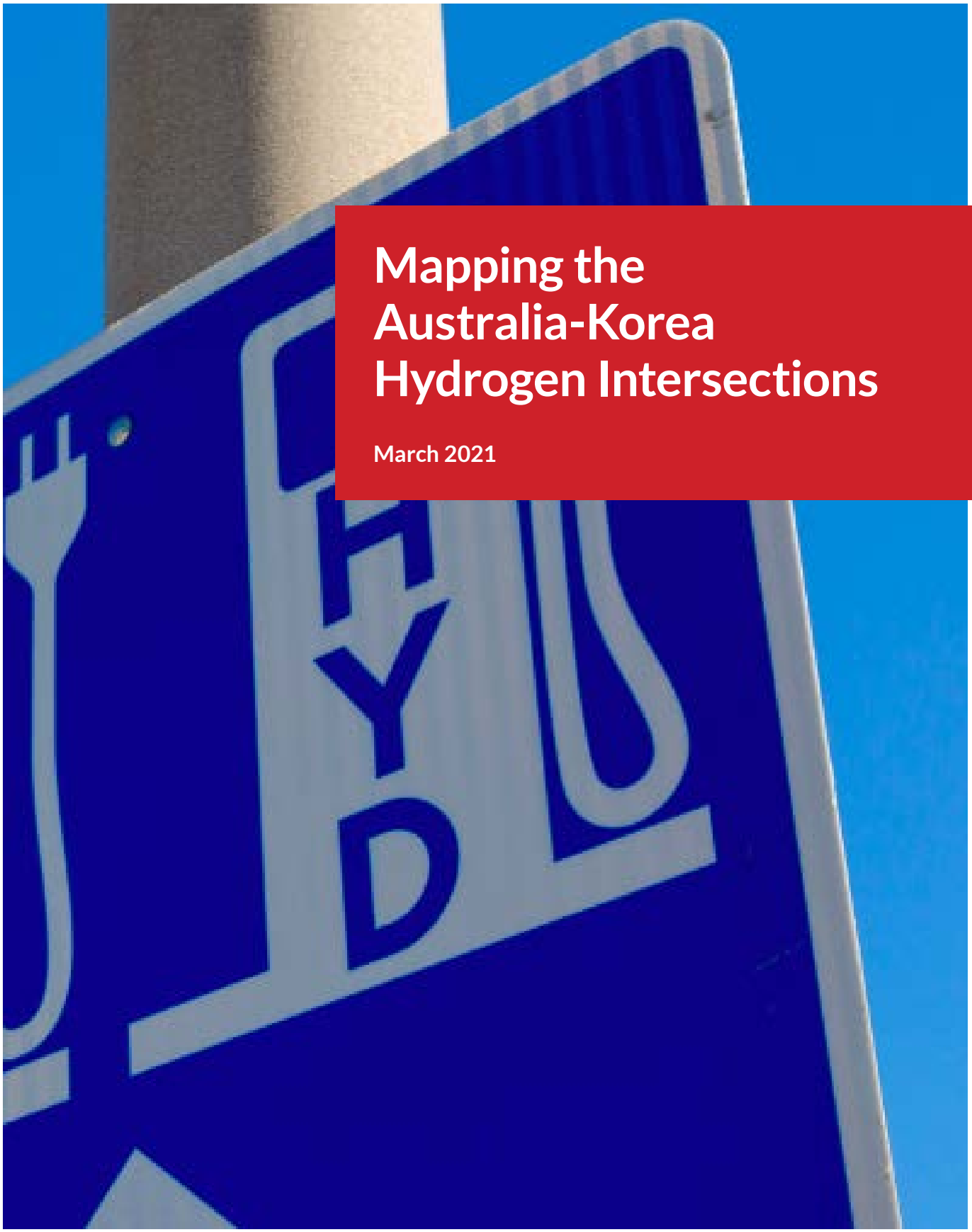
AUSTRALIA - KOREA BUSINESS COUNCIL

DISCUSSION PAPER



Mapping the Australia-Korea Hydrogen Intersections

March 2021

THE AUSTRALIA-KOREA BUSINESS COUNCIL (AKBC) EXISTS ON BEHALF OF ITS MEMBERS TO PROMOTE AND FURTHER THE AUSTRALIA-KOREA BILATERAL RELATIONSHIP.

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Background

The development of a sustainable and mature hydrogen market between Australia and Korea has the potential to define the bilateral relationship over the next century. The Australia-Korea Business Council has been at the forefront of communicating the burgeoning possibilities of this partnership to its members and stakeholders across business and government.

This Discussion Paper is our latest contribution to the dialogue on hydrogen, which is being led by our energy sub-committee comprising executives of member firms who are deeply engaged in the opportunities in hydrogen between Australia and Korea. Its objective is to map the key intersections of the Australia-Korea hydrogen collaboration and define the areas of collaboration that can be seized in the short, medium and long term.

The AKBC invites its members and other interested parties to provide their feedback to the questions posed throughout this paper. Your feedback will inform our Final Paper, which will be released in the second quarter of 2021 and form the basis of the AKBC's policy position on hydrogen, highlighting opportunities for the private and public sectors across our two countries.

The deadline for feedback is Friday, 12 March 2021.

Mapping hydrogen's future

Australia and Korea, as both strong trading partners and APAC neighbours, are natural strategic allies. Australia and Korea's current trade and investment statistics are largely dominated by commodities, notably coal, iron ore, LNG and increasingly, battery minerals. As public sentiment shifts away from carbon intensive commodities towards lower emission technologies, the benefits of decarbonising logistics chains as early as possible are becoming increasingly recognised. This provides Australia and Korea, as an exporting and importing nation respectively, with an unprecedented opportunity to lead the way on the global stage.

Hydrogen is the energy source, technology and export market of Australia and Korea's futures. This future is quickly becoming a commercial reality as the benefits of hydrogen and its applications strike the imagination of businesses in both countries. Hydrogen has the capacity to reduce emissions, be developed sustainably, transported efficiently, and solve an energy transition challenge as the globe shifts away from carbon-intensives fuels. For Australia and Korea, this speaks not only to a compelling investment prospect – but also to a bilateral trade and diplomatic opportunity that could lay the foundation for a hydrogen market in the 21st century.

The great potential for an Australia-Korea hydrogen market lies in the synergy between our strengths and weaknesses. Korea is the world's leading fuel cell technology producer and has a wealth of experience developing refuelling stations and fuel cell electric vehicles (FCEV). However, it relies heavily on importing its energy needs. Since 2015, roughly 93% of its energy production came from foreign imports and as the country transitions away from thermal coal and other resources, it has identified a stable supply of hydrogen as crucial to securing its energy security.

Australia holds the key to Korea's hydrogen needs – a secure market of hydrogen and, in particular, green hydrogen. On the global stage, Australia is likely to be one of top three exporters of hydrogen by 2030 and will be in need of global partners to realise the full potential of its hydrogen strategy. Korea, which has the fuel cell expertise and import shortfall, could accelerate Australia's transition to becoming a global hydrogen powerhouse.

Korea to Australia to enable mobility, power generation and industrial processes such as steel/chemical with green hydrogen. Most recently, Korea passed the Economic Promotion and Safety Control of Hydrogen Act (Hydrogen Law) on 5 February 2021, the world's first hydrogen law, which demonstrates the seriousness of the Korean Government in driving its hydrogen economy.

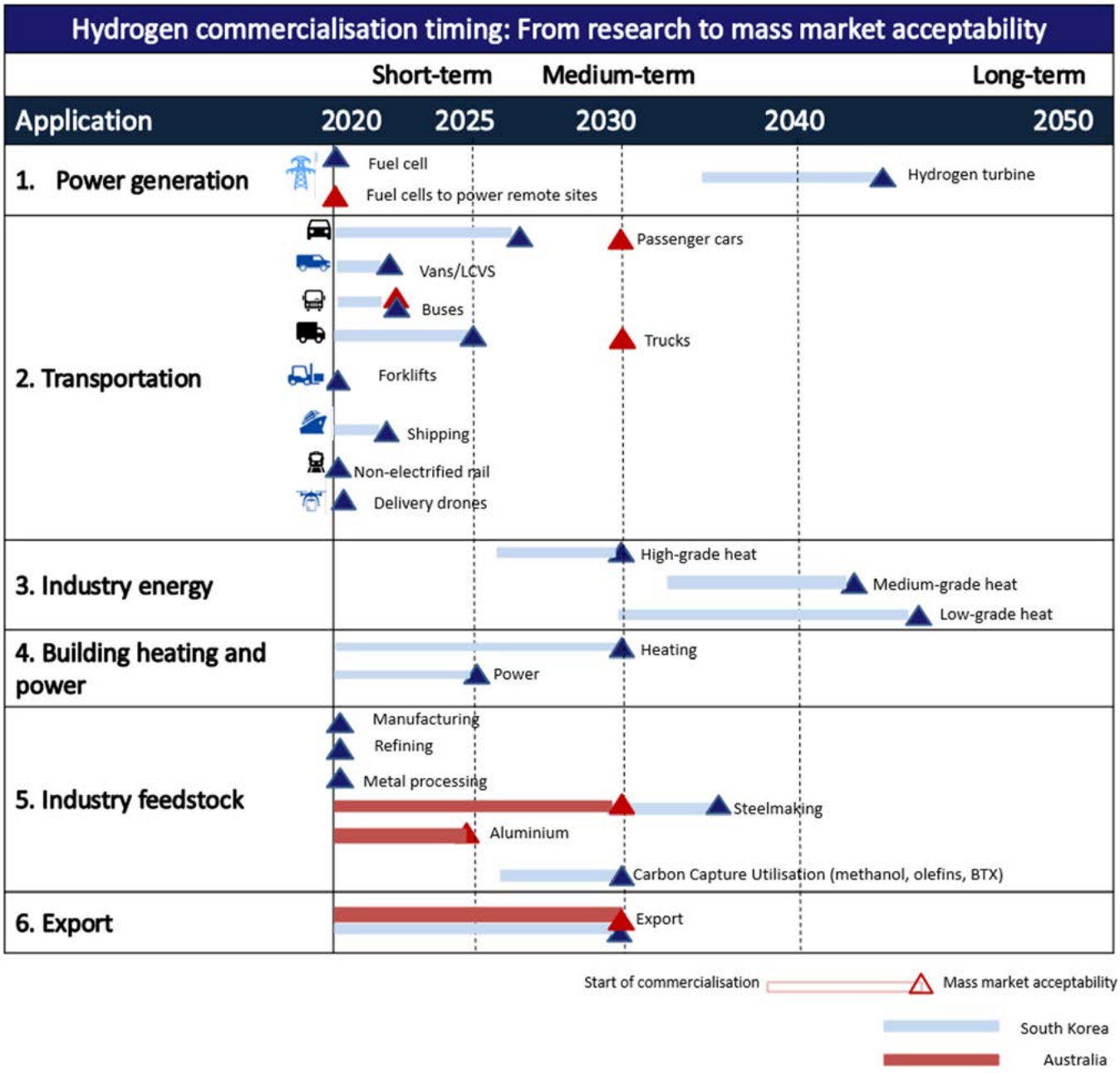
Vital to the strength and maturity of any major bilateral market is the buy-in and strategic policy direction government. Both the Australian and Korean governments have identified hydrogen as a crucial technology to transition to a lower carbon future. In 2019, the Korean government released the Hydrogen Economy Roadmap of Korea and the National Roadmap of Hydrogen Technology Development. These set specific targets and timelines for developing and deploying hydrogen technologies with overarching objective of becoming a global leader in stationary fuel cells for power generation and FCEV. Another major pillar of Korea's hydrogen strategy is securing a stable supply of hydrogen. In July 2020, the Korean Government announced the Green New Deal policy, outlining eight projects in three sectors, amounting to an investment of approximately $60 billion. Korea has also set the goal of achieving 70% of hydrogen imports from C02-free sources. With Australia's abundant renewable energy generation capability through solar, wind an hydropower, one of the key opportunities between our countries is to export green hydrogen from Korea to Australia to enable mobility, power generation and industrial processes such as steel/chemical with green hydrogen.

The Australian Government, meanwhile, released its National Hydrogen Strategy in 2019, which outlines the key hydrogen milestones between 2020-2030, based on the speed in which the hydrogen market advances. The Australian Government also recently released its First Low Emissions Technology Statement 2020 identifying hydrogen as one of five key priority low emission technologies with the accompanying stretch goal of achieving H2 under $2 per kilogram. While the Australian Government has been less strident in its hydrogen ambitions, private sector interest in domestic hydrogen projects has initiated the beginning of a wave of investment in the technology and has set a foundation for an export market to be developed over the coming decade. With government funding expected to decrease in the longer term, the economic viability and commercial success of hydrogen across different applications remains to be seen.

As these national strategies coalesce, the myriad of opportunities in hydrogen are emerging. This paper identifies five key areas of potential bilateral cooperation, collaboration and application of hydrogen energy and technology, including:

1. Power generation
2. Transportation
3. Industry energy and feedstock
4. Export
5. Research and development

By mapping these opportunities, we hope to establish an investment roadmap for the Australian and Korean private and public sectors. The diagram on the following page provides an overview of the key opportunities in hydrogen across multiple applications in the short, medium and long term. It is worth noting the limitations of this diagram; first, new technologies are consistently being developed, which may shift projected timelines and second, this diagram fails to identify the transition of when hydrogen becomes a low carbon fuel.



***Source**: Hydrogen Coalition Members' Study; Hydrogen Korea Study team and Australian Government policy documents.*

Question 1:

Are there any other major areas of opportunity not captured?

Question 2:

What other insights, context and background are important to note as part of the backdrop to the Australia-Korea hydrogen relationship?

1. Power generation– the future of hydrogen fuel cells

Korea's hydrogen strategy sets a goal to supply hydrogen fuel cells for power generation and achieve commercialisation to enable their export, with a view to expand the use of hydrogen fuel cells in households and buildings. Korea is also developing hydrogen gas turbines as a commercial energy generation source and expect this to be commercialised by 2030.

Australia's hydrogen strategy highlights the opportunity for hydrogen to be used in combination with renewable electricity to power remote sites like mines and small regional communities. This could be an alternative to diesel based remote area power systems which have adverse environmental impacts and this may be commercially competitive before 2025.

Australia-Korea intersections	
Short-term (2020-2025)	In the short term, it is expected that fuel cells will initially use natural gas and then transition to hydrogen as low carbon hydrogen becomes available, providing additional opportunities in the Australia-Korea relationship, given our existing and robust trade in LNG. Australia and Korea to partner to use Korean hydrogen fuel cell technology for remote sites such as mining and regional communities in Australia.
Medium-term (2025-2030)	Future regional industrial precincts/zones (e.g. NSW Government's Special Activation Precinct), critical infrastructure (e.g. telecoms) to scale up and integrate with existing/future energy systems being part of microgrid.
Long-term (2030-2050)	Expansion into aviation, space, defence assets/sites.

Question 3:

What other short, medium or long term opportunities in power generation should be included in the final paper?

Question 4:

What opportunities already identified should be expanded upon or require greater focus?

Question 5:

What defines success by 2030, 2040 and 2050 assuming the absence of continuing government support?

2. Transportation – Korea a manufacturer and global leader, Australia a consumer

Positioning itself as a global leader in fuel cells and FCEV technology, Korea's hydrogen strategy outlines the transportation industries as a potential new industrial ecosystem including passenger cars, commercial vehicles, trucks, forklifts trains, ships and airplanes.

In Australia, together with passenger vehicles, hydrogen is expected to play a key role as a fuel for heavy machinery used in industry, particularly fleet vehicles requiring rapid refuelling such as agriculture, mining and forestry. Australia

is therefore well positioned to be an early adopter or test-bed for Korea's technology in hydrogen mining vehicles and long-distance trucks. In a high hydrogen technology uptake scenario, it is predicted that hydrogen haulage vehicles will be the haulage vehicle of choice in Australia by 2030. However, overcoming challenges such as the capital cost of vehicles and required infrastructure will be critical to the development of a hydrogen mobility market in Australia. With strong existing Korean investment across Australia, especially in the mining sector, Korean companies are uniquely positioned to promote and pioneer a decarbonised agenda, and this could be accelerated by bringing in Korean Original Equipment Manufacturers (OEMs), and/or securing funding from the Export Council of Australia (ECA).

Australia-Korea intersections	
Short-term (2020-2025)	• The ACT Government has acquired a fleet of 20 Hyundai NEXOs. • Hyundai has expressed interest in participating in NSW Government trial of electric buses as NSW Government looks to transition to a zero emissions electric fleet. • Public refuelling stations to support hydrogen vehicles are being constructed in Canberra, Melbourne and Brisbane.
Medium-term (2025-2030)	• Creation of test-bed in Australia for Korean technology to decarbonise vehicle fleets such as haulage trucks and drones used in agriculture, mining and forestry. • Pioneering of a decarbonisation agenda by Korean investors across a number of sectors, and opportunity to advance this by engaging Korean OEMs and attracting ECA funding. • Pilot projects for fuel cell-powered automated (unmanned) trains operating between mining sites and export ports.
Long-term (2030-2050)	• Cruise (leisure), bulk/container carriers (commercial), small-mid size airplanes (passenger/freight).

Question 6:

What other short, medium or long term opportunities relating to hydrogen transportation should be included in the final paper?

Question 7:

What opportunities already identified should be expanded upon or require greater focus?

Question 8:

What defines success by 2030, 2040 and 2050 assuming the absence of continuing government support?

3. Industry energy and feedstock – replacing carbon-intensive fossil fuels with hydrogen

Globally, industries such as shipping, steel-making and chemical production see hydrogen as a long-term alternative to their dependence on fossil fuels. Abundant clean hydrogen will present the opportunity to decarbonise sectors currently dependent on thermal coal, gas and liquid fossil fuels. It could give Australian and Korean manufacturers of energy-intensive products such as steel a comparative market advantage because they will be able to use low-cost hydrogen near where it is produced. As an example, POSCO, Korea's largest steel maker, has indicated it will become the largest green hydrogen consumer when the hydrogen reduction steelmaking process is adopted, which involves hydrogen replacing coal as the reductant.

Due to Korea's large-scale industrial base and refining and petrochemical industry, one of Korea's major goals is to utilise hydrogen generated as a by-product of petrochemical processes. To that end, it has already secured the technologies necessary to produce hydrogen pipelines and high-purity hydrogen. For example, Hanwha Energy has built a power plant which uses by-product hydrogen to generate electricity using Doosan hydrogen fuel cells, which will power up to 160,000 households per year.

In Australia, an immediate opportunity is the use of clean hydrogen as an industrial feedstock (primarily for refining and ammonia production), which requires the displacement of grey hydrogen used in steam methane reforming with green hydrogen from renewable energy. The point that this will be economically viable is driven by the price of natural gas against reductions in the cost of hydrogen via electrolysis. With the cost of renewable energy falling and no further development of technology required, the cost of green hydrogen is expected to become comparative to grey hydrogen by approximately 2030. While it is difficult to estimate accurately when green hydrogen will be cost competitive, it is important to note that this timeframe may be brought forward if a green premium starts to emerge for commodities produced on a low carbon basis or through the introduction of other incentives such as subsidies.

The falling cost of renewable energy is also expected to help Australia transition its economy from a resource extraction energy industry to a manufacturing one. It will also help preserve the longevity of Australia's existing exports and potentially create new industries. Australia's Low Emissions Statement highlights low emissions aluminium and steel as two priority areas for Australia, with the production of renewable hydrogen as a way of linking low cost renewable energy with energy intensive industries such as metals manufacturing. Low cost renewable energy, for example, can allow for more iron ore and bauxite processing in Australia whilst continuing more advanced processing offshore in Korea. The technological risks of production of aluminium and steel, however, must be addressed before this becomes a reality.

Rio Tinto is working with its joint venture partner Alcoa to manufacture a green aluminium product and both Australia and Korea have identified green steel as a future industry. Whyalla steelworks is planning to use hydrogen in place of metallurgical coal in the steelmaking process, and has set a goal to be the largest producer of carbon-neutral steel by 2030. While this could represent an area of competition between Australia and Korea, it may also provide opportunities for further R&D collaboration between our two countries.

Australia-Korea intersections	
Short-term (2020-2025)	Small scale corporates start to transition from grey hydrogen to green hydrogen to meet net zero targets.
Medium-term (2025-2030)	Larger scale displacement of grey hydrogen with green hydrogen for hydrogen as an industrial feedstock.
Long-term (2030-2050)	Manufacture of green steel and green aluminium.

Question 9:

What other short, medium or long term opportunities in industry energy and feedstock should be included in the final paper?

Question 10:

What opportunities already identified should be expanded upon or require greater focus?

Question 11:

What defines success by 2030, 2040 and 2050 assuming the absence of continuing government support?

4. Export – Australia positioned as a future supplier of hydrogen to Korea

Given Australia's abundance of solar and wind resources and the falling cost of renewable energy, together with our reputation as a trusted energy exporter, Australia has the potential to lead the global shift to hydrogen and produce hydrogen for global export. South Korea has identified that by 2030 it will require hydrogen imports to sustain its energy needs. Technologies required to store hydrogen in liquid form for transportation have yet to be developed and further research is required. Korea is also seeking to develop a liquid hydrogen carrier, utilising LNG carrier building technology starting in 2025. In the short-term, it is likely that hydrogen will be developed and produced in partnership with existing fossil fuel industries and over time, that this will transition from grey hydrogen to at least 70% of green hydrogen or CO2 free hydrogen by 2040.

The Korean Government strategy indicates that Korea's need for hydrogen will increase from 130,000 tonnes in 2018, to 470,000 tonnes in 2022 to 5,260,000 tonnes in 2040 for energy use. An additional 2,000,000 tonnes will also be required for industrial use. As indicated at the 2020 AKBC-KABC Joint Meeting, POSCO is interested in forming a joint venture with an Australian partner to produce green hydrogen and with the opportunity to also use POSCO's PosMAC non-corrosive steel in PV's used in solar panels.

Australia-Korea intersections	
Short-term (2020-2025)	AUS-KOR Joint Feasibility Study on Export Supply Chain followed by pilot project(s)
Medium-term (2025-2030)	Joint assessment of pilot project(s) and scale up to commercialisation
Long-term (2030-2050)	Australia becomes a major supplier of hydrogen to Korea

Question 12:

What other short, medium or long term opportunities relating to the export of hydrogen should be included in the final paper?

Question 13:

What opportunities already identified should be expanded upon or require greater focus?

Question 14:

What defines success by 2030, 2040 and 2050 assuming the absence of continuing government support?

5. Australia-Korea research and development partnerships

Both Australia and Korea recognise that international collaboration in is essential to develop global hydrogen supply chains and expand the global hydrogen market. In particular, scientific and technological cooperation and partnerships are essential to address the technical barriers, economic costs and support a hydrogen economy, especially around fuel cell efficiency and storage. International collaboration offers an effective way to accelerate hydrogen technology development while simultaneously supporting relationship building. Australia and Korea are natural partners, with Australia an existing and reliable energy exporter to Korea. In their respective strategies, both the Australian and Korean governments identify each other as critical to realising their goals and there are several examples of cooperation across many different aspects of the value chain.

5.1 Government

The Australian and Korean Governments signed a Letter of Intent for Hydrogen Cooperation in September 2019 demonstrate commitment at the government level.

5.2 Industry

Supporting this, several industry partnerships between Australia and Korea exist, including:

- Australian Hydrogen Council & H2 Korea MoU, signed November 2019.
- ATSE & National Academy of Engineering of Korea (NAEK) joint workshop of Hydrogen Futures in March 2020.
- Jemena, Coregas & Hyundai Motors Australia MoU in August 2020 for supply of green hydrogen to Hyundai's Macquarie Park hydrogen refuelling station.
- Woodside, Hyundai Motor Group & KOGAS. Woodside has invested in the Korean Hydrogen Energy Network (HyNet) consortium, which is led by KOGAS and Hyundai Motor Company.
- Hyundai Motor Company, CSIRO and Fortescue Metals Group signed an MOU in August 2020, to collaborate on innovative hydrogen production technology including technology relating to an ammonia cracker which would provide a solution for the large-scale transportation of hydrogen overseas.
- Santos and SK Group signed an MOU which provides a framework to jointly investigate zero emissions hydrogen, including potential to export and supply hydrogen to overseas markets, including Korea as well as future carbon abatement projects including CCS projects.
- As mentioned at the 2020 AKBC-KABC Joint Meeting, POSCO is currently seeking partnerships for joint development of ammonia steam reforming technology for hydrogen production and other areas for joint research include hydrogen liquefication, hydrogen extraction, electrolysis and carbon capture and storage.

Korean companies are also investing heavily in R&D:

- Hyundai Motors Group (HMG) is strongly committed to the hydrogen economy. HMG was the first company to mass produce FCEV and with the production of NEXO they have been committed to sector and estimate investment of 7.6 trillion won in 2030 with applications of the fuel cell beyond passenger cars, expanding into other vehicle applications such as train rolling stock and forklifts. HMG is committed to investing in the whole supply chain, beyond just mobility applications including production (including LNG reforming, liquefied hydrogen production), storage and delivery, refuelling (business models such as integrated stations) and application.
- POSCO has set targets to reduce its reliance on fossil fuels and transition to renewable energy sources. POSCO plans to establish a hydrogen business and collaborate with research agencies at home and abroad to develop related technologies and meet the growing demand for the clean energy source and foster new growth drivers. POSCO aims to scale up its hydrogen production capacity to five million tons in the next three decades and reduce its carbon emission to net-zero by 2050.[1]
- Hydrogen is high on the agenda for SK Holdings with a newly established hydrogen business team comprising some 20 energy experts from relevant subsidiaries SK E&S, SK Innovation and others to report directly to the CEO. The hydrogen team members have over 15 years of experience in the energy business on average, according to SK Holdings. It also plans to start mass-producing liquefied hydrogen from 2023.[2]

Question 15:

Are there any other industry collaborations or R&D projects that should be highlighted?

5.3 University

The Australian Embassy in Korea is currently working with the Korean Government to identify potential research and technology related collaborations between Australian and Korean Universities in hydrogen.

5.4 Hydrogen hubs and pilot cities

In order to realise the hydrogen potential, both countries are seeking to create hydrogen hubs or pilot cities that are clusters of large-scale demand and will complement other areas of hydrogen use in transport, industry and gas distribution networks. In Korea, Ansan, Ulsan and Jeonju/Wanju have been named as the test cities and in Australia it is expected that the hubs will comprise ports, cities, regional and/or remote areas. These hubs will provide opportunities for Korean participation, and investment, from conglomerates such as Hyundai and Hanwha Group who may be able to participate in several aspects of the value chain, such as power generation, mobility and logistics.

1. https://koreajoongangdaily.joins.com/2020/12/13/business/industry/Posco-hydrogen/20201213183100472.html
2. http://www.koreaherald.com/view.php?ud=20210124000153

Australia-Korea intersections	
Short-term (2020-2025)	• Australia and Korea to form industry partnerships and work together on research and development projects relating to the hydrogen economy. • Opportunity for Korean conglomerate participation and investment in Australian hydrogen hubs to assist in technology development and use of hydrogen. • Korea to establish pilot projects in Australia.
Medium-term (2025-2030)	• Scale up pilot project(s).
Long-term (2030-2050)	• Convert pilot projects into 'Smart H2 City/Precinct/Zone' that is coupled with advanced digital technologies (e.g. AI, Big Data, IoT, Blockchain)

Question 16:

What other short, medium or long term opportunities relating to hydrogen research and development should be included in the final paper?

Question 17:

What opportunities already identified should be expanded upon or require greater focus?

Question 18:

What defines success by 2030, 2040 and 2050 assuming the absence of continuing government support?

Consultation

Please email your response to this Discussion Paper to:

Liz Griffin – **lgriffin@akbc.com.au** by Friday, 12 March 2021.

All feedback will be considered by the AKBC's energy-subcommittee and form the basis of AKBC's Final Paper on mapping the key opportunities and intersections in hydrogen.

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