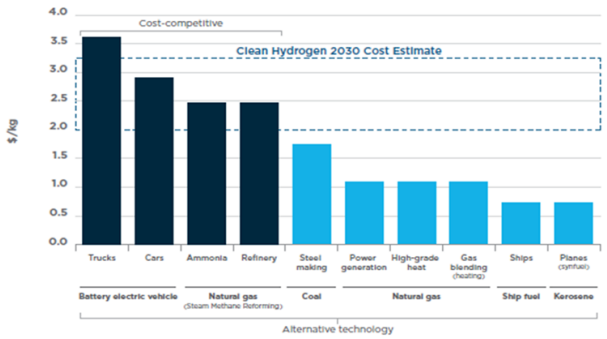
James Hetherington, Manager of Hydrogen Strategy, International Climate and Technology Division, Department of Industry, Science, Energy and Resources, kicked off the session by highlighting Australia's National Hydrogen Strategy, released in 22 November 2019. Mr **Hetherington** set the scene by explaining why there has been significant interest in clean hydrogen in recent times. He noted that with energy linked to over 70% of global emissions, a clean fuel option, alongside clean electricity production to help decarbonise, is required.

Clean hydrogen (i.e., hydrogen produced with little or no CO_2 emissions such as renewable energy) and its derivatives could be this fuel, particularly given its only by-product is water (i.e., no carbon emissions), it has a high energy content on a weight basis, and is highly versatile. From a transport perspective, hydrogen can be used in fuel cell technology to power buses, trains and other road-going vehicles. It can also be used to store energy when there is excess capacity from the power grid, which could prove a particularly effective way to harness unused power from renewable energy such as solar and wind. He also highlighted that there were significant export opportunities for Australia.

Mr Hetherington explained that transport offers a promising early use case for hydrogen. With costs falling, hydrogen fuel cell technology can complement battery electric vehicles, particularly for heavy load and long-distance applications. It also offers shorter refuelling times when compared to recharging a battery electric vehicle. However, there are challenges and barriers to be overcome to make hydrogen in transport a reality. Refuelling infrastructure needs to be deployed, hydrogen fuel cell vehicles need to become widely available and cost competitive, and low-cost hydrogen supply will need to be in place. In this regard, refuelling stations and hydrogen supply will need to develop in step with each other to ensure the businesses involved can be commercially viable (refer to Figure 1). Furthermore, rollout will need to be structured in a way that overcomes any anxiety about vehicle range.

He explained the importance of electrification in helping to promote the transition to clean mobility, and highlighted the current mix of vehicle technologies, including plug-in hybrid electric vehicles (PHEVs), battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEV). He further highlighted the crucial importance of increasing the use of renewable or low-carbon energy for such electricity generation.

F1. Breakeven cost of hydrogen against alternative technology for major applications in 2020



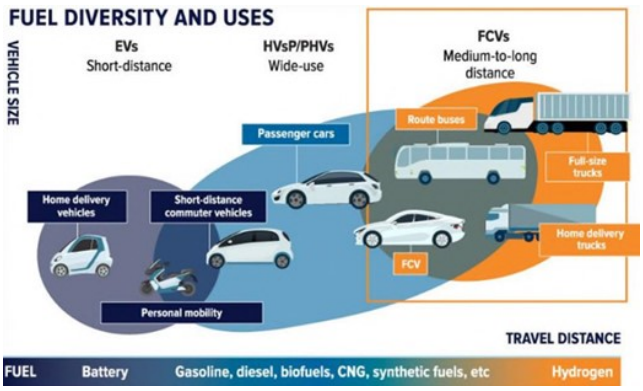
Source: McKinsey & Company 2019

Mr Hetherington explained that through the National Hydrogen Strategy, governments have agreed to encourage consortia models which will bring together vehicle manufacturers, hydrogen producers and fuel suppliers to build up supply and demand at the same time, and to lower project risk. The initial focus will be on transport tasks that do not rely on a network of refuelling stations and which offer compelling advantages. Early opportunities include 'back to base' transport applications, such as fleet vehicles, metropolitan public transport, and freight transport (refer figure 2).

In the longer term, the Strategy seeks to encourage deployment of refuelling stations along major transport corridors as well as promoting open access to government supported infrastructure to enhance vehicle range.

Mr Hetherington also explained that in the future, hydrogen production and use will create new sectoral linkages, which if intelligently managed, could create additional value and accelerate the commercial case for hydrogen in transport.

F2. Expected Opportunities for Hydrogen in Road Transport



Source: Green Cars Report

In the future, hydrogen production and use will more closely link operation of the electricity grid, the gas distribution network and the infrastructure supplying fuel for vehicles and will create new linkages between the transport, energy, industrial and agricultural sectors.

These properties mean that that the opportunities from hydrogen need to be thought about more broadly than through a focus on transport uses alone. Done well, intelligent sector coupling could improve the viability of projects and provide broader benefits such as greater fuel security through domestic fuel supply, improved electricity grid reliability and security, health benefits from cleaner air, more efficient and lower cost energy supply, as well as major export revenue and job opportunities.

Mr Hetherington concluded by highlighting the significant support from Australian governments to help accelerate hydrogen industry's growth. This includes a $1.9 billion investment package for future technologies to lower emissions, including hydrogen, as well as over $500 million of funding that has already been specifically committed to hydrogen industry development. From a transport perspective, some of the noteworthy initiatives being supported include a $74.5 million investment in refuelling infrastructure and schemes to promote the expansion of future fuels, including hydrogen.

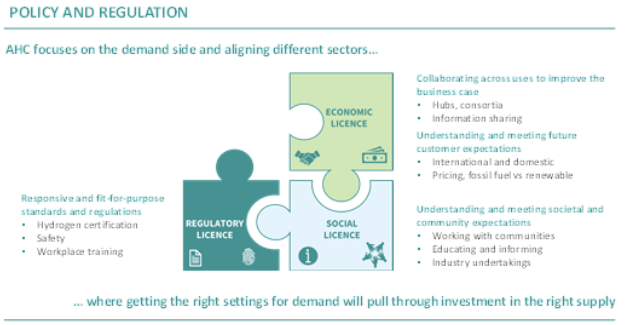
Dr Fiona Simon, Chief Executive Officer, Australian Hydrogen Council (AHC), provided an overview of the AHC. She explained that the AHC is the peak body for the emerging hydrogen industry, with the objective to grow the industry to have clean hydrogen as a key part of Australia's energy mix.

Dr Simon highlighted several key characteristics of hydrogen that make it desirable, particularly in the context of the transport sector. First, hydrogen is storable over time and transportable, and unlike batteries, does not lose its energy potency. Second, hydrogen is made, not found, which means it is not a limited resource. Furthermore, hydrogen can be made in different ways, with the clean and green versions presenting the longer-term opportunity. Third, hydrogen is versatile, and can be converted for different uses across energy, transport and industrial processes. She stated that in the opinion of the AHC, it's not a matter of *if* Australia could be a global hydrogen powerhouse, but *how*, and *by when*.

Dr Simon reinforced the importance of the AHC working with Government and other key stakeholders to ensure a coordinated approach to delivering against the National Hydrogen Strategy, including development of policy and regulation. She highlighted that there is already great interest in hydrogen in Australia, with recent estimates that there are over 50 industry projects and 30 research projects currently in progress or announced.

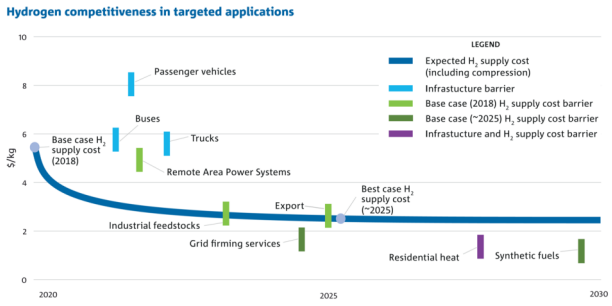
Dr Simon explained that from the AHC's perspective, the nation's immediate policy focus was on two key objectives. The first related to developing the export market, and it was noted that the National Hydrogen Strategy set an objective for Australia to be a top three exporter by 2030. The second related to the cost of hydrogen, and helping to reduce this price to a point where we can achieve the Low Emissions Technology Statement stretch target of below $2 per kilo. She highlighted that to achieve such objectives, a robust set of standards and regulation needed to be further developed, and presented the AHC's model showing that with the pursuit of economic, regulatory and social licence, supply and demand could be properly aligned (refer Figure 3).

F3. AHC Hydrogen Policy and Regulation



Dr Simon identified possible early adopters (Figure 4). Consistent with James Hetherington's earlier comments, the AHC's position was that there would be an industry-wide need to replace diesel vehicles. This would likely include: (1) **buses**, a 'back-to-base' segment, which were typically operated by public agencies and therefore amenable to policy-driven procurement; (2) **light commercial vehicles**, with this category considered to include vehicle fleets operated by public agencies (also 'back-to-base' fleets), with public agencies also amenable to policy-driven procurement; and (3) **heavy road trucking**. She concluded that as the world moves to decarbonise, Australia has the chance to boost its resilience to economic and environmental shocks through using clean and green hydrogen in the energy mix.

F4. Hydrogen Demand



Source: CSIRO 2018

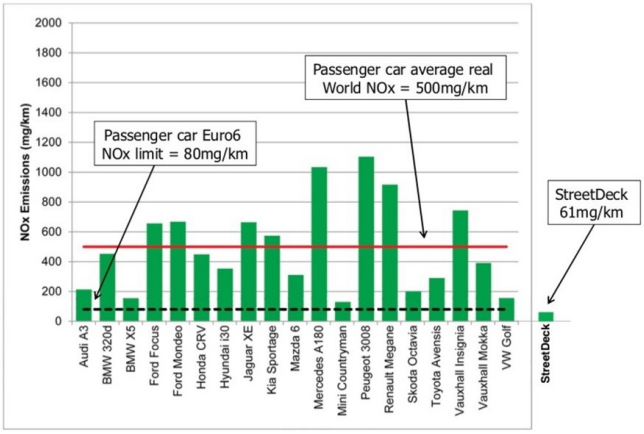
Katy Taylor, Chief Strategy and Customer Officer, The Go-Ahead Group plc (UK) (Go-Ahead), joined to provide an overview of Go-Ahead, with a focus on their bus services, one of the transport modes identified by Dr Simon as an early adopter of hydrogen technology.

Ms Taylor explained that Go-Ahead operates buses and trains, primarily across the UK. In terms of volume, this includes a third of all journeys in the UK, and a quarter of all buses in London. She highlighted that the organisation also operates buses in Singapore and in Ireland, and trains in Germany and Norway.

Considering the UK market, **Ms Taylor** explained that UK buses are already some of the cleanest vehicles on the road, even taking into account that most are still diesel powered (Figure 5).

However, many are converting these buses to battery-electric operation, with hydrogen fuel-cell trials underway. Furthermore, when considering the number of passengers moved on a bus, they offer a very clean alternative to the equivalent number of cars. It was noted that in the context of hitting the UK's net zero emissions target for 2050, shared and low or zero emissions vehicles will be priorities for the Government.

F5. Diesel Vehicle Emissions



Source: Go-Ahead Group plc (UK)

Ms Taylor set out Go-Ahead's experience with battery-electric and hydrogen fuel-cell buses. Go-Ahead now operates two all-electric bus depots, both in London. They also have 22 hydrogen buses currently in production for use around Gatwick airport, with delivery expected in late 2021. Additionally, a further 32 hydrogen buses are in production for use in the south-east of England, which are expected to be in operation by 2022. Once operational, Go-Ahead will be become the largest operator of hydrogen buses in Europe.

To help build the case for hydrogen buses, **Ms Taylor** contrasted the differences between battery-electric and hydrogen fuel-cell buses. For electric buses, significant changes were needed to depot layout, with charging taking place over 8 hours. This longer charge time meant that a larger fleet size was required.

Furthermore, current battery-electric technology offered limited range. Additionally, battery-electric buses were relatively more expensive to operate, particularly given the high battery cost (approx. £100K), which typically needed to be replaced up to three times during the lifecycle of the bus (12-15 years).

In contrast, hydrogen fuel-cell buses could be fuelled in a similar way to diesel buses, with refuelling taking between 5-8 minutes. The other major advantage was that depot layouts required minimal modifications, and no charging infrastructure was required, thereby saving £Millions. Significantly, there were no range issues, making it extremely flexible for route planning and operations.

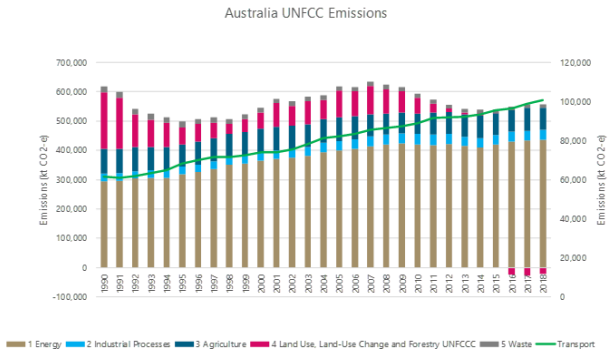
She conceded that whilst the upfront capital costs of hydrogen fuel-cell buses (£400K) were much higher than their battery-electric (£300K) and diesel (£200K) counterparts, the lifetime costs were much lower, making a compelling business case. **Ms Taylor** acknowledged that although hydrogen was currently a more expensive fuel option, it was more efficient, and in the longer term, the price of hydrogen was expected to drop significantly as scale was increased (noting again the Low Emissions Technology Statement stretch target of below $2 per kilo).

Ms Taylor went on to explain, however, that there was a role for government to provide innovation funding to help kick-start manufacturing. It was noted that this would help to bring prices of hydrogen fuel-cell buses down further, thus reducing that initial capital outlay and speeding up investment. She also highlighted that there were already robust systems in place (including to address safety) for storing and transporting hydrogen. Furthermore, and based on trials, the customer experience was further enhanced by the fact that hydrogen fuel-cell buses were even quieter than their battery-electric counterpart.

To provide context as to the emissions buses generate in the UK, **Ms Taylor** concluded by pointing out that only 4% of roadside emissions came from buses. As such, the journey to creating an entire zero emissions bus fleet was only one piece of the puzzle of tackling climate change and improving air quality.

Phil O'Neil, Senior Associate – New Energy, from Advisian, further expanded on the important role hydrogen could play in the transport sector, particularly in the context of helping to reduce emissions as tracked as part of United Nations Framework Convention on Climate Change. **Mr O'Neil** explained that emissions from transport had steadily been climbing since 1990, with a 64% increase to 2018, making up over 20% of all emissions (Figure 6). As such, the sector required urgent attention to reverse this trend and bring about meaningful reductions.

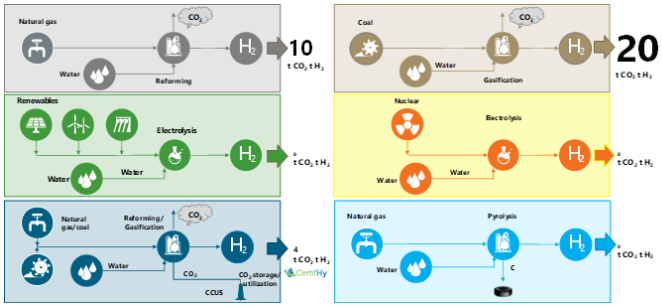
F6. Hydrogen Cost: Central vs. Local Production



Source: Australian Greenhouse Emissions Information System, Department of Industry, Science, Energy and Resources (Advisian Analysis)

Mr O'Neil explained that if hydrogen is to play a significant role, the way it is produced is key. It was noted that while 'tail pipe' emissions from hydrogen fuel cell vehicles were zero, this could be negated if fossil fuels were used to generate hydrogen. To help illustrate this scenario, **Mr O'Neil** explained six methods used to produce hydrogen (see Figure 7). He noted that methods such as those using natural gas (reforming, denoted as 'grey' hydrogen) and coal (gasification, denoted as 'brown' hydrogen) generated significant amounts of CO_2, with coal the most polluting, generating at least 20 tonnes of CO_2 per tonne of hydrogen. In contrast, hydrogen generated using renewables (electrolysis, denoted as 'green' hydrogen), produced no CO2, and hydrogen utilising carbon capture (denoted as 'blue hydrogen'), offer low emissions and are the preferred option for reducing transport emissions.

F7. The Hydrogen Rainbow

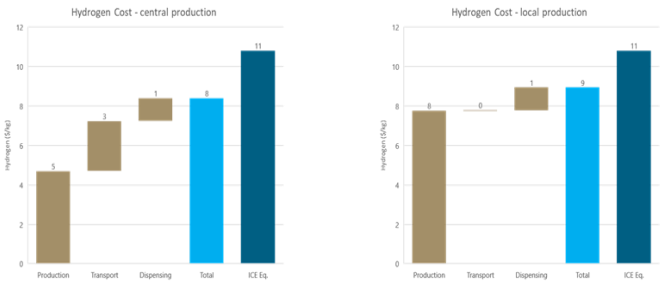


Source: Advisian

For hydrogen to be a viable alternative to other fuel sources within the transport sector, particularly for heavy transport vehicles, then consistent with earlier comments from other speakers, cost would play a crucial role. To illustrate this point, **Mr O'Neil** went on to explain the current costs of hydrogen production, contrasting central versus local production (see Figure 8). With central production, costs were currently at approximately $5 per kg, and it was estimated that it would cost a further $3 to transport to a refuelling station. Adding on a small amount for dispensing brought the cost in at approximately $8 per kg to deliver.

He noted that future transportation costs could be reduced to as little as $1 per kg if hydrogen could be moved via a network of pipelines, helping to bring delivery cost to around $6 per kilo. In contrast, local production resulted in a higher production cost of $8 per kg (driven by capital costs, electricity costs, and capacity factors), but only a relatively small difference in total cost at $9 per kg. It was noted that in both cases, it was reasonably cost-competitive when compared to a diesel option at $11 per kg.

F7. Hydrogen Cost: Central vs. Local Production



Source: Advisian

Mr O'Neil concluded by noting that prices were in fact dynamic, and other non-hydrogen options were also becoming cheaper and more effective, including battery-electric, so the jury was still out on the long-term cost competitiveness of hydrogen. He also pointed out that there were other factors impacting costs, such as fleet size and effectiveness, utilisation of infrastructure and supply chain challenges, which made the long-term outcome of hydrogen's role still somewhat uncertain.

It was noted however, that to the extent hydrogen production costs could be reduced to the target of $2 per kg as mentioned earlier, then the business case would become more compelling.

RECENT DEVELOPMENTS

In further developments, a recent article in The Age indicated that hydrogen industry hubs were being set up across the country by National Energy Resources Australia to capitalise on an emerging business opportunity.

Additionally, a recent article in the Australian Financial Review indicated that hydrogen-powered buses would be shipped to Australia in April and made in Australia from 2022 as manufacturers responded to state governments' calls for zero emissions vehicles.

EVENT OUTPUTS & NEXT STEPS

A snapshot of the event was promoted through Roads Australia's LinkedIn channel, with the presentations available on the RA website.

RA will continue its commitment to progressing policy discussions on the role of hydrogen, with further webinars and roundtable discussions being considered for later in 2021

Further details will be made available on the RA website.