

Hydrogen RD&D Collaboration Opportunities: The Republic of Korea

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Executive summary: The Republic of Korea

The Republic of Korea (Korea) is a global leader in hydrogen and has positioned themselves as a leading country in the development of a hydrogen economy. The *Hydrogen RD&D Collaboration Opportunities: The Republic of Korea* chapter aims to enhance country-to-country engagement by providing stakeholders with an overview of Korea's hydrogen priorities and ecosystem. This report also includes a publication and intellectual property (IP) scan, identifying the key stakeholders in Korea actively undertaking hydrogen RD&D, both at the early research and commercialisation stages.

The Republic of Korea's hydrogen strategy

Korea's hydrogen push is driven primarily by three key factors – economic growth, emissions reduction, and energy security. Korea's hydrogen strategy focuses strongly on the expansion of fuel cell vehicles domestically and internationally. Korea seeks to be a leader and technology exporter in fuel cells for both vehicles and stationary applications. This also involves the deployment of hydrogen refuelling stations domestically. Korea has also recognised the importance of transitioning from hydrogen derived from fossil fuels to hydrogen derived from renewables, including for their energy imports. Korea is also pursuing the expansion of fuel cells for stationary power generation, currently a small fraction of Korea's energy mix.

The Republic of Korea's targets and RD&D priorities

Korea's targets for 2040 are to supply 5.26 million tonnes of hydrogen a year (70% of which would be imported or produced via electrolysis or as a by-product of the petrochemical sector, and 30% of which would be extracted), to manufacture 6.2 million fuel cell vehicles (exporting 3.3 million), to produce 15GW of fuel cell power generation (exporting 7GW), and to produce 2.1GW of fuel cell energy for homes and buildings. Korea also wants to develop and commercialise hydrogen gas turbine technology before 2030. Korea has also expressed an interest to increase its self-sufficiency rate of renewable hydrogen to at least 60% by 2050.

To achieve these goals, Korea is investing in RD&D in a variety of areas.

Production
Electrolysis: polymer electrolyte membrane, alkaline
Fossil fuel conversion: methane reforming
Biomass and waste conversion

Utilisation
Transport: fuel cells, refuelling stations, fuel cell trains, fuel cell ships
Electricity generation: hydrogen turbines, fuel cells
Industrial processes: steel processing, combustion

Storage and distribution
Compression and liquefaction: pressurised storage, pipelines
Chemical: ammonia, hydrides, synthetic fuels
Other: Tube trailers, tank lorries and carrier ships

Cross-cutting
Safety (fuel cell vehicles and refuelling stations)

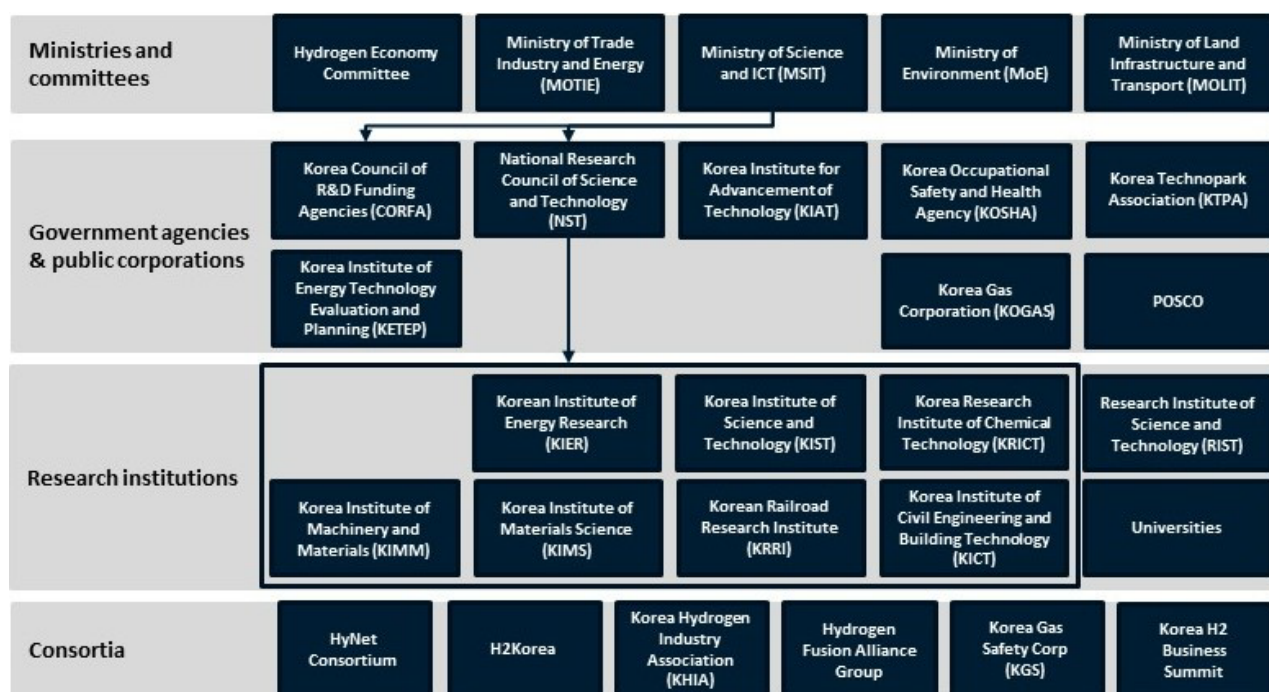
The Republic of Korea's domestic hydrogen landscape

The main government body driving hydrogen strategy and RD&D policy in Korea is the Ministry of Trade, Industry and Energy (MOTIE). MOTIE also receives contribution from other ministries, industry and academia captured in its two roadmaps – the *Hydrogen Economy Roadmap* and *National Roadmap of Hydrogen Technology Development*.

Implementation of hydrogen RD&D in Korea takes place in a decentralised manner across numerous public research institutions, each looking at discrete hydrogen technology areas. Notable bodies are the National Research Council of Science and Technology (NST) which manages 25 national research institutes such as the Korean Institute of Energy Research (KIER) and the Korea Institute of Science and Technology (KIST), and the Korea Institute of Technology Evaluation and Planning (KETEP) as the main national RD&D funding institute which manages the full cycle of all hydrogen and energy related projects.

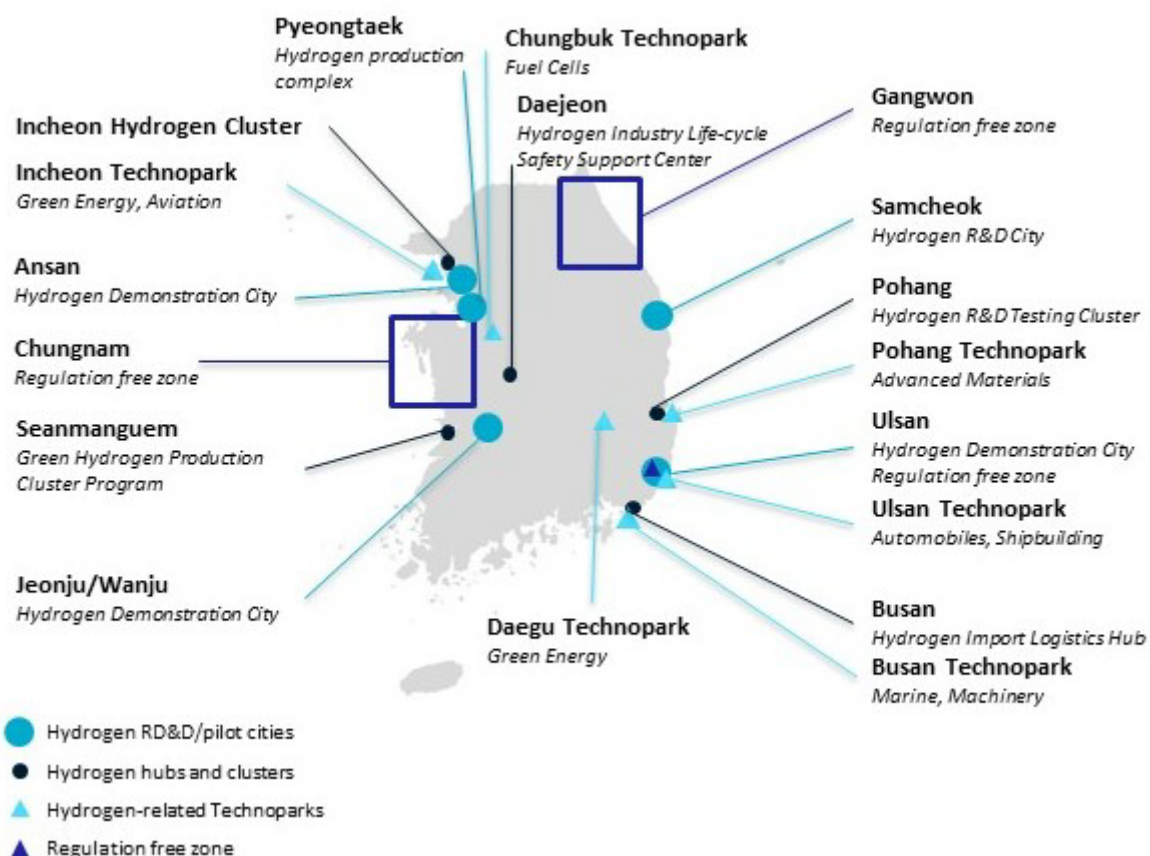
There are also several hydrogen consortia within Korea's hydrogen ecosystem, notably H2Korea, the HyNet Consortium and the Korea Hydrogen Industry Association (KHIA).

Figure 1: Summary of main players in Korea's hydrogen RD&D ecosystem



Industry, academia and government are collaborating to bring about hydrogen clusters (also known as hydrogen valleys or ecosystems). These are hydrogen value chain demonstrations and pilot projects that cut across sector applications. The major clusters of hydrogen activity in Korea include hydrogen RD&D cities, hydrogen pilot cities, hydrogen hubs and clusters, and hydrogen-related 'Technoparks':

Figure 2: Korea's hydrogen clusters



IP and publications scan

Several universities, public research institutions and private companies are highly active in early-stage hydrogen research and late-stage technology commercialisation. This is reflected in hydrogen research publication output and patent output data.

Table 1: Top organisations active in early-stage and late-stage hydrogen RD&D

Rank	Top organisations (Research publication output)	Top organisations (Hydrogen patent output)
1	Korea Advanced Institute of Science and Technology (KAIST)	Hyundai Motor
2	Korea University	Korea Institute of Energy Research (KIER)
3	Seoul National University (SNU)	KIA Motors
4	Yonsei University	Daewoo Shipbuilding & Marine Engineering
5	Korea Institute of Science and Technology (KIST)	Korea Institute of Science and Technology (KIST)

International collaboration

Korea's *Hydrogen Economy Roadmap* signalled a strong intent to collaborate on hydrogen safety and the establishment of international standards, infrastructure to establish overseas hydrogen import bases, and on hydrogen technologies which align with Korea's RD&D strategic priorities. Korea has strong international partnerships with respect to hydrogen RD&D and commercial deployment, including with the United States, Norway and the European Union. Korean industry bodies and consortia have also signed Memorandums of Understanding (MoUs) with Israel, the UAE, Saudi Arabia and Qatar.

Activity levels for hydrogen and net-zero initiatives is high. While effort has been made to capture major announcements and key information as at 28 January 2022, the content is intended to provide a starting point for informing international engagement, particularly when used in conjunction with other reports in the series, and is non-exhaustive.

1 Country analysis: The Republic of Korea

1.1 Introduction

For at least the last decade, the Republic of Korea (Korea) has been considered a global leader in hydrogen. Driven primarily by the desire for economic and technological development, emission reduction efforts and energy security, Korea has positioned itself as a frontrunner in the hydrogen economy and has set long-term targets through to 2040. The purpose of these targets and the related roadmaps are to shape the development of Korea's hydrogen industry and maintain Korea's position as a key global market in the hydrogen economy.

Backing this hydrogen push is strong public funding in the form of research, demonstration and deployment (RD&D)¹ projects and subsidies and an increasingly active private sector taking on demonstration and commercialisation activities. This has led to world-leading developments, such as Korea-based car manufacturer Hyundai commercialising the first fuel cell vehicle in 2013 and first fuel cell truck in 2020, and Korea accounting for one-third of global installed capacity of utility-scale stationary fuel cells. Korea is also expanding demonstration and innovation activity across the country by way of 'hydrogen cities', designated 'hubs and 'clusters', 'regulation free zones', and regional 'Technoparks'.

The *Hydrogen RD&D Collaboration Opportunities: Republic of Korea* report presents an overview of the hydrogen RD&D landscape in Korea, starting from the national strategy level, down to activity in specific hydrogen technology areas.

1.2 The Republic of Korea's hydrogen drivers, strategy and RD&D priorities

1.2.1 The Republic of Korea's key drivers

Korea's hydrogen push is driven primarily by three key factors – economic growth, emissions reduction, and energy security.² However, while Korea has specified emissions reductions as a driver for their hydrogen strategy, it is primarily driven by the desire for economic growth and improving industrial competitiveness.³ With limited natural resources, hydrogen provides a way to improve Korea's energy security.⁴

- **Economic growth:** Korea's primary driver for developing its hydrogen industry is economic growth and national technology development. Korea sees hydrogen utilisation in industry and the mobility market as key for potential future economic growth, alongside a portfolio of other emerging technologies such as 5G networks, artificial intelligence (AI), system semiconductors, biotechnology and autonomous vehicles.⁵ Specifically, Korea has identified the transport and energy sectors as key end markets for utilisation (particularly fuel cells), and the industries and small to medium enterprises (SMEs) involved in supply chain activities (chemical and mechanical design, materials and

¹ As defined by the IEA Guide to Reporting Energy RD&D Budget/Expenditure Statistics, 2011

² Government of Korea (2019) Hydrogen Economy Roadmap of Korea.
https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

³ WEC, Ludwig-Bölkow-Systemtechnik (2020) International Hydrogen Strategies, Weltenergierrat Deutschland.

⁴ South Korean efforts to transition to a hydrogen economy <https://link.springer.com/content/pdf/10.1007/s10098-020-01936-6.pdf>

⁵ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

components) as key growth areas. This highlights Korea's focus on employment opportunities that will result from investing in the development of the national hydrogen economy.

- **Emissions reduction:** Secondary to economic growth and industrial competitiveness, Korea recognises hydrogen's potential to achieving its emissions reductions targets. Korea's National Assembly has passed a carbon neutrality act, which includes reduction target of carbon dioxide (CO₂) emissions by at least 35% of 2018 levels by 2030, and a national vision to achieve net zero by 2050.⁶
- **Energy security:** Finally, Korea has identified that domestically producing hydrogen enables them to reduce their energy dependency on foreign countries and diversify their imports. This is particularly important for Korea given their low energy independence, which ranked 33rd out of 35 OCED countries in 2016.⁷

1.2.2 The Republic of Korea's strategic hydrogen industry priorities

Korea has outlined six key opportunities for the development of their hydrogen economy – hydrogen production, hydrogen storage and transportation, exports, hydrogen fuel cell electric vehicles (FCEVs), hydrogen vehicles, and the economics of hydrogen. However, while Korea's *Hydrogen Economy Roadmap*⁸ covers various areas of the hydrogen economy, much of the plan focuses on the expansion of FCEV's domestically and internationally.⁹ Korea is also pursuing the expansion of fuel cells for stationary power generation, currently a small fraction of Korea's energy mix.¹⁰

- **Fuel cells:** Korea's first priority is the acceleration of the utilisation of hydrogen domestically, particularly in the transportation and energy sectors. Specifically, Korea wishes to be a world leader in fuel cell electric vehicles and large-scale stationary fuel cells for power generation.¹¹ This includes use in fuel cell vehicles across private and public transportation (e.g. taxis, buses and trucks), improving accessibility to hydrogen fuelling stations, export of hydrogen fuel cells, and use of fuel cells in households and buildings.
- **Production:** Korea has recognised the importance of transitioning hydrogen production from fossil fuels to hydrogen production from renewables. This includes both domestic production and mass-importing hydrogen produced from renewables. However, this is not the central focus of their hydrogen strategy. Korea's near-term strategy pursues the production of hydrogen from fossil fuels, to provide greater flexibility in light of limited renewable resources and reliance on energy imports.
- **Storage and distribution:** Korea aims to reduce the cost of hydrogen distribution by establishing mass-scale efficiency infrastructure. For storage, this involves converting from high-pressure gas storage to high-efficiency liquefaction, liquid storage and solid storage. For distribution this also involves high-efficiency and high-capacity storage and transportation systems.

⁶ Hyeon-woo K (2021) Korea becomes 14th in world to legislate carbon neutrality act. The Korea Herald <http://www.koreaherald.com/view.php?ud=20210901000812>

⁷ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

⁸ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

⁹ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

¹⁰ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

¹¹ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

- **Cross-cutting:** Safety is Korea's primary cross-cutting priority. The two priorities in safety are to promote systematic safety management measures, including the enactment of the Hydrogen Safety Act, the establishment of the Hydrogen Safety Support Centre, and to raise public awareness around hydrogen safety.¹² In addition to this, Korea sees standardisation and social infrastructure as important. This includes the development of a cross-ministerial technology roadmap to facilitate technological innovation (incorporated in the 2019 roadmap document), implementing open innovation for international cooperation, enacting the Hydrogen Economy Act as a legal base, and positioning hydrogen as a growth opportunity for SMEs in downstream industries.

The Republic of Korea's hydrogen targets

The *2020 Carbon Neutral Strategy of the Republic of Korea*¹³ outlines a vision to move to carbon neutrality by 2050, citing its *Green New Deal*¹⁴ as a central pillar, and expanding the use of clean power and hydrogen across all sectors as a key element.¹⁵

In the preceding 2019 *Hydrogen Economy Roadmap*¹⁶ and *National Roadmap of Hydrogen Technology Development*.¹⁷ Korean government outlined more specific hydrogen industry targets up until 2040. These targets were across end-use applications and production. The hydrogen targets were separated by domestic consumption goals and export goals.¹⁸

- **Hydrogen vehicles:** Korea is aiming to have 120,000 hydrogen taxis, 60,000 hydrogen buses, and 120,000 hydrogen trucks on their roads by 2040. In addition, they are aiming for 1,200 hydrogen fuelling stations as well as commercialisation and export projects for trains, ships and drones to be implemented before 2030 through RD&D. The more recent *2050 Carbon Neutral Strategy*¹⁹ also sets a 2030 target of 850,000 hydrogen vehicles deployed.²⁰
- **Hydrogen supply:** As well as quantity, Korea has included goals for hydrogen production methods. For 2022, the goal is for hydrogen to be supplied as a by-product of petrochemical processes, electrolysis and 'hydrogen extraction' (production from natural gas).

¹² Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

¹³ Government of the Republic of Korea (2020) 2050 Carbon Neutral Strategy of the Republic of Korea. https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

¹⁴ MOEF (2020) Korean New Deal: National Strategy for a Great Transformation. <https://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=4948>

¹⁵ Korea has not legally defined the terms 'clean' or 'low-carbon' hydrogen. However, in practice, Korea has used these terms to refer to hydrogen that has been produced from renewable sources, or from fossil fuel conversion with CCUS; Government of the Republic of Korea (2020) 2050 Carbon Neutral Strategy of the Republic of Korea. https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

¹⁶ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

¹⁷ Monthly Hydrogen Economy (2020) 'Hydrogen technology development roadmap' at a glance. <https://www.h2news.kr/mobile/article.html?no=8559>; Sichao Kan (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. https://www.ifri.org/sites/default/files/atoms/files/sichao_kan_hydrogen_korea_2020_1.pdf

¹⁸ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

¹⁹ Government of the Republic of Korea (2020) 2050 Carbon Neutral Strategy of the Republic of Korea. https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

²⁰ Government of the Republic of Korea (2020) 2050 Carbon Neutral Strategy of the Republic of Korea. https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

Further, at the 4th Hydrogen Economic Committee, held in November 2021, the Korean government announced it had discussed the ‘1st Basic Hydrogen Economy Implement Plan’²¹ and associated targets. This plan is the first legal plan related to the hydrogen economy. Through this, Korea plans to provide nearly 28 million tons of hydrogen produced from renewables and fossil fuel conversion with CCUS per year by 2050, and to increase Korea’s self-sufficiency rate to over 60% by expanding domestic production and importing hydrogen from overseas that is produced using Korean technology and/or via investment.²²

Table 2: The Republic of Korea’s hydrogen targets²³

	2018	2022	2040
Hydrogen vehicles	18,000 (export 900)	81,000 (export 14,000)	6,200,000 (export 3,300,000)
Passenger Vehicle	1,800	79,000	5,900,000
Taxis	-	-	120,000
Buses	2	2,000	60,000
Trucks	-	-	120,000
Other (Trains, Ships, Drones)	RD&D, commercialisation and export projects before 2030		
Fuelling Stations	14	310	1,200+
Energy (Fuel Cell Power Generation)	307 MW	1.5 GW (1 GW domestic demand)	15 GW (8 GW domestic demand)
Energy (Fuel Cells Homes/buildings)	7 MW	50 MW	2.1 GW
Energy (Hydrogen Gas Turbine)	Technology developed before 2030		
Hydrogen supply	130,000 t/year	470,000 t/year	5,260,000 t/year
Supply Method	By-product petrochemical (1%) Hydrogen Extraction (99%)	By-product petrochemical Hydrogen extraction Water Electrolysis	By-product petrochemical, water electrolysis, overseas production (70%) Hydrogen Extraction (30%)
Hydrogen price	-	KRW 6,000/kg	KRW 3,000/kg

²¹ Lee Min-jae & YS Jung (2021) Utility/Renewable Energy Industry: Hydrogen Economy 1st Basic Plan Unveiled. <http://www.businesskorea.co.kr/news/articleView.html?idxno=82476>

²² Ministry of Trade, Industry and Energy (2021) Minister Moon attends Hydrogen Economy Committee Meeting. Viewed at http://english.motie.go.kr/en/pc/photoneews/bbs/bbsList.do?bbs_cd_n=1&bbs_seq_n=1150

²³ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

1.2.3 The Republic of Korea's hydrogen RD&D priorities

Table 3 describes Korea's RD&D priorities across the value chain and is broken down by supply chain area. The table below outlines the sub-technology areas where Korea is focussing their RD&D efforts and the key priorities under those areas. These priorities are collated from the *Hydrogen Technology Roadmap* within the 2019 *The Hydrogen Economy Roadmap*.²⁴

Table 3: The Republic of Korea's hydrogen RD&D priorities²⁵

Supply chain area	Sub-technology areas	Korea's key RD&D priorities
Production	Electrolysis	<p>Alkaline electrolysis (AE):</p> <p>Standardise and localise manufacturing polymer and electrolytic cell parts.</p> <p>Secure high-capacity alkaline electrolysis technology.</p> <p>Polymer electrolyte membrane (PEM):</p> <p>Localise manufacturing for standardise polymer and electrolytic cell parts.</p> <p>Secure high-capacity PEM electrolysis technology.</p> <p>Systems:</p> <p>Water electrolytic integration system technology linked with renewable energy.</p> <p>Improve lifespan and power consumption of water electrolytic systems.</p>
	Biomass	Secure hydrogen production technology utilising biomass such as waste.
	Natural gas reforming	Localise and improve efficiency.
Storage and distribution	Compressed gas	<p>Demonstrate large-scale hydrogen gas storage and transportation (450 bar).</p> <p>Develop high-pressure complex vessels for hydrogen fuelling (900 bar).</p>
	Liquefied hydrogen	Develop designs and core parts related to liquefied hydrogen storage and transportation.
	Solid carriers	<p>Develop solid hydrogen storage technology for transportation.</p> <p>Develop high-pressure gas-solid/liquid-solid hybrid storage technology.</p>
	Liquid carriers	Develop liquid compound materials and storage/transportation technology.
	Pipelines	<p>Demonstrate pipeline transport of hydrogen.</p> <p>By 2022, establish hydrogen pipelines near sources of by-product hydrogen production. Short distance piping infrastructure (within 10km).</p>

²⁴ Government of Korea (2019) Hydrogen Economy Roadmap of Korea.
https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

²⁵ Government of Korea (2019) Hydrogen Economy Roadmap of Korea.
https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

Supply chain area	Sub-technology areas	Korea's key RD&D priorities
		<p>By 2025 demonstrate hydrogen supply to adjacent areas by installing pipelines at import bases.</p> <p>By 2030 high-pressure hydrogen pipelines to service high-demand areas nationwide. This includes improved materials.</p>
	Transportation (ships)	<p>Develop liquid hydrogen carriers utilising LNG carrier building technology.</p> <p>Construct a liquid hydrogen storage and acquisition base.</p>
	Transportation (tank lorries and tube trailers)	<p>Develop transportation (tank lorry) low-pressure liquid hydrogen (3 bar) and fuelling technology.</p> <p>Develop ultra-high pressure tube trailers (450, 900 bar).</p>
Utilisation	Gas turbines	Develop and localise manufacturing of hydrogen gas turbine technology.
	Steel	Developing and demonstrating hydrogen in direct iron reduction steelmaking technologies using carbon as fuel and ingredient from 2025. ²⁶
	Hydrogen vehicles	<p>Develop metropolitan hydrogen bus technology (including design, motor, vessel etc.).</p> <p>Launch 5-10 ton hydrogen trucks by 2021, and 30 ton trucks by 2024. Note that this has progressed at that 35-ton hydrogen trucks are already on the road in Korea.²⁷</p> <p>Establish local manufacture of hydrogen truck parts by 2030.</p> <p>Develop and demonstrate 5-10 ton public special freight vehicles by 2023. This includes garbage trucks, honey wagons, sprinkler trucks and others.</p> <p>Secure high pressure hydrogen vessels and high-voltage converters for buses.</p> <p>Demonstrate hydrogen taxis to analyse and improve durability of parts.</p> <p>Develop technology for localising electric parts (inverters and converters).</p> <p>Localise, scale-up and reduce cost of production for core parts (compression valves, storage containers) and fuelling technology.</p> <p>Improve hydrogen storage density/gravimetric capacity (wt%).</p>
	Fuelling stations	<p>Develop 1 to 2-ton per day hydrogen refuelling technology.</p> <p>Develop liquid hydrogen refuelling station technology.</p> <p>Develop high-pressure complex vessel for hydrogen fuelling stations (900 bar).</p>
	Fuel cells (power generation)	<p>Develop technology for high-power fuel cells.</p> <p>Standardise and localise all parts of fuel cells for power generation.</p> <p>Improve lifespan and efficiency of parts for homes and buildings.</p>

²⁶ The Government of the Republic of Korea (2020) 2050 Carbon Neutral Strategy of the Republic of Korea
https://unfccc.int/sites/default/files/resource/LTS1_RKorea.pdf

²⁷ Consultation with in-country stakeholders.

Supply chain area	Sub-technology areas	Korea's key RD&D priorities
		Develop automated manufacturing of fuel cell technology for power generation. Develop IoT-linked products to maximise fuel and heat utilisation.
	Fuel cells (ships and trains)	Develop and demonstrate fuel cells for trains and ships. Improve hydrogen train efficiency.
Cross-cutting	Safety (mobility)	R&D to improve hydrogen vehicle safety related to collisions, rollovers, and fires. Minimise safety incidents with respect to storage of hydrogen within FCEVs. Develop safety evaluation method for fuelling station and parts. Safety for hydrogen trains.

1.3 The Republic of Korea's hydrogen RD&D ecosystem

1.3.1 Public bodies and policy ecosystem

Overview of the Republic of Korea's STI policy landscape

Korea's science and technology innovation (STI) system has historically been described as 'top-down' and derives much of its success from the promotion of close collaboration between government, industry and research.²⁸ Since the early 2000s, Korea's focus has been on developing creative capabilities in science and technology.

The Creative Economy Initiative, introduced in 2013, was a strategy implemented to shift Korea from an industrial economy to a knowledge economy by leveraging their domestic science, technology and innovation ecosystems. The primary aim was to change the focus of their research and innovation system on the innovative application of technology and entrepreneurship.²⁹

The latest *Basic Plan*³⁰ outlined by Korea's Government for science and technology (for 2018-2022) outlines the latest strategies for STI. These include expanding the capacity of STI, by actively exploring and supporting creative talent; linking research outcomes to new industries; strengthening the private sector to play a leading role in an innovation-centred science and technology ecosystem; and fostering new industries to prepare and capitalise on the fourth industrial revolution.³¹

Overview of the Republic of Korea's hydrogen policy landscape

The Hydrogen Economy Committee (established under the Hydrogen Economy Law) is the "control tower" of hydrogen policy in Korea. The Committee is made up of experts from eight related ministries including

²⁸ Dayton L (2020) How South Korea made itself a global innovation leader, *Nature*, <https://www.nature.com/articles/d41586-020-01466-7>

²⁹ The Innovation Policy Platform (2016) Korea: STI Outlook 2016 Country Profile, <https://www.innovationpolicyplatform.org/www.innovationpolicyplatform.org/content/korea/index.html>

³⁰ Korea Institute of S&T Evaluation and Planning (2017) Public Hearing on the 4th Science and Technology Basic Plan (2018-2022). https://kistep.re.kr/board.es?mid=a20501000000&bid=0051&act=view&list_no=37019&tag=&nPage=16

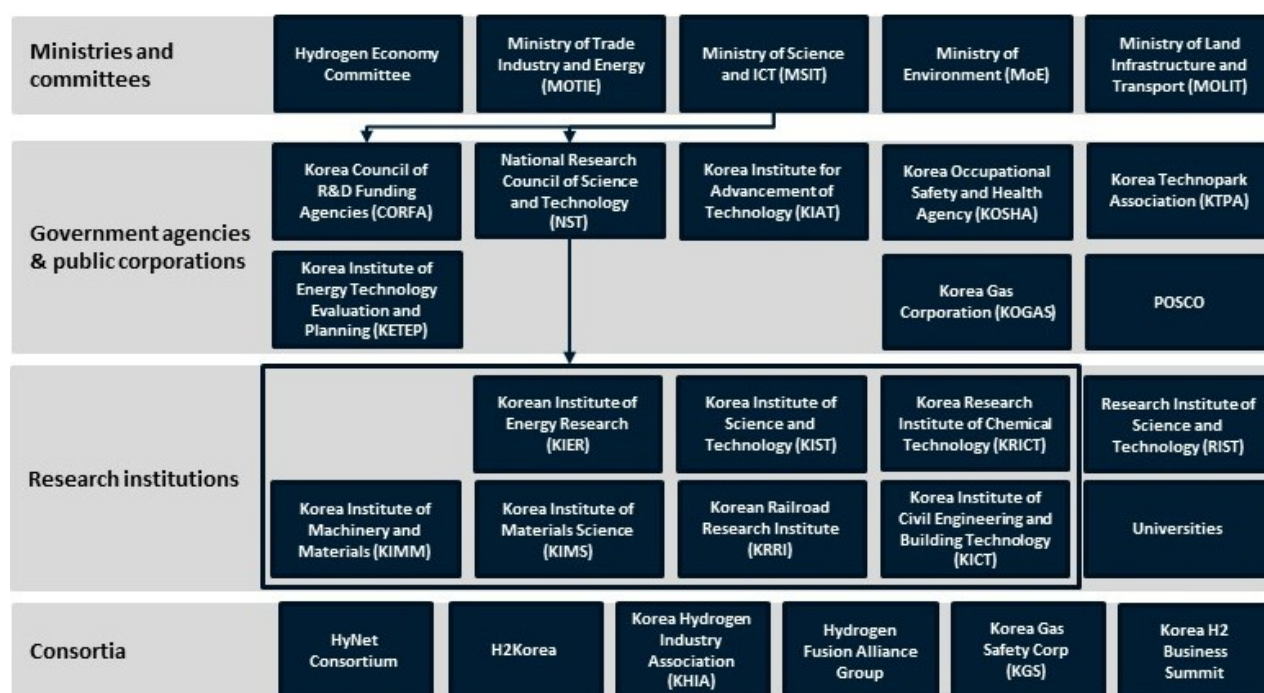
³¹ United Nations ESCAP (2018) Evolution of Science, Technology and Innovation Policies for Sustainable Development: The Experiences of China, Japan, and Singapore, https://www.unescap.org/sites/default/d8files/knowledge-products/UN_STI_Policy_Report_2018.pdf

the Ministry of Trade, Industry and Energy (MOTIE), as well as industry and academia.³² Hydrogen-specific strategies are drafted at the ministerial level by MOTIE with contribution from other ministries. These strategies are captured in Korea's strategy – the *Hydrogen Economy Roadmap*³³ and *National Roadmap of Hydrogen Technology Development*.³⁴

The implementation of hydrogen RD&D takes place in a decentralised manner, with several government research institutions undertaking different aspects of hydrogen RD&D. The National Research Council of Science and Technology (NST) acts as a management agency for the government research institutes, and the Korea Council of R&D Funding Agencies (CORFA) also plays a promotion and coordination role. Hydrogen demonstration projects in Korea are usually undertaken jointly by ministries, regional and city governments, research institutions and large industry groups, with strong involvement from MOTIE.

The key bodies involved in hydrogen RD&D and the overall system structure are depicted below in Figure 3. A more detailed description of their roles in Korea's STI system and their specific hydrogen activity are summarised in Table 4. Details of funding for hydrogen (bodies providing major funding, the types of funding, and what specific hydrogen areas are targeted) are explained in section 1.3.3 *Funding mechanisms*. Finally, sections 1.4 *The Republic of Korea's domestic hydrogen RD&D* and 1.5 *International collaboration* provide details of the specific domestic and international RD&D programs and their budgets.

Figure 3: Summary of the Republic of Korea's hydrogen RD&D policy ecosystem



³² Herh M (2020) Korea Government Launches Hydrogen Economy Committee, Business Korea, <https://www.businesskorea.co.kr/news/articleView.html?idxno=48415>.

³³ Government of Korea (2019) Hydrogen Economy Roadmap of Korea. https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

³⁴ Monthly Hydrogen Economy (2020) 'Hydrogen technology development roadmap' at a glance. <https://www.h2news.kr/mobile/article.html?no=8559>; Sichao Kan (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. https://www.ifri.org/sites/default/files/atoms/files/sichao_kan_hydrogen_korea_2020_1.pdf

Table 4: Summary of key public bodies

Body	Role in RD&D ecosystem	Hydrogen initiatives
National Assembly	National legislative body of Korea.	<p>Passed the Carbon Neutrality and Green Growth act mandating a 35% cut in greenhouse gas emissions by 2030 and carbon neutrality by 2050.</p> <p>Passed the Hydrogen Economy Promotion and Hydrogen Safety Management Law in 2020, legislating government support for hydrogen and safety standards.³⁵</p> <p>The Hydrogen Economy Law establishes “Clean Hydrogen Energy Portfolio Standards” (certification system). And Renewable Portfolio Standards.</p> <p>Hydrogen Economy Committee (established under the Hydrogen Economy law) is the “control tower” of hydrogen economy policy in Korea.</p>
Hydrogen Economy Committee	Chaired by the Prime Minister, this committee is comprised of 8 ministries (including the Ministry of Energy, Ministry of Economy and Finance, the Ministry of Science and ICT, the Ministry of Environment and the Ministry of Land, Infrastructure and Transport). It also comprises of industry, academic and civil experts.	<p>“Control tower” of hydrogen economy policy in Korea. Enacts the hydrogen strategies outlined by MOTIE.</p>
MOTIE <i>Ministry of Trade Industry and Energy</i>	Ministry concerned with economic policy with respect to industrial and energy sectors.	<p>Released the Community Energy Supply Basic Plan in 2020 which includes policies stimulating fuel cell use.</p> <p>Contributed to the development of the <i>Hydrogen Economy Roadmap</i>.³⁶</p> <p>Provides funding for establishing a public-private hydrogen vehicle industry ecosystem by 2022.³⁷</p> <p>Establishment of hydrogen ‘Technoparks’ and hydrogen demonstration cities.</p> <p>Procurement of ‘base’ or ‘mother’ hydrogen refuelling stations that include a SMR (small modular reactor) to produce hydrogen on</p>

³⁵ Kan S (2020) South Korea’s Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

³⁶ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

³⁷ Kan S (2020) South Korea’s Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

Body	Role in RD&D ecosystem	Hydrogen initiatives
		site, and also to supply hydrogen to other refuelling stations in the region. ³⁸
MSIT <i>Ministry of Science and ICT</i>	Ministry focused on the convergence of science and ICT (e.g. AI, 5G) to help advance Korea.	<p>Contributed to the development of the <i>Hydrogen Economy Roadmap</i>.³⁹</p> <p>Holds the Korea-Australia Joint Committee on Science and Technology jointly with the Department of Industry, Innovation and Science of Australia, where hydrogen is frequently discussed.⁴⁰</p> <p>Funds R&D projects in hydrogen and CCUS.</p>
MOLIT <i>Ministry of Land, Infrastructure and Transport</i>	Ministry focused on sustainable territorial development and management, residential welfare, transport, logistics and aviation.	<p>Contributed to the development of the <i>Hydrogen Economy Roadmap</i>.⁴¹</p> <p>Implements demonstration projects and hydrogen fuelling station projects.</p> <p>Spearheads the establishment and implementation of the hydrogen demonstration city projects.</p>
MoE <i>Ministry of Environment</i>	Ministry concerned with environmental protection.	<p>Contributed to the development of the <i>Hydrogen Economy Roadmap</i>.⁴²</p> <p>Procurement of ‘base’ or ‘mother’ hydrogen refuelling stations that include a small modular reactor to produce the hydrogen on site, and also to supply hydrogen to other refuelling stations in the region.⁴³</p> <p>The ministry of environment is responsible for hydrogen subsidy projects.⁴⁴</p> <p>Works closely with MOTIE, MOLIT and private companies such as Hyundai motors</p>

³⁸ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

³⁹ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

⁴⁰ MSIT (2020) MSIT to Strengthen Cooperation with Australia in Hydrogen and Rare-Earth Elements, <https://english.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&mPid=2&pageIndex=&bbsSeqNo=42&nttSeqNo=386&searchOpt=&searchTxt=>

⁴¹ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

⁴² Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

⁴³ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

⁴⁴ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

Body	Role in RD&D ecosystem	Hydrogen initiatives
		and logistics companies to build and run hydrogen infrastructure. ⁴⁵
KIAT <i>Korea Institute for Advancement of Technology</i>	<p>Public research institute under MOTIE.</p> <p>Promotes industrial development in Korea by advising on R&D strategies for industrial technology, planning and policy research.⁴⁶</p> <p>Involved in the commercialisation of industrial technologies, and establishment of industrial technology infrastructure and regionally specialised industries.⁴⁷</p>	<p>KIAT handles applications and deliberations on two regulatory sandbox systems (out of the 5) in Korea: Industrial Convergence and Regional Innovation. Foreign investment into Korean hydrogen RD&D occurs through these regulatory sandboxes.⁴⁸</p>
CORFA <i>Korea Council of R&D Funding Agencies</i>	<p>CORFA sits under the MSIT (Ministry of Science and ICT) and the Ministry of Education.</p> <p>Comprised of 16 public funding institutions and agencies. Established to provide management of national R&D projects, facilitate cooperation between institutions, and evaluate achievements of institutions.⁴⁹</p>	<p>Several institutions within CORFA are active in hydrogen RD&D, namely KIAT and KETEP.</p>
NST <i>National Research Council of Science & Technology</i>	<p>The NST sits under the MSIT (Ministry of Science and ICT).</p> <p>The NST supports national RD&D projects, and manages, supports and promotes 25 government-funded research institutions.</p>	<p>Supports RD&D activities across the hydrogen value chain.</p> <p>Several of the NST's member government research institutions are focused on hydrogen R&D. The most hydrogen-relevant member institutions are listed below.</p>
KIER <i>Korean Institute of Energy Research</i>	<p>Public R&D Institution (NST member) focused on energy efficiency, emerging renewable energy, CO₂ processing and utilisation, clean use of fossil energy, integration and convergence, and providing technology diffusion services (adoption and spread of innovations) and policy support.</p>	<p>The KIER is the national centre under MOTIE in charge of the Hydrogen R&D Roadmap.</p> <p>KIER has a dedicated hydrogen energy research division, spanning the entire hydrogen value chain, including cross-cutting areas such as life cycle, system and performance testing.</p> <p>Facilities at the KIER include a hydrogen research department (focused on generation and storage), a fuel cell laboratory, an</p>

⁴⁵ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

⁴⁶ KIAT. About KIAT: President's Message, <https://kiat.or.kr/site/main/publish/view.jsp?menuID=002001001>

⁴⁷ KIAT. About KIAT: President's Message, <https://kiat.or.kr/site/main/publish/view.jsp?menuID=002001001>

⁴⁸ Invest Korea (2021) Success Stories: Korea Institute for Advancement of Technology (KIAT), https://www.investkorea.org/ik-en/bbs/i-468/detail.do?ntt_sn=490756

⁴⁹ CORFA (2012) Summary of member organisations, http://corfa.or.kr/eng/main/?skin=intro_summary.htm

Body	Role in RD&D ecosystem	Hydrogen initiatives
		energy materials laboratory, and a separate fuel cell research & demonstration centre. ⁵⁰
KIST (and the GTCK) <i>Korea Institute of Science and Technology (and the Green Technology Center-Korea)</i>	<p>Public research institution (NST member) focussed implementing Korea's national science and technology strategies.</p> <p>The Green Technology Center is affiliated with the KIST and operates as a strategic advisory body. The GTCK is involved in support activities including international cooperation with respect to R&D and climate change response technologies.</p> <p>The KIST has overseas centres located in Germany and India, and joint laboratories with research institutions in Canada and the US. Furthermore, it has partner institutions across Europe, Africa, Asia, Latin America and North America.</p>	<p>The KIST Centre for Hydrogen and Fuel Cell Research drives the national commercialisation of fuel cell systems and currently researches renewable water electrolysis, chemical hydrogen storage, and fuel cells in the transportation, power generation and portable devices context.⁵¹</p>
KETEP <i>Korea Institute of Energy Technology Evaluation and Planning</i>	<p>Public institution/agency which was established under MOTIE to efficiently support in the planning, evaluation and management of all national fundings in energy technology.⁵²</p>	<p>In charge of planning R&D and pilot projects in the energy sector (including hydrogen projects).⁵³</p>
KRICT <i>Korea Research Institute of Chemical Technology</i>	<p>Public research institution (NST member) concerned with cross-cutting chemical technologies.</p>	<p>The KRICT is active in the development of chemicals for the hydrogen industry, including carbon valorisation, petrochemical processes, and energy materials.⁵⁴</p> <p>Key achievements include the development of hydrogen carriers and CCUS technologies.</p>
KRRI <i>Korean Railroad Research Institute</i>	<p>Public R&D institution (NST member) concerned with developing rail and next-generation public transport.</p>	<p>Announced plans to demonstrate the world's first fuel cell and liquid hydrogen rail system (2021-2024) in Ganwon province, in partnership with Hyundai Rotem, VC Tech and Parity.⁵⁵</p>
KIMM	<p>Public R&D institution (NST member).</p>	<p>Launched a liquid hydrogen technology research group to develop hydrogen</p>

⁵⁰ Korea Institute of Energy Research. Hydrogen Energy Research <https://www.kier.re.kr/board?menuId=MEN00936&siteId=null>

⁵¹ CMS (n.d.) Hydrogen Law and Regulation in South Korea <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea>

⁵² Korea Council of R&D Funding Agencies. Summary of member organisations, http://corfa.or.kr/eng/main/?skin=intro_summary.htm

⁵³ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

⁵⁴ KRICT. Division of Specialty and Bio-based Chemicals Technology, https://www.kRICT.re.kr/eng/sub02_04_01.do

⁵⁵ Smith K (2021) Korean project to develop liquefied hydrogen fuel cell traction, *International Railway Journal*, <https://www.railjournal.com/technology/korean-project-to-develop-liquefied-hydrogen-fuel-cell-traction/>

Body	Role in RD&D ecosystem	Hydrogen initiatives
<i>Korea Institute of Machinery and Materials</i>		liquefaction technology, as part of the private-public consortium with the KIST, KOGAS and DSME. ⁵⁶
KICT <i>Korea Institute of Civil Engineering and Building Technology</i>	Public R&D institution (NST member) dedicated to national infrastructure. Part of KICT's portfolio is in energy and carbon reduction for built environments.	Has conducted some work on the safety of FCEV vehicles. ⁵⁷
KIMS <i>Korea Institute of Materials Science</i>	Public R&D institution (NST member) concerned with developing advanced materials and their processing techniques.	Material developments include advanced metal alloys and composites, rare metals, thin films, and electrodes, all of which can have hydrogen and fuel cell applications.
KBSI <i>Korea Basic Science Institute</i>	Public R&D institution (NST member) concerned with providing research support and joint research. Provides and manages large laboratories and facilities.	The KBSI has some hydrogen-related R&D achievements. For example, the KBSI developed a photocatalyst that stably produces high-efficiency hydrogen from sunlight, jointly with Incheon University. ⁵⁸
KERI <i>Korea Electrotechnology Research Institute</i>	Public R&D institution (NST member). The KERI leads R&D in testing in the electric power, electricity and electric utility fields. ⁵⁹	The KBSI has activities related to the electricity grid, integrated systems, and some hydrogen-related R&D such as electrolysis. For example, the KBSI has researched photoelectrodes for photoelectrochemical water splitting, jointly with the University of Science and Technology (UST), The University of Hong Kong, Pusan National University, and the KIMS. ⁶⁰
KITECH <i>Korea Institute of Industrial Technology</i>	Public R&D institution (NST member). KITECH is concerned three primary areas: 'Root Industry Technology' (basic manufacturing techniques such as casting and heat treatment), 'Green Manufacturing System Technology' (energy-efficient and eco-friendly manufacturing), and 'Industry	KITECH has undertaken some hydrogen-related work in its research in energy-efficient and eco-friendly manufacturing. Examples include energy optimisation of steam methane reforming (joint with Yonsei

⁵⁶ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

⁵⁷ KICT (2021) Technology for Fire Safety in Underground Spaces to Support the Commercialisation of Fuel Cell Electric Vehicles, <https://www.kict.re.kr/researchResultWeb/getResearchResultView.es?mid=a20301000000&id=197&keyField=&keyWord=>

⁵⁸ FuelCellsWorks (2020) KBSI-Incheon University Develop Photocatalyst that Produces Stable and High-Efficiency Hydrogen from Sunlight, <https://fuelcellworks.com/subscribers/kbsi-incheon-university-develops-photocatalyst-that-produces-stable-and-high-efficiency-hydrogen-from-sunlight/>

⁵⁹ KERI. General Information, https://www.keri.re.kr/html/en/sub01/sub01_010201.html

⁶⁰ Ahn J et al (2020) 3D-printed Cu₂O photoelectrodes for photoelectrical water splitting. *Nanoscale Advances* 2, 5600-5606.

Body	Role in RD&D ecosystem	Hydrogen initiatives
	<p>Convergence Technology' (i.e. integrated systems).</p> <p>KITECH has international branches located in the US, China, Indonesia and Vietnam. It has partnered with many institutions across Europe, Asia, North America, Latin America and Africa. KITECH has partnered with Curtin University, Australia in the past.</p>	<p>university and LG Chem),⁶¹ feasibility of biological hydrogen production using bioreactors (joint with Yonsei University, JEONJIN ENTECH and CSIR, India), and high purity hydrogen production using modular adsorption separation system (joint with Gungang Co, Ltd).</p>
<p>POSCO (and RIST)</p> <p><i>Research Institute of Science and Technology</i></p>	<p>POSCO is Korea's largest steel-making company and is publicly owned.</p> <p>Funded by the POSCO group, the RIST is a research institute specialising in commercialisation. The RIST leads the growth of the POSCO group, develops technologies for future industries such as advanced materials, and fosters SMEs and technology diffusion.⁶²</p>	<p>POSCO is involved in the development of green steel using hydrogen produced from renewables. It expects to be using more than 3 million tonnes of hydrogen per year by 2050 for steelmaking, and 2 million tonnes for power generation.⁶³</p> <p>POSCO is participating in a 'green steel' production project using hydrogen produced by renewables provided by the Fortescue Metals Group in Australia.⁶⁴ POSCO and Origin Energy have also signed a Memorandum of Understanding (MoU) to cooperate on hydrogen and ammonia supply chains.⁶⁵</p>
<p>KOGAS</p> <p><i>Korea Gas Corporation</i></p>	<p>Public natural gas company that owns a significant portion of gas infrastructure in Korea. KOGAS handles almost all of Korea's liquefied natural gas (LNG) imports.</p>	<p>KOGAS's main role is to stabilise hydrogen cost, establish hydrogen distribution infrastructure in Korea and develop the hydrogen trade market.⁶⁶</p> <p>KOGAS's 2030 hydrogen business development targets include the construction of 25 hydrogen production plants and more than 700 km of hydrogen pipelines; and operation of 110 hydrogen refuelling stations and 500 hydrogen tube trailers.⁶⁷</p>

⁶¹ Lee J et al (2021) Machine learning-based energy optimisation for on-site SMR hydrogen production. Energy Conversion and Management. DOI:10.1016/j.enconman.2021.114438.

⁶² RIST (2021) Greetings. http://www.rist.re.kr/rist/class/intro/intro_01.jsp?floc=1

⁶³ Macdonald-Smith A (2021) POSCO eyes Australia for strategic hydrogen base. Financial Review. <https://www.afr.com/policy/energy-and-climate/posco-eyes-australia-for-strategic-hydrogen-base-20211005-p58x94>

⁶⁴ POSCO (2020) POSCO to carry out green hydrogen project with Fortescue Metal Group. Press Release. <https://newsroom.posco.com/en/posco-to-carry-out-green-hydrogen-project-with-fortescue-metal-group/>

⁶⁵ FuelCellsWorks (2021) Origin Energy and POSCO to cooperate on green hydrogen. <https://fuelcellworks.com/news/origin-energy-and-posco-to-cooperate-on-green-hydrogen/>

⁶⁶ MOTIE (2021) Korean new Deal and Hydrogen Economy. Presentation, April 2021.

⁶⁷ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

Body	Role in RD&D ecosystem	Hydrogen initiatives
		<p>KOGAS aims to import 0.3 million tons of hydrogen by 2030 and 1.2 million tons by 2040.⁶⁸</p> <p>Procurement of ‘base’ or ‘mother’ hydrogen refuelling stations that include a small modular reactor to produce the hydrogen on site, and also to supply hydrogen to other refuelling stations in the region.⁶⁹</p>
KGS <i>Korea Gas Safety Corp</i>	Governmental organisation under MOTIE. Its role is to enact Korea’s gas safety laws, including testing, inspection and education.	Established as Korea’s hydrogen safety agency to set up the hydrogen safety ecosystem. This includes safety standards on hydrogen products, facilities and infrastructure, international cooperation, and R&D; and promoting education on hydrogen safety. ⁷⁰
KOSHA <i>Korea Occupational Safety and Health Agency</i>	Governmental agency concerned with worker safety and health issues at workplaces across all types of industries. KOSHA also conducts R&D on health and safety.	<p>Issues Certificates of Compliance for foreign hydrogen technology.</p> <p>Conducts R&D on hydrogen safety, such as the handling of hydrogen facilities, risks of hydrogen leakage, and range of explosion hazards.⁷¹</p>
KTPA <i>Korea Technopark Association</i>	The KTPA is a network hub of 19 Technoparks across Korea. Technoparks are regional (sub-national) programs that build infrastructure for innovation, promote regional industry, support business and link innovation actors, and build academic-industry collaboration platforms.	There are several Technoparks that have activity related to hydrogen (see <i>Section 1.6</i> on hydrogen RD&D clusters).

1.3.2 Hydrogen consortia

Outside of government bodies, hydrogen RD&D activity in Korea is driven by peak bodies and public-private-research consortia. These bodies are significantly involved in international hydrogen collaboration and spearhead several domestic demonstration and commercialisation projects. Table 5 outlines the key consortia stakeholders in Korea.

⁶⁸ Kan S (2020) South Korea’s Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

⁶⁹ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

⁷⁰ Herh M (2020) Korean Government Launches Hydrogen Economy Committee, Business Korea, <http://www.businesskorea.co.kr/news/articleView.html?idxno=48415>; MOTIE (2021) Korean new Deal and Hydrogen Economy. Presentation, April 2021.

⁷¹ Pyo DY, Lim OT (2019) A Study on Explosive Hazardous Areas in Hydrogen Handling Facility. Transactions of the Korean hydrogen and new energy society 30(1), 29-34.

Table 5: Hydrogen consortia

Consortium	Description
HyNet Consortium	The HyNet Consortium comprises of 13 parties, including Woodside Energy, and aims to stimulate demand for hydrogen use in mobility with support from the Korean government. The consortium (13 companies) will invest KRW 135 billion to construct 100 refuelling stations by 2022 and will run the stations through to 2028. ⁷²
H2KOREA <i>Hydrogen Convergence Alliance Promotion Team</i>	H2KOREA is a private-public body launched in 2017, connecting central government and local government with private companies. This organisation represents the public and private fuel-cell industry of Korea, and operates as a “control tower” for Korea’s hydrogen economy. ⁷³
KHIA <i>Korea Hydrogen Industry Association</i>	The KHIA is made up of more than 50 members spanning the hydrogen value chain. The association is involved in the development of the hydrogen economy in the city of Ulsan, Korea’s most active hydrogen pilot city. ⁷⁴
Hydrogen Fusion Alliance Promotion Group	The Hydrogen Fusion Alliance Promotion Group was established in 2016 and designated by the government as an organisation in charge of the hydrogen industry. ⁷⁵ The Hydrogen Fusion Alliance Promotion group is promoting a pilot project to promote the distribution of hydrogen commercial vehicles and taxis, alongside Hyundai motors, MOTIE, Changwon City, Seoul Taxi Operator, and Korea Automobile Research Institute. ⁷⁶
Green Ammonia Alliance	Launched in July 2021, the Green Ammonia Alliance is made up of 13 private companies and 5 public institutions representing all parts of the ammonia value chain. ⁷⁷ Confirmed areas of cooperation and information exchange include R&D in ammonia synthesis, transportation, fuel utilisation, green ammonia extraction, and direct use in industry, energy sector and fuel cells. ⁷⁸ The alliance is led by the KIER.
Korea H2 Business Summit	The Korea H2 Business Summit, established in September 2021, is a coalition of 15 Korean companies that discuss hydrogen development and industry challenges, and provide policy recommendations to the Korean government. The council predominantly acts as a consultancy and investment group with five members of the council announcing a combined investment of KRW 43.4 trillion in hydrogen production, distribution, storage and utilisation by 2030. ⁷⁹

⁷² Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

⁷³ Lim C (2020) H2KOREA head urges bold investment to nurture hydrogen industry as next growth engine, Aju Business Daily, <https://www.ajudaily.com/view/20200918142837002>

⁷⁴ Kim J. Hydrogen Industry and Association of Korea, Korea Hydrogen Industry Association, https://iea.blob.core.windows.net/assets/imports/events/191/1.10_HydrogenIndustryKOREAJunbomKim.pdf

⁷⁵ Herh M (2020) Korean Government Launches Hydrogen Economy Committee. Business Korea <http://www.businesskorea.co.kr/news/articleView.html?idxno=48415>

⁷⁶ FuelCellsWorks (2020) Hyundai Motor Expands its Commitment to Hydrogen with Agreement on Commercial Vehicles and Taxi’s <https://fuelcellsworks.com/news/hyundai-motor-expands-its-commitment-to-expand-hydrogen-commercial-vehicles-and-taxis/>

⁷⁷ Ammonia Energy Association (2020) The Korean Green Ammonia Alliance. <https://www.ammoniaenergy.org/articles/the-korean-green-ammonia-alliance/>

⁷⁸ MOTIE (2021) Green Ammonia MOU Press Release. <https://www.ammoniaenergy.org/articles/the-korean-green-ammonia-alliance/>

⁷⁹ OUT-LAW News (2021) South Korean Companies launch hydrogen business council, Pinsent Masons. <https://www.pinsentmasons.com/out-law/news/south-korean-companies-launch-hydrogen-business-council>

1.3.3 Funding mechanisms

Overview of the Republic of Korea's hydrogen public budget allocations

Public funding for hydrogen RD&D

Korea has three main public hydrogen RD&D funding mechanisms, summarised in the table below

Table 6: Public funding for hydrogen RD&D

Funding mechanism	International eligibility to participate
<p>The Green New Deal: To deal with the economic consequences of COVID-19 and to prepare the economy in the future, the Korean government developed the Korean New Deal. This deal is comprised of two components: the Digital New Deal and the Green New Deal. The Green New Deal's purpose is to accelerate Korea's transition to a low-carbon economy, and it contains several specific hydrogen policies and funding arrangements.</p> <p>Korea's 2020 R&D budget for hydrogen-related technologies was roughly KRW 43.1 billion.⁸⁰ MOTIE's investment of KRW 6.9 billion in 2020 for the Green New Deal package includes R&D support programs for hydrogen production and storage, as well as safety enhancement projects.⁸¹ The Green New Deal contains KRW 5.6 trillion by 2022 and KRW 13.1 trillion by 2025 to the expansion of the supply of electric and hydrogen vehicles as well as establishing a hydrogen distribution base.⁸² The Green New Deal also focuses on hydrogen-related subsidies, which are outlined below under 'subsidy funding'.</p> <p>Public RD&D funding from the Green New Deal has recently been directed to three designated hydrogen pilot cities (Ansan, Wanju/Jeonju and Ulsan) as well as hydrogen developments in other cities and Technoparks. Korea is intending to create 3 hydrogen cities by 2022 and 3 more by 2025.⁸³ For more information on hydrogen demonstration cities, see <i>Section 1.6</i> on hydrogen RD&D clusters.</p>	Yes. Subsidies and loans can be provided for collaborative projects with foreign entities. ⁸⁴
<p>The Innovative Platform Program: Under the Innovative Platform Program (2018), Korea's government strategically invested in three major topics, one of which is hydrogen industry (specific budget details below).</p>	No data.
<p>The National Research Foundation of Korea: The National Research Foundation of Korea also offers funding to researchers and research groups associated with Korean universities, public institutes and companies. Most hydrogen research projects fall under two National Strategic R&D Programs: (1) the <i>Technology Development Program to Solve Climate Change</i>⁸⁵ which offers KRW 200 million per project per year on technologies that aim to reduce greenhouse gas</p>	Potentially. Must be a registered Korean body to apply for the National Strategic R&D Programs, however, the NRF offers several research exchanges and joint research

⁸⁰ Stangarone T (2021) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6;

⁸¹ IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>

⁸² Lee J and Woo J (2020) Green New Deal Policy of South Korea: Policy Innovation for a Sustainability Transition. DOI: 10.3390/su122310191

⁸³ Lee J and Woo J (2020) Green New Deal Policy of South Korea: Policy Innovation for a Sustainability Transition. DOI: 10.3390/su122310191

⁸⁴ CMS (2021) Hydrogen law and regulation in South Korea <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea>
<https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea>

⁸⁵ NRF (2019) Technology Development Program to Solve Climate Change, <https://www.nrf.re.kr/eng/page/4b1d36cb-9c24-4513-bbe4-75a1bd82e1bb>

Funding mechanism	International eligibility to participate
emissions and respond to the climate change crisis, and up to KRW 17.4 billion for CCS project groups; and (2) the <i>Creative Materials Discovery Program</i> ⁸⁶ which provides KRW 1.5 billion per research group per year for R&D in the area of materials science.	programs that may be available. ⁸⁷

The specific government RD&D budgets available for the **Innovative Platform Program** are as follows:⁸⁸

Table 7: Innovate Platform Program funding

RD&D	Budget	Timeframe
Development of water electrolysis and 'stable' storage	KRW 49.2 billion	2019-2023
Development of power to hydrogen, methanation and LOHC	KRW 5.2 billion	2019-2021
Development of liquid hydrogen (LH2) technologies	KRW 29 billion	2019-2023
Development of ship using hydrogen fuel (including infrastructure)	KRW 17.8 billion	2019-2023
Budget for the Center for Product Safety in Hydrogen Industry	KRW 21 billion	2018-2021

Public-private funding for demonstration and commercial projects

The private sector in Korea is actively involved in hydrogen technology development and demonstration projects, often playing a leading role, with support from government. The Korean government supports the private sector with subsidies for hydrogen projects, R&D funding, and regulatory reform.⁸⁹

Much of hydrogen funding for demonstration and commercialisation in Korea is related to fuel cells and hydrogen vehicles:

- Hyundai Motors announced KRW 7.6 trillion for its "FCEV Vision 2030" as part of the HyNet consortium (HyNet plans to build 100 refuelling stations by 2022).⁹⁰
- KOGAS (Korea's state-owned gas corporation) has developed its own hydrogen plan and aims to invest KRW 4.7 trillion by 2030 on RD&D related to hydrogen production facilities and pipelines.⁹¹

⁸⁶ NRF (2019) Creative Materials Discovery Program Information, <https://www.nrf.re.kr/eng/page/1c41658a-0e33-4bec-8e43-065b1ce62052>

⁸⁷ NRF (2019) Programs: Directorate for International Cooperation. <https://www.nrf.re.kr/eng/page/31752ceb-b028-4721-a493-1d46d43b2285>

⁸⁸ Yoon Y (2020) Current Status of the Korean Hydrogen Economy. H2Korea and MOTIE <https://www.wko.at/service/aussenwirtschaft/presentation-yeon-yeo-gwang.pdf>

⁸⁹ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

⁹⁰ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6;

⁹¹ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

- In 2020 the government provided KRW 30 billion for the construction of production facilities for vehicles across 6 designated cities.⁹²
- In June 2018, MOTIE announced a KRW 2.6 trillion budget for the establishment of a public-private hydrogen vehicle industry ecosystem by 2022.⁹³

Additionally, the “Hydrogen Economy and e-New Industry Start-Up Fund” was launched in December 2020, with roughly KRW 34 billion, which will be supplemented by private sector funding.⁹⁴

MOTIE, KOGAS and the MoE are also funding hydrogen facilities, refuelling stations and hydrogen clusters across Korea.

International funding for hydrogen RD&D

Outlined below are the funding arrangements that can be accessed, either directly or indirectly, by international organisations or researchers.

Table 8: International funding for hydrogen RD&D

Provider	Funding mechanism	International eligibility to participate
Australia-Korea Foundation	Annual grants: the Australia-Korea Foundation was established to promote bilateral relations between Korea and Australia. Annual funding is provided to Australian entities or well-established Korean entities that seek to advocate for Australian business, education and/or cultural interests. This is across several priority areas, including technological and scientific innovation (e.g., hydrogen technology). ⁹⁵	Yes.
KIER	The International Joint R&D Project Funding Program: ⁹⁶ Offers up to KRW 200 million for successful projects that align with the concept papers provided for each call. Both FY2021 and FY2022 have contained mention of hydrogen-related technologies. Successful international applicants are matched with a KIER project director to work jointly on proposed topics. See section 1.5.3 <i>The Republic of Korea’s joint international RD&D</i> for further information.	Yes.

⁹² IPHE (2021) Republic of Korea. [https://www.iphe.net/republic-of-korea#:~:text=The%20government%20of%20Korea%20funds,vehicles%20in%206%20cities%20nationwide.&text=The%20fund%20itself%20is%20subordinate,KRW%20\(US\\$24456million\)](https://www.iphe.net/republic-of-korea#:~:text=The%20government%20of%20Korea%20funds,vehicles%20in%206%20cities%20nationwide.&text=The%20fund%20itself%20is%20subordinate,KRW%20(US$24456million))

⁹³ Kan S (2020) South Korea’s Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

⁹⁴ Fuelcellworks (2020) Korea: Ministry of Trade, Industry and Energy Announces Establishment of a KRW 34 Billion Hydrogen Economy Development Fund. <https://fuelcellworks.com/news/korea-ministry-of-trade-industry-and-energy-announces-establishment-of-a-krw-34-billion-hydrogen-economy-development-fund/>

⁹⁵ DFAT (n.d.) Australia-Korea Foundation Grants. <https://www.dfat.gov.au/people-to-people/foundations-councils-institutes/australia-korea-foundation/grants>; DFAT (n.d.) Australia-Korea Foundation: Eligibility. <https://www.dfat.gov.au/people-to-people/foundations-councils-institutes/australia-korea-foundation/grants/Pages/eligibility>

⁹⁶ KIER (2021) 2022 KIER International Joint R&D Project Funding Program [Media Notice]. <https://www.kier.re.kr/board/view?pageNum=2&rowCnt=10&no1=264&linkId=255731&menuId=MENU00642&schType=0&schText=&boardStyle=&categoryId=&continent=&country=>

1.3.4 Other key hydrogen policies, regulation and legislation

In addition to the governance, strategy and funding mechanisms for hydrogen RD&D programs, Korea has several policies, regulations and laws to facilitate and regulate the commercial uptake of hydrogen technologies. Notable policies and regulations are outlined below.

Legislation

The Hydrogen Economy Promotion and Hydrogen Safety Management Act (Hydrogen Act), which came into force in February 2021, regulates hydrogen in Korea. The legislation's purpose is to establish a legal framework to support the development of hydrogen technologies and a commercial-scale hydrogen economy.⁹⁷ The Act sets out a series of broad reforms, which include:

- the creation of a 'Hydrogen Economy Committee' which aims to implement strategies, policies and regulations at a national level, and coordinate project financing;
- the creation of a transparent hydrogen pricing system. The system requires the reporting and disclosure of retail hydrogen prices for FCEVs;
- support for hydrogen-related businesses through a subsidy and loan program, which includes R&D subsidies, loans and tax exemptions. Foreign entities collaborating with domestic entities can access funding and subsidy programs;
- the ability for government to request the operators of certain facilities (such as logistics centres and highway rest stops) to construct and operate hydrogen charging stations;
- the establishment of minimum safety regulations in areas including manufacturing facilities, hydrogen-related businesses and maintenance inspections of hydrogen-powered facilities. The provisions include related penalties and mandatory insurance cover;
- provisions to support the transition towards a hydrogen economy, including standardisation of products, personnel training and international collaboration and investment approval frameworks; and
- hydrogen imports and export requirements.

In addition, the *Safe Management of the High-Pressure Gas Act* (Safe Management Act) regulates the transportation of hydrogen. In accordance with the Safe Management Act, and in general terms, transportation must occur through tube trailers or specialised pipelines. It is expected that more specific rules and regulations regarding storage, distribution and transportation of hydrogen will be enacted.

⁹⁷ CMS (n.d.) Hydrogen Law and Regulation in South Korea. <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea>; IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>

Subsidy funding

Under Korea's Green New Deal, eligibility for subsidies for hydrogen vehicles will be expanded to hydrogen trucks in 2021, refuelers for commercial vehicles in 2022, and all hydrogen vehicles by 2025.⁹⁸

Capital expenditure subsidies in the last two years were as follows:⁹⁹

Table 9: Subsidy funding for FCEVs and refuelling stations

Subsidy	Cost	Subsidy	Provided by
Hydrogen refuelling stations (light vehicles)	KRW 2.7 billion	KRW 1.3 billion	Ministry of Environment Plus, additional MOLIT funding for highways: KRW 700 million in 2019 KRW 928 million in 2020
Hydrogen refuelling stations (buses)	KRW 5.7 billion	KRW 4 billion	Ministry of Environment

Current policies

The production of hydrogen requires a licence as specified under the *Renewable Energy Act*. This act also led to the establishment of the Renewable Portfolio Standard (RPS) in 2012, which is a key policy for commercial uptake of renewables. Established in 2012, the RPS mandates large power producers to meet a minimum portion of power generation from new and renewable technologies, including fuel cell power generation.¹⁰⁰ Producers buy Renewable Energy Certificates (REC) to fulfil their obligations and will be required to increase their share of renewables from 7% in 2019 to 10% by 2022.¹⁰¹ As part of the 2021 Hydrogen Economy Law, some revisions were proposed to the RPS: the establishment of Clean Hydrogen Energy Portfolio Standards (CHPS), effectively separating hydrogen from the RPS, a national certification system; and some revisions on the RPS's characteristics.¹⁰²

In response to the COVID-19 pandemic, the National Assembly developed the Korean New Deal which provides further policy incentives for commercial uptake of renewables. The Korean New Deal is split into two streams: the Digital New Deal and the Green New Deal. Under the Green New Deal, the government seeks to accelerate the transition to a low-carbon economy and will spend KRW 47 trillion to fund green projects by 2025. Korea has articulated a new target to have 200,000 hydrogen FCEVs operational by 2025. The Green New Deal will expand subsidies for hydrogen vehicles and components and by 2025, all hydrogen vehicles will be eligible for state subsidies.¹⁰³ See *Section 1.3.3* for further details.

⁹⁸ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

⁹⁹ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

¹⁰⁰ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹⁰¹ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹⁰² Lee E (2020) S. Korea to make hydrogen fueling mandatory from 2022. Pulse. <https://pulsenews.co.kr/view.php?year=2020&no=1057289>; IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>

¹⁰³ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policies. DOI: 10.1007/s10098-020-01936-6.

1.4 The Republic of Korea's domestic hydrogen RD&D projects

1.4.1 Major domestic hydrogen RD&D projects

Projects led by government bodies

While government is funding RD&D in hydrogen, publicly available information on individual RD&D projects is scarce (see *Section 1.3.3* for program budgets and specific technology areas of focus). Further engagement with prominent research institutions may be required to understand current projects.

However, demonstration and pilot projects occurring across Korea have been publicly announced:

- Korea's MOTIE in May 2020 selected 5 cities to install mid-to-large size hydrogen reforming stations and help increase the number of fuel cell vehicles in Korea. The selected cities are Busan, Daejeon, Chuncheon, Gwangju and Changwon. These stations will reform hydrogen from natural gas and have an expected production rate of 7,380 tonnes per year.¹⁰⁴
- In June 2020, Korea established the 'Hydrogen Green Mobility Regulation-Free Special Zone' in Ulsan, which allows for the demonstration of hydrogen-based mobility technologies. This zone is intended to trial technologies such as small ship fuel cell propulsion systems and hydrogen-powered forklifts.¹⁰⁵
- In June 2020, the MOTIE, MOLIT and MoE signed an 'MoU on Demonstration of Hydrogen Fuel Cell Truck Deployment' with Hyundai Motors and leading domestic companies including CJ and Coupang. Under the MoU, these parties will construct and operate key hydrogen logistics infrastructure.¹⁰⁶
- In June 2021, Korea's government launched a research project on hydrogen production from renewables for the ammonia carrier supply chain. This includes building a 1,000Nm³/hr plant by 2025 and developing storage, distribution, decomposition, combustion systems, safety measures and pollution prevention.¹⁰⁷
- By 2022, Korea plans to establish three hydrogen demonstration cities (Ansan, Busan, Jeonju/Wanju) and one hydrogen R&D city (Samcheok). See *Section 0* for more details on hydrogen pilot cities.¹⁰⁸

¹⁰⁴ Clifford Chance (2020) Focus on Hydrogen: Korea's New Energy Roadmap
<https://www.cliffordchance.com/content/dam/cliffordchance/briefings/2020/10/focus-on-hydrogen-korea-new-energy-roadmap.pdf>

¹⁰⁵ IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>; Michael Herh (2020) Hyundai Mobis Develops Hydrogen-powered Forklift, BusinessKorea. Viewed at <http://www.businesskorea.co.kr/news/articleView.html?idxno=52404>; FuelCellsWorks (2020) South Korea: Vinssen Selected in Developing and Demonstrating Small Ships with Hydrogen Fuel Cell Propulsion System in Ulsan. Viewed at <https://fuelcellsworks.com/news/south-korea-vinssen-selected-in-developing-and-demonstrating-small-ships-with-hydrogen-fuel-cell-propulsion-system-in-ulsan/>

¹⁰⁶ IPHE (2021) Partners: Republic of Korea. Viewed at <https://www.iphe.net/republic-of-korea>

¹⁰⁷ IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>

¹⁰⁸ KTPA (2010) Technopark Nationwide. <http://www.technopark.kr/regional#self>; Intralink (2021) The Hydrogen Economy The Republic of Korea: Market Intelligence Report, prepared for the UK Department for International Trade. Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>; Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

Projects by consortia

Several demonstration and research projects are also being led by the private sector and supported by public research institutes and government departments:

- **Hydrogen extraction from ammonia:** Korean steel-making company, POSCO, has signed an agreement to promote research cooperation with KIST and RIST to advance catalysts and technology for the extraction of hydrogen from ammonia;¹⁰⁹
- **Hydrogen gas turbine demonstration:** Doosan Heavy Industries & Construction (DHIC) has signed an agreement with Korea East-West Power and SK gas to begin Korea's first large-scale hydrogen gas turbine demonstration in Ulsan. To be completed by 2027, the project will involve the conversion of a 25-year-old gas turbine into a 270MW hydrogen gas fired turbine;¹¹⁰
- **Liquefied hydrogen storage for rail transport:** The Korean Railroad Research Institute (KRRI) is partnering with Hyundai Rotem, VC Tech, and Parity to develop a 2.7MW module-based fuel cell propulsion system using liquified hydrogen storage to support operation at up to 150km/h and offer a range of 1000km, as well as reduce refuelling times by 20%. The system and its fast-refuelling technology is to be installed for testing in the second half of 2022;¹¹¹ and
- **Hydrogen port demonstration project:** In September 2021, SK Group signed an MoU with the Korean Ministry of Ocean and Fisheries to spearhead a state project to build a 'hydrogen port' in the southern port of Yeosu and the adjacent Gwangyang port by 2023. The port is designed to be an energy ecosystem that will encompass hydrogen production, logistics, consumption and utilisation.¹¹²

1.4.2 Major domestic commercial hydrogen projects

The scope of this report is on research, development and demonstration (RD&D) projects. For information on commercial hydrogen projects, see *HyResource*, an online knowledge sharing platform across the hydrogen community led by CSIRO, Future Fuels CRC, NERA and the Australian Hydrogen Council.

HyResource provides a directory of publicly available databases and information sources on international projects:

- <https://research.csiro.au/hyresource/projects/international/>

¹⁰⁹ POSCO (2021) POSCO Promotes Technology Improvement & Business Cooperation to Secure Green Hydrogen Capabilities. <https://newsroom.posco.com/en/posco-promotes-technology-improvement-business-cooperation-to-secure-green-hydrogen-capabilities/>

¹¹⁰ Patel, S (2021) South Korea Eyes First Hydrogen Gas Turbine Demonstration in 2027. <https://www.powermag.com/south-korea-eyes-first-hydrogen-gas-turbine-demonstration-in-2027/>

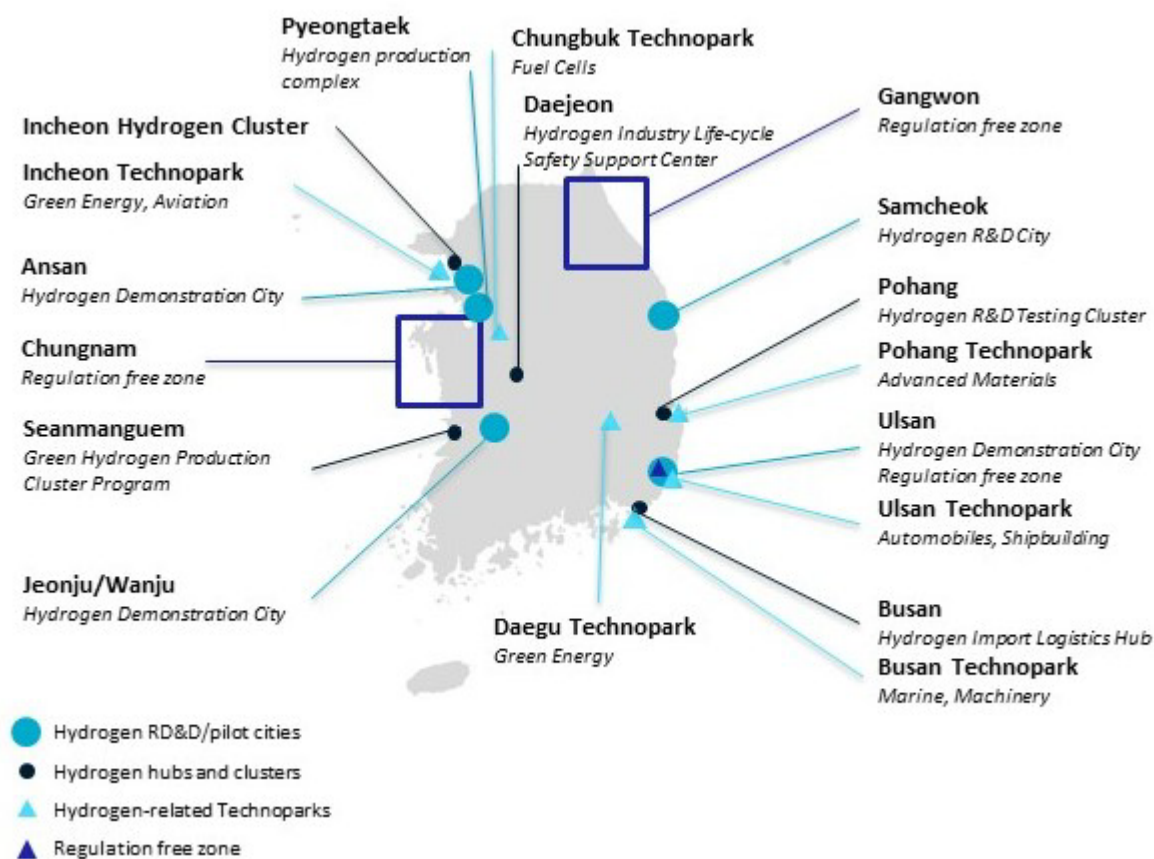
¹¹¹ Smith K (2021) Korean project to develop liquefied hydrogen fuel cell traction. <https://www.railjournal.com/technology/korean-project-to-develop-liquefied-hydrogen-fuel-cell-traction/>

¹¹² FuelCellsWorks (2021) Korea's SK Group to Build South Korea's Hydrogen Port. <https://fuelcellsworks.com/news/koreas-sk-group-to-build-south-koreas-hydrogen-port/>

1.4.3 The Republic of Korea's hydrogen RD&D clusters

There are several sites across Korea that can be considered as clusters of hydrogen RD&D activity (Figure 4). These include three hydrogen demonstration cities, one hydrogen R&D city, designated hydrogen 'hubs' and 'clusters', 'regulation free zones', and regional 'Technoparks' undertaking hydrogen-related innovation:¹¹³

Figure 4: The Republic of Korea's hydrogen clusters¹¹⁴



Hydrogen pilot/demonstration cities: Ulsan, Ansan, Wanju/Jeonju were selected by the government as pilot/demonstration cities for infrastructure development, with regional governments also contributing significant resources to the cities.¹¹⁵

- Ulsan: Ulsan is Korea's most active hydrogen pilot city with KRW 1.2 trillion investments planned from 2020-2030 for demonstrating hydrogen pipelines, housing and mobility.¹¹⁶ Ulsan has a long history of promoting hydrogen industry, was also involved in the 2012 Demonstration of Hydrogen Town

¹¹³ MOTIE (2021) Korean New Deal and Hydrogen Economy. Presentation, April 2021

¹¹⁴ KTPA (2010) Technopark Nationwide. <http://www.technopark.kr/regional#self>; Intralink (2021) The Hydrogen Economy The Republic of Korea: Market Intelligence Report, prepared for the UK Department for International Trade. Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>; Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹¹⁵ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹¹⁶ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

project, and benefits from cheap hydrogen by-product supply from its large local petrochemical complex.¹¹⁷

- Ansan: The hydrogen economy is seen as a booster for industrial revival in Ansan, and the city benefits from the ability to produce hydrogen from natural gas reforming and hydrogen from a local tidal power station.¹¹⁸ Ansan City plans to invest KRW 30.8 billion by 2022 to construct an eco-friendly hydrogen infrastructure.¹¹⁹
- Wanju/Jeonju: Here there are plans to invest KRW 15.4 million in government funding for 3 years until 2022, with Wanju serving as the hydrogen production and supply base, and neighbouring Jeonju as utilisation hub in residential and transport applications.¹²⁰ Jeonju benefits from already having one of Hyundai's manufacturing plants for heavy vehicles.¹²¹

Hydrogen R&D City: Samcheok has been announced by MOLIT as a hydrogen RD&D city, which involves the development of a hydrogen and clean-energy based residential complex and associated infrastructure.¹²² To do so, the Korea Institute of Energy Research (KIER) plans to invest KRW 16.6 billion to use metal hydride-based storage and non-mechanical compression technologies, as well as the 'RoRen' construction technique (low-energy detached homes with solar panels) with excess power used to produce hydrogen.¹²³

Additional hydrogen hubs and clusters:

- Busan is planning a hydrogen import logistic hub using liquified ammonia and bunkering infrastructure and maritime usages.¹²⁴
- Chungnam province also has plans for a USD 20 million investment to build fuel cell infrastructure and hydrogen drones for coastal surveillance from 2020-2022.¹²⁵
- Pohang city is building a national KRW 242.7 billion R&D/testing cluster between 2020-2025 with Doosan Fuel Cell, Korea Hydro-Nuclear Power and POSTECH.¹²⁶
- Saemangeum, Jeonbuk will have a USD 500 million Green Hydrogen Production Cluster Program from 2022-2031 (currently under feasibility study)¹²⁷

¹¹⁷ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹¹⁸ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹¹⁹ Lee G and Wijnhuizen P (2019) Three hydrogen pilot cities in Korea. Netherlands Enterprise Agency. <https://www.rvo.nl/sites/default/files/2020/01/Three-hydrogen-pilot-cities-in-Korea.pdf>

¹²⁰ Lee G and Wijnhuizen P (2019) Three hydrogen pilot cities in Korea. Netherlands Enterprise Agency. <https://www.rvo.nl/sites/default/files/2020/01/Three-hydrogen-pilot-cities-in-Korea.pdf>

¹²¹ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹²² Lee G and Wijnhuizen P (2019) Three hydrogen pilot cities in Korea. Netherlands Enterprise Agency. <https://www.rvo.nl/sites/default/files/2020/01/Three-hydrogen-pilot-cities-in-Korea.pdf>; Korea Bizwire (2020) Hydrogen-powered Town Coming to Samcheok by 2023. Korea Bizwire. <http://koreabizwire.com/hydrogen-powered-town-coming-to-samcheok-by-2023/163168>

¹²³ Korea Bizwire (2020) Hydrogen-powered Town Coming to Samcheok by 2023. Korea Bizwire. <http://koreabizwire.com/hydrogen-powered-town-coming-to-samcheok-by-2023/163168>

¹²⁴ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

¹²⁵ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2020/07/Korea-Hydrogen-economy-overview-2020-final.pdf>

¹²⁶ Fuelcellworks (2020) South Korea: Consortium Creating a Hydrogen Fuel Cell Power Generation Cluster in Gyeongsang Province. <https://fuelcellworks.com/news/south-korea-consortium-creating-a-hydrogen-fuel-cell-power-generation-cluster-in-gyeongsang-province/>

¹²⁷ Lee G and Wijnhuizen P (2019) Three hydrogen pilot cities in Korea. Netherlands Enterprise Agency. <https://www.rvo.nl/sites/default/files/2020/07/Korea-Hydrogen-economy-overview-2020-final.pdf>

- The Korean government and city of Daejeon invested KRW 26.3 billion to open a Hydrogen Industry Life-cycle Safety Support Center in December 2021, a pilot facility that will test and inspect hydrogen equipment and mobility related components.¹²⁸

Regional ‘Technoparks’: There are also a number of Technoparks across Korea with the key objectives of building innovation infrastructure, promoting regional industry, and connecting businesses and innovation actors. Of the 19 Technoparks in total, there are 6 that are especially relevant for hydrogen activity. These are located in Incheon, Daegu, Busan, Ulsan, Pohang and Chungbuk.

Key universities in Korea that are highly active in hydrogen RD&D include:

- PNU (Pusan National University) leads a AUD 57 million hydrogen R&D platform program jointly with a number of industry stakeholders, which plans to establish a R&D and testing facility in Busan.¹²⁹
- Sungkyunkwan University (SKKU) plays a leading role in producing hydrogen research. Noteworthy research projects include: the development of a novel high-efficiency, long-lasting hydrogen fuel electrocatalyst using RuO₂ and IrO₂ (Lee Hyoyoung research group);¹³⁰ the development of new manufacturing pathways that have produced high-performing proton-conducting fuel cells (Lee Won-young research group);¹³¹ hydrogen production by anodized TiO₂ nanotubes under UV light irradiation (Han Gui Young research group);¹³² and hydrogen production by catalytic decomposition methane over carbon black catalyst in a pilot scale fluidised bed reactor (Han Gui Young research group).¹³³
- POSTECH (Pohang University of Science & Technology) places a strong focus on renewable energy and the environment. The emerging hydrogen economy, fuel cells, gas hydrates, gas-to-liquid technology, biomass conversion, secondary batteries, and super-capacitors are noted research areas of interest.¹³⁴

Key industry stakeholders in the Korean hydrogen landscape include:¹³⁵

Table 10: Key hydrogen industry stakeholders

Value chain area	Organisations
Hydrogen supply	Deokyang co Ltd, SPG Hydrogen, Air Liquide, Linde Group
Electrolysis	EM Solutions Co Ltd, Elchem Tech Co Ltd, WESPE, ACRO LABS, Kolon Group
Engineering, procurement & construction	Hanyang ENG, Daewoo E&C, GS E&C, Hyundai Engineering & Construction

¹²⁸ IPHE (2021) Republic of Korea <https://www.iphe.net/republic-of-korea>

¹²⁹ Ha JE (2019) Hydrogen Economy Plan in Korea, Netherlands Enterprise Agency, <https://www.rvo.nl/sites/default/files/2019/03/Hydrogen-economy-plan-in-Korea.pdf>

¹³⁰ Alicia Moore (2020) South Korean team develops high-efficiency hydrogen fuel electrocatalyst, hydrogen fuel news, <https://www.hydrogenfuelnews.com/south-korean-team-develops-high-efficiency-hydrogen-fuel-electrocatalyst/8541085/>

¹³¹ FuelCellsWorks (2021) Professor Won-Young Lee’s Team at Sungkyunkwan University Develops the World’s Best-Performing Proton-Conducting Fuel Cell, <https://fuelcellworks.com/news/professor-won-young-lees-team-at-sungkyunkwan-university-develops-the-worlds-best-performing-proton-conducting-fuel-cell/>

¹³² School of Chemical Engineering (n.d.) HAN Gui Young | 한귀영. Sungkyunkwan University. <https://cheme.skku.edu/han-gui-young/>

¹³³ School of Chemical Engineering (n.d.) HAN Gui Young | 한귀영. Sungkyunkwan University. <https://cheme.skku.edu/han-gui-young/>

¹³⁴ POSTACH Chemical Engineering (n.d.) ENERGY & ENVIRONMENT: Creating the Future, https://ce.postech.ac.kr/eng/eng5_5.php

¹³⁵ Intralink (2021) The Hydrogen Economy South Korea: Market Intelligence Report, prepared for the UK Department for International Trade, Intralink. <https://www.intralinkgroup.com/Syndication/media/Syndication/Reports/Korean-hydrogen-economy-market-intelligence-report-January-2021.pdf>

Value chain area	Organisations
Gas equipment supply	Hyosung Heavy Industries, NKTech, KwangShin, Valmax, VINAtch, ILJIN Hysolus
Gas/Power companies	KOGAS, Samchully, Kepco
Utilisation (mobility)	Hyundai, Doosan, Edison Motors, Tata-Daewoo
Utilisation (fuel cells)	Doosan, Bumhan, Gaoncell, S-Fuelcell
Utilisation (industrial)	GS Caltex, Lotte Chemical, Samsung, Samsung SDI, Hyundai Steel, POSCO

1.5 International collaboration and joint RD&D projects

1.5.1 Overview of the Republic of Korea's approach to international collaboration

There are several references to Korea's intention for international collaboration in the *Hydrogen Economy Roadmap*. These include:¹³⁶

- **Safety:** Collaboration with countries such as the United States (US) for research on hydrogen safety and the establishment of international standards.
- **Standards:** Actively participating in international cooperation organisations, strengthening exchange and collaboration among certification bodies, and establishing an international standardisation response system.
- **Import infrastructure:** Collaboration for the establishment of overseas hydrogen import bases. For example, Korea highlighted the Korea-Australia Resource Collaboration as an important example for hydrogen projects and agenda coordination under this topic.
- **RD&D:** Focusing on technical cooperation in specific areas across sectors and value chains of the hydrogen economy. Key areas include water electrolysis technology, carbon capture technology for hydrogen production from LNG, and medium and large-scale liquid hydrogen production plant technology. For hydrogen utilisation, key areas include hydrogen gas turbine technology.
- **Supply chain collaborations:** Korea is seeking to develop the global hydrogen ecosystem through building CO₂-free hydrogen supply chains, importing from other countries. This will involve three phases: Initial investigation based on business needs, feasibility studies and public-private co-operation on demonstration projects, and large-scale commercialisation by the private sector. Countries under consideration are Australia, Canada, the US, New Zealand, India, Brunei, Saudi Arabia, United Arab Emirates and Norway. Production resources being considered are renewables, LNG, fossil fuels with CCS, enhanced oil recovery, and oil. Transport mediums being considered are high pressure gas, liquid toluene, liquid ammonia, and liquid hydrogen.¹³⁷

¹³⁶ Government of Korea (2019) Hydrogen Economy Roadmap of Korea.
https://docs.wixstatic.com/ugd/45185a_551e67dca75340569e68e37eea18f28e.pdf

¹³⁷ MOTIE (2021) Korean New Deal and Hydrogen Economy. Presentation, April 2021.

1.5.2 The Republic of Korea's bilateral hydrogen relationships

Korea is also undertaking collaborations with countries, particularly those with strong hydrogen RD&D and commercial activity. The majority of publicly announced international MoUs are with Korea's industry consortia bodies. Major relationships are detailed in Table 11.

Table 11: Bilateral relationships with other countries

Country	Relationship	Description
US	MoU	<p>In November 2021, the US and South Korea elevated the existing Energy Policy Dialogue to a ministerial-level forum. A key focus of the Dialogue is to enhance collaboration on R&D on hydrogen storage and the technologies necessary for renewable energy deployment.¹³⁸</p> <p>In February 2020, Hyundai signed an MoU with the US DOE to collaborate on hydrogen vehicle technology viability assessments (February 2020).¹³⁹</p> <p>H2KOREA and the US Fuel Cell & Hydrogen Energy Association signed an MoU across many areas of collaboration, including information sharing, codes and standards advancement and message development (February 2020).¹⁴⁰</p>
Australia	Partnership	<p>Korea has recognised Australia as a strong partner for their hydrogen economy, which was highlighted by the Australian and the Korean government signing an LoI for Hydrogen Cooperation in September 2019.</p> <p>In December 2021, Australia and Korea further cemented this partnership with the establishment of the Australia-Republic of Korea Low and Zero Emissions Technology Partnership under which both parties agree to collaborate on new and emerging low/zero-emissions technologies.¹⁴¹ Hydrogen supply and trading systems, low emissions steel and iron ore, and CCUS are flagged as early priorities. The announcement also gives mention to supporting domestic RD&D efforts and commercialisation projects through funding assistance, with such initiatives being industry-led and able to receive financial contributions from the private sector and other sources.</p> <p>In December 2021, Australia and Korea signed new deals on clean energy technology and critical minerals. Under these deals, both governments aim to invest up to a combined KRW 84 billion towards supporting clean hydrogen production, CCS, and low-emission steel and iron ore technologies.¹⁴² Each party will contribute an initial KRW 42 billion towards this commitment.</p>

¹³⁸ MOTIE (2021) Korea, U.S. agree to launch cooperation platform for carbon neutrality targets.

https://english.motie.go.kr/en/tp/energy/bbs/bbsView.do?bbs_seq_n=1143&bbs_cd_n=1&view_type_v=TOPIC&¤tPage=1&search_key_n=&search_val_v=&cate_n=3

¹³⁹ Stangarone T (2020) South Korean efforts to transition to a hydrogen economy. Clean Technologies and Environmental Policy. DOI: 10.1007/s10098-020-01936-6

¹⁴⁰ FuelCellsWorks (2020) Leading Industry Associations in Korea and U.S. Strengthen fuel Cell and Hydrogen Collaboration with Memorandum of Understanding. <https://fuelcellsworks.com/news/leading-industry-associations-in-korea-and-u-s-strengthen-fuel-cell-and-hydrogen-collaboration-with-memorandum-of-understanding/>

¹⁴¹ Department of the Prime Minister and Cabinet (2021) THE AUSTRALIA-REPUBLIC OF KOREA LOW AND ZERO EMISSIONS TECHNOLOGY PARTNERSHIP [Media Release]. Viewed at <https://www.pm.gov.au/media/australia-republic-korea-low-and-zero-emissions-technology-partnership>

¹⁴² Department of the Prime Minister and Cabinet (2021) AUSTRALIA AND REPUBLIC OF KOREA SIGN NEW DEALS ON CLEAN ENERGY TECH AND CRITICAL MINERALS [Media Release]. Viewed at <https://www.pm.gov.au/media/australia-and-republic-korea-sign-new-deals-clean-energy-tech-and-critical-minerals>

Country	Relationship	Description
		<p>Korea and Australia also hold numerous industry partnerships for research and development purposes. These are:</p> <ul style="list-style-type: none"> • In July 2021, Rio Tinto and POSCO signed an MoU to jointly explore, develop and demonstrate technologies to transition to a low-carbon emission steel value chain.¹⁴³ • In April 2021, Santos and SK Group signed an MoU to investigate zero emissions hydrogen.¹⁴⁴ • In March 2021, POSCO signed an agreement with Origin Energy regarding hydrogen production from renewables.¹⁴⁵ • In August 2020, Jemena, Coregas and Hyundai Motors Australia signed an MoU for the supply of hydrogen produced from renewables to Hyundai's Macquarie Park H2 refuelling station.¹⁴⁶ • In August 2020, Hyundai Motors Group, CSIRO and Fortescue Metals Group signed an MoU to collaborate on hydrogen production technology including ammonia cracking technology.¹⁴⁷ • In July 2020, H2KOREA signed an MoU with the Australian Hydrogen Council.¹⁴⁸ • In March 2020, the ATSE and the National Academy of Engineering of Korea held a joint workshop of Hydrogen Futures.¹⁴⁹ • In March 2019 Woodside joined the Korean HyNet consortium.¹⁵⁰
Chile	MoU	In November 2021, the South Korean Ministry of Trade, Industry and Energy and Chile's Minister of Energy and Minister of Mining signed the 'Korea-Chile low-carbon hydrogen cooperation MoU' to strengthen bilateral cooperation on hydrogen energy. Under the MoU the two countries will share hydrogen-related information and technologies, and pursue the development of global business consortia to expand business opportunities. ¹⁵¹
Qatar	MoU	In October 2021, QatarEnergy and Korea's Hydrogen Convergence Alliance (H2KOREA) signed an agreement for cooperation on the development of the hydrogen energy sectors in their respective countries by sharing information and plans to encourage industry growth and technological advancement. ¹⁵²

¹⁴³ Rio Tinto (2021) Rio Tinto and POSCO sign climate MOU. <https://www.riotinto.com/en/news/releases/2021/Rio-Tinto-and-POSCO-sign-climate-MOU>

¹⁴⁴ Santos (2021) Santos Completes Bayu-Undan and Darwin LNG Sell-Down to SK. News & Announcements <https://www.santos.com/news/santos-completes-bayu-undan-and-darwin-lng-sell-down-to-sk/>

¹⁴⁵ Fuelcellworks (2021) Origin Energy and POSCO to Cooperate on Green Hydrogen. <https://fuelcellworks.com/news/origin-energy-and-posco-to-cooperate-on-green-hydrogen/>

¹⁴⁶ Jemena (2020) Hydrogen Vehicle Refuelling Deal Could be Green Light for Australian Fuel Cell Electric Vehicles. Newsroom. <https://jemena.com.au/about/newsroom/media-release/2020/hydrogen-vehicle-refuelling-deal-could-be-green-li>

¹⁴⁷ AKBC (2021) Mapping the Australia-Korea Hydrogen Intersections Report. https://www.hydrogenforum.com.au/sites/hydrogenforum.com.au/files/AKBC_Mapping-the-Australia-Korea-Hydrogen-Intersections-Report_Digital.pdf

¹⁴⁸ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹⁴⁹ The University of Melbourne (2020) Hydrogen Futures Workshop. <https://energy.unimelb.edu.au/news-and-events/news/hydrogen-futures-workshop>

¹⁵⁰ Woodside (2019) Woodside Joins Korean Hydrogen Consortium. Media Release. https://files.woodside/docs/default-source/media-releases/woodside-joins-korean-hydrogen-consortium.pdf?sfvrsn=a0b38037_2

¹⁵¹ The Korean Herald (2021) S. Korea, Chile sign MOU on hydrogen energy cooperation. Viewed at <http://www.koreaherald.com/view.php?ud=20211109000136>

¹⁵² The Peninsula (2021) QatarEnergy and H2Korea sign hydrogen cooperation agreement. Viewed at <https://thepeninsulaqatar.com/article/25/10/2021/QatarEnergy-and-H2Korea-sign-hydrogen-cooperation-agreement>

Country	Relationship	Description
Saudi Arabia	MoU	In March 2021, an MoU was signed between Hyundai OilBank Co. and Saudi company Aramco under which Hyundai will convert Aramco liquified petroleum gas to hydrogen. The hydrogen will then be used at desulfurisation facilities and to power vehicles in Korea, while the CO ₂ by-product will be returned to Saudi Arabia and used in oil production facilities. ¹⁵³ In June 2019, the South Korean Ministry of Trade, Industry and Energy and the Saudi Ministry of Energy, Industry and Mineral Resources signed an MoU for bilateral cooperation in the hydrogen economy. ¹⁵⁴
UAE	MoU	Korea and the UAE in March 2021 signed an MoU to share hydrogen trade regulations and policies and strengthen cooperation between H2KOREA and the UAE Hydrogen Alliance. ¹⁵⁵
European Union	MoU	In February 2020, Hydrogen Europe and H2KOREA signed an MoU to strengthen cooperation on technological and personnel exchange and to facilitate joint industry projects. ¹⁵⁶
Israel	MoU	Korea and Israel signed an MoU in July 2019 for bilateral cooperation in the hydrogen economy.
Norway	MoU	In June 2019, Korea and Norway announced co-operation on shipbuilding for liquefied hydrogen transportation. ¹⁵⁷

1.5.3 The Republic of Korea's joint international RD&D projects

Korea's joint RD&D projects with other countries are not widely publicised. However, Korea's research institutions have partnered with multiple international institutions in many research areas (other than hydrogen), and have research centres located overseas (e.g. the KIST and KITECH).

Further, the KIER also promotes international cooperation through the KIER International Joint R&D Project Funding Program that offers a maximum of KRW 200 million per successful project. Projects must relate to the concept papers provided during each round call, however at least one concept paper from both the FY2021 and FY2022 have contained mention of hydrogen or hydrogen-related technologies. Successful international project leads will be partnered with a project lead at the KIER.¹⁵⁸

¹⁵³ Verity Ratcliffe, Seyoon Kim, and Kyung Park (2021) Saudi Arabia to Ship Gas to South Korea and Take CO₂ Back, Bloomberg. <https://www.bloomberg.com/news/articles/2021-03-03/saudi-arabia-to-ship-gas-to-south-korea-and-take-back-the-co2>

¹⁵⁴ Yonhap News Agency (2019) S. Korea, Saudi Arabia sign hydrogen economy MOU. <https://en.yna.co.kr/view/PYH20190626146700320>

¹⁵⁵ Byung-wook K (2021) Korea partners with UAE for hydrogen economy. The Korea Herald. <http://www.koreaherald.com/view.php?ud=20210304000936>

¹⁵⁶ FuelCellsWorks (2020) Hydrogen Europe Signs MoU with H2KOREA. FuelCellsWorks. <https://fuelcellsworks.com/news/hydrogen-europe-signs-mou-with-h2korea/>

¹⁵⁷ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edition-energie/south-korea-s-hydrogen-strategy-and-industrial>

¹⁵⁸ KIER (2021) 2022 KIER International Joint R&D Project Funding Program [Media Notice]. <https://www.kier.re.kr/board/view?pageNum=1&rowCnt=10&no1=264&linkId=255731&menuId=MENU00642&schType=0&schText=&boardStyle=&categoryId=&continent=&country=>

Joint RD&D projects with other countries include:

Table 12: Joint hydrogen RD&D projects with other countries

Country	Projects
US	Bloom Energy, a US based producer of solid oxide fuel cells, collaborated with Korea-based SK Engineering and Construction Co for a pilot project in Ulsan, Korea. 100kW of solid oxide fuel cells were deployed and powered by hydrogen by-product generated by SK Advanced.
Australia	<p>Announced in November 2021, an arm of Korea Zinc will receive KRW 17.5 billion in funding from the Australian federal and Queensland state governments to produce hydrogen from renewables at Korea Zinc's refinery in Queensland. The produced hydrogen will be utilised in refuelling fuel cell electric trucks which will transport zinc from the refinery to the port of Townsville.¹⁵⁹</p> <p>In September 2019, KOGAS signed an agreement with Woodside Petroleum to conduct a feasibility study on a renewable hydrogen pilot project.¹⁶⁰</p> <p>Korea is also seeking an overseas partner to consolidate their hydrogen supply chain by securing an overseas production base. MOTIE will conduct a feasibility analysis on each of the 6 short-listed countries, which includes Australia, to determine which country to partner with. The Australia-Korea Joint Feasibility Study on Export Supply chain is expected to occur between 2020-2025, followed by a pilot project.¹⁶¹ Other candidate countries include Saudi Arabia and the US. The goal for Korea is to supply 1.58 million tonnes of hydrogen from the overseas base.¹⁶²</p> <p>In 2017 CSIRO and the National Research Council of Science & Technology (NST) signed an MoU to collaborate on a diverse range of technologies, including in the area of energy. Several RD&D projects emerged from this including with the KICT, and KITECH.¹⁶³</p> <p>The Australia-Korea Foundation grant funds a diverse range of RD&D areas, including a metal organic framework project between the KIST and the CSIRO,¹⁶⁴ and a joint workshop with the KIST and KITECH on roadmapping the establishment of hydrogen refuelling infrastructure.¹⁶⁵</p> <p>The CSIRO and RMIT have worked with the KRICT on a joint project for the electrochemical synthesis of ammonia.¹⁶⁶</p> <p>CSIRO and KIER are working in the area of electrochemical ammonia synthesis under the KIER's international collaboration program.¹⁶⁷</p>

¹⁵⁹ Reuters (2021) Korea Zinc's Ark gets Australian funding for hydrogen project, Reuters. <https://www.reuters.com/business/sustainable-business/korea-zincs-ark-gets-australian-funding-hydrogen-project-2021-11-08/>

¹⁶⁰ Kan S (2020) South Korea's Hydrogen Strategy and Industrial Perspectives. IFRI. <https://www.ifri.org/en/publications/editoriaux-de-lifri/edito-energie/south-koreas-hydrogen-strategy-and-industrial>

¹⁶¹ AKBC (2021) Mapping the Australia-Korea Hydrogen Intersections Report. https://www.hydrogenforum.com.au/sites/hydrogenforum.com.au/files/AKBC_Mapping-the-Australia-Korea-Hydrogen-Intersections-Report_Digital.pdf

¹⁶² Australia-Korea Business Council (2020) Korea seeks to secure an overseas hydrogen production base <https://www.akbc.com.au/hydrogen-base/>

¹⁶³ CSIRO (2020) Developing diverse technologies: urban development, natural resources and manufacturing technology <https://www.csiro.au/en/work-with-us/international/asia/north-asia/korea>; Consultation with CSIRO, November 2021

¹⁶⁴ Consultation with CSIRO, November 2021

¹⁶⁵ Australian Government (2019) Grant Award View – GA57034. Grant connect <https://www.grants.gov.au/Ga/Show/229a8256-df99-66a7-4cbf-972deeb158d4>

¹⁶⁶ Consultation with CSIRO, November 2021

¹⁶⁷ Consultation with CSIRO, January 2022

1.5.4 The Republic of Korea's joint international commercial projects

The scope of this report is on research, development and demonstration (RD&D) projects. For information on commercial hydrogen projects, see *HyResource*, an online knowledge sharing platform across the hydrogen community led by CSIRO, Future Fuels CRC, NERA and the Australian Hydrogen Council.

HyResource provides a directory of publicly available databases and information sources on international projects:

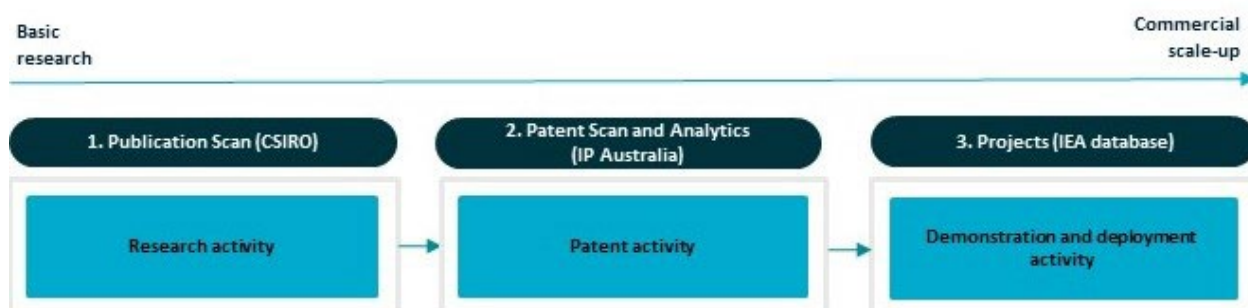
- <https://research.csiro.au/hyresource/projects/international/>

1.6 Data insights: The Republic of Korea's hydrogen RD&D activity

The following section provides data-driven insights on Korea's RD&D activity in hydrogen technologies. Research publication data, patent data, and commercial project data has been used to understand hydrogen related activity. While limitations exist with such an approach, these data sources do provide an opportunity to consider activity across the innovation spectrum from basic research to demonstration. It also aims to help identify technology areas that have received significant focus in each country and key organisations to support international collaboration efforts.

The data for this section was sourced from CSIRO's publications team, CSIRO's IP team, IP Australia, and the IEA's hydrogen projects database.

Figure 5: Hydrogen innovation activity data



1.6.1 Research publication data

Research publications in hydrogen are an indicator of basic and applied research activity. CSIRO's publications team has conducted a research publication scan to identify Korean organisations conducting research across the hydrogen value chain. The publications search approach was developed in 2019 to support the report *Hydrogen Research, Development and Demonstration: Priorities and opportunities for Australia*.¹⁶⁸ This search approach was applied in 2021 to provide an updated dataset for this report.

¹⁶⁸ CSIRO (2019) Hydrogen Research, Development and Demonstration (RD&D): Priorities and Opportunities for Australia. Available at <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/futures-reports/hydrogen-research>

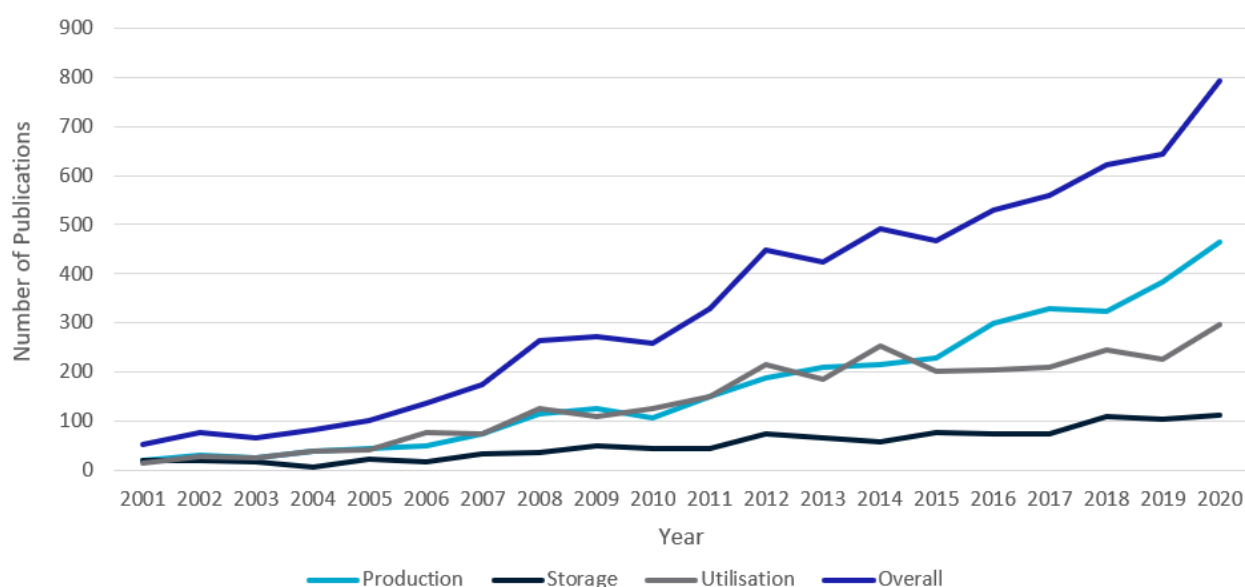
The details of the search approach can be found in the *National Hydrogen Research, Development and Demonstration (RD&D): Technical Repository*.¹⁶⁹

Figure 6 shows Korean institutions ranked in terms of publication output across hydrogen production, storage and distribution, and utilisation from 2016-2020. Figure 7 shows Korea's country-wide research publication output trends across the hydrogen value chain.

Figure 6: Top Institutions by publication output (2016-2020)

Rank	Production	Storage and Distribution	Utilisation	Overall
	6 th Global Rank	6 th Global Rank	6 th Global Rank	6 th Global Rank
1 st	Yonsei University	Jeonbuk National University	Korea Advanced Institute of Science & Technology (KAIST)	Korea Advanced Institute of Science & Technology (KAIST)
2 nd	Korea University	Korea Institute of Science & Technology (KIST)	Korea Institute of Science & Technology (KIST)	Korea University
3 rd	Seoul National University (SNU)	Seoul National University (SNU)	Seoul National University (SNU)	Seoul National University (SNU)
4 th	Ulsan National Institute of Science & Technology (UNIST)	Korea University	Yonsei University	Yonsei University
5 th	Korea Advanced Institute of Science & Technology (KAIST)	Hanyang University	Korea University	Korea Institute of Science & Technology (KIST)

Figure 7: The Republic of Korea's hydrogen-related publication output (2001-2020)



¹⁶⁹ CSIRO (2019) National Hydrogen Research, Development and Demonstration (RD&D): Technical Repository. Available at <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/futures-reports/hydrogen-research>

1.6.2 Patent data

Patent activity in hydrogen is an indicator of applied R&D and innovation occurring across the value chain. This section draws on two different patent analytics approaches. CSIRO developed a search approach in 2019 to support the *Hydrogen Research, Development and Demonstration: Priorities and opportunities for Australia*¹⁷⁰ report. CSIRO applied this approach to provide a patent landscape across the hydrogen value chain for each country. The details of the search approach and any limitations can be found in the *National Hydrogen Research, Development and Demonstration (RD&D): Technical Repository*.¹⁷¹ The second approach, performed by IP Australia, builds on the hydrogen technology taxonomy developed in CSIRO's 2019 report to provide information on specific hydrogen technologies that sit within production, storage and utilisation. The full data visualisations, details of the search approach and any limitations can be found at *Patent analytics of hydrogen technologies: an interactive visualisation*.¹⁷²

It should be noted that analysis of patent data is not necessarily representative of patent impact. As such, this data should be viewed holistically with the other data presented in this section, particularly project deployment.

Patent landscape of hydrogen value chain

Performed by the CSIRO, this patent landscape analyses patent family¹⁷³ filings across the hydrogen value chain. Figure 8 outlines patent filings over time across the areas of hydrogen production, storage/distribution and utilisation. Figure 9 shows the jurisdictions in which Korean patent applicants are filing patents, outside of Korea. This provides an indication of which global markets, or manufacturing/commercialisation destinations are of interest to Korean patent applicants or inventors.

Note that patent databases have a delay of roughly 18 months, therefore 2020 and 2021 have been omitted from the graphs below. Some patent filings may also be counted twice as the categories of production, storage and utilisation may not be mutually exclusive in all instances and some could relate to multiple areas of the hydrogen value chain.

¹⁷⁰ CSIRO (2019) Hydrogen Research, Development and Demonstration (RD&D): Priorities and Opportunities for Australia. Available at <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/futures-reports/hydrogen-research>

¹⁷¹ CSIRO (2019) National Hydrogen Research, Development and Demonstration (RD&D): Technical Repository. Available at <https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/futures-reports/hydrogen-research>

¹⁷² IP Australia (2021) Patent Analytics on Hydrogen Technology, Australian Government. Available at <https://www.ipaustralia.gov.au/tools-resources/publications-reports/patent-analytics-hydrogen-technology>

¹⁷³ Applications with the same priority, but filed in different jurisdictions, are known as patent families. Patent families enable us to analyse inventive activity regardless of the number of countries in which protection is sought. Patent families are used in analytics to represent a single invention.

Figure 8: Patent filings over time across production, storage/distribution and utilisation

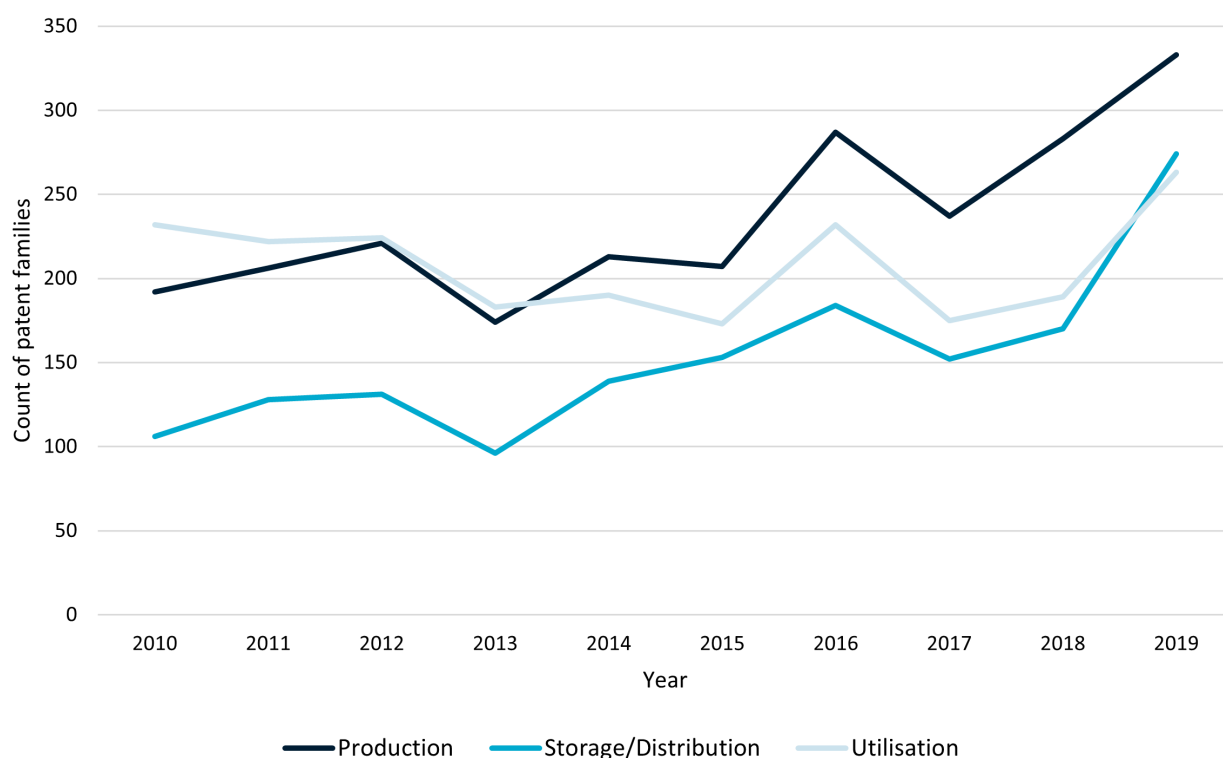
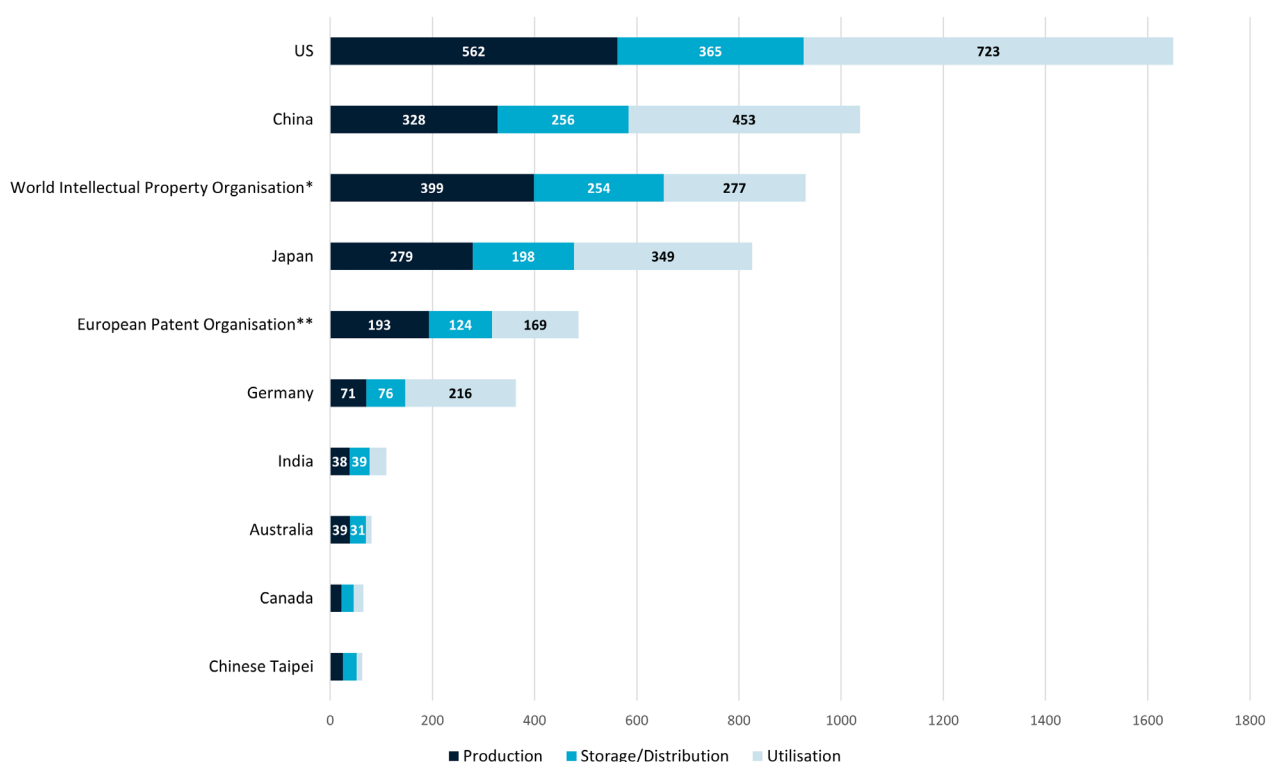


Figure 9: Location of patent filings by patent applicants of the Republic of Korea



* The World Intellectual Property Organisation (WIPO) is an international organisation that promotes the protection of intellectual property and supervises administrative cooperation amongst the intellectual unions regarding protection of intellectual property. Patents filed in the WIPO enable applicants to obtain protection for their inventions in up to 153 of the parties to the Patent Cooperation Treaty.

** The European Patent Office enables investors, researchers and companies to obtain protection for their inventions in up to 44 countries, including all 27 EU member states.

Patent analytics of specific hydrogen technologies

Data extracted from IP Australia's interactive visualisation provides an in-depth analysis of specific hydrogen technology developments. Figure 10 shows the number of patent families filed since 2010 for specific technology areas by Korean applicants.

Table 13 shows the number of patent families filed by Korean applicants since 2010 by sub-technology area, expressed as a percentage of total global patent family filings. Table 13 also shows the top organisations in Korea filing patents in each technology area. It should be noted that the majority of fuel cell technologies are categorised under the 'electricity generation' category.

Figure 10: Korea's patent family output by sub-technology area (2010-2020)

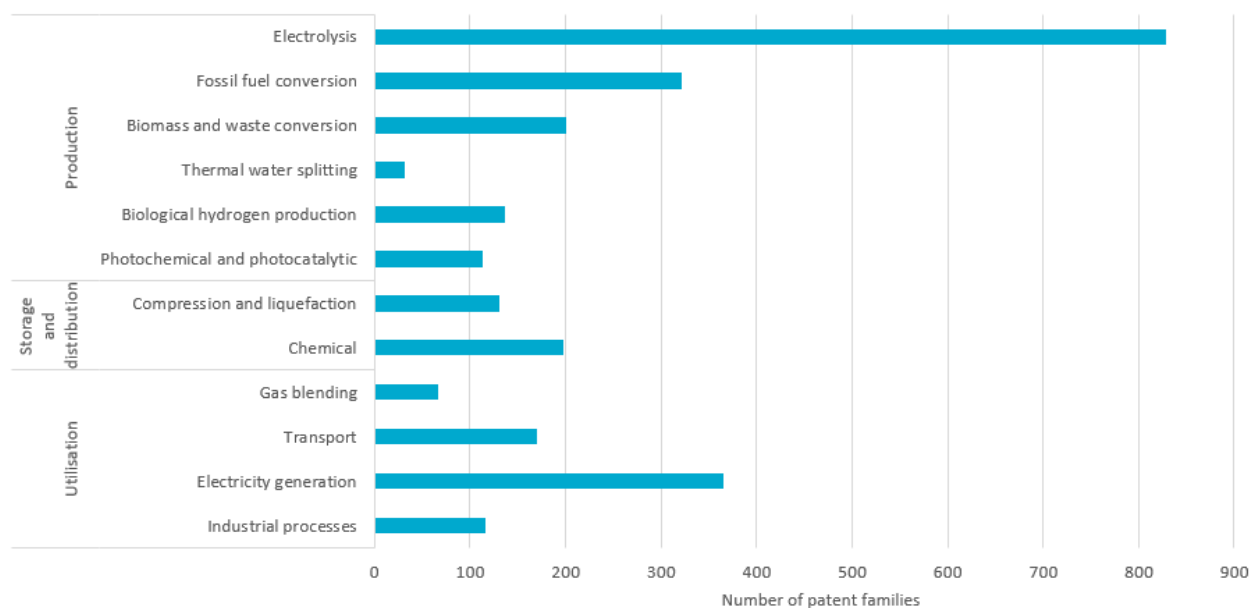


Table 13: Korea's IP output (number of patent families filed by Korean applicants) by sub-technology area from 2010-2020

Technology area		IP output (% of global)	Leading companies	Leading non-profits and universities
Production	Electrolysis	10.3%	Solco Biomedical, Daewoo Shipbuilding & Marine Engineering Company, Techwin Company, Vision Technologies Company, Korea Electric Power Corporation	KIER, KIST, Sungkyunkwan University, Kyonggi University Industry & Academia Cooperation Foundation
	Fossil fuel conversion	5.2%	POSCO, Research Institute of Industrial Science & Technology, Daewoo Shipbuilding & Marine Engineering, SK Innovation Company, Korea Gas Corporation	KIER, Korea Research Institute of Chemical Technology, KIST, UNIST, Korea Institute of Energy Research
	Biomass and waste conversion	6.7%	SK Innovation Company, Daewoo Shipbuilding & Marine Engineering, KIST,	KIER, KIST, Korea Research Institute of Chemical Technology, Sungkyunkwan University

Technology area		IP output (% of global)	Leading companies	Leading non-profits and universities
			Korea Gas Corporation, Samsung Electronics	
	Biological	5.7%	Dodram Environment Research Centre Company, M&C Life Science Company, RIST, Amorepacific, SK Innovation	KIER, Kyonggi University Industry & Academia Cooperation Foundation, KRIBB, Korea Institute of Ocean Science & Technology
	Photochemical and photocatalytic	5.9%	Samsung Electronics, Kwatercraft, Wizinnotek, Daewoo Shipbuilding & marine Engineering, Elchem Tech, Sinkang Hi-Tech	Sogang University Research Foundation, POSTECH, Academy-Industry Foundation, KIER, KIST
	Thermal water splitting	4.4%	Samsung Electronics, Taewon Paper, Taewon Corporation, Hyundai, S-Oil Corporation	UNIST, KIST, Inha-Industry Partnership Institute, Sogang University Research Foundation
Storage and distribution	Compression and liquefaction	18.2%	Hyundai, Kia, Daewoo Shipbuilding & Marine Engineering, HN-Power, Samsung Heavy Industries	Tongmyong University Industrial-Academic Cooperation Foundation, KIST, Chonnam National University, KOCETI, Pusan National University
	Chemical storage	8.0%	Hyundai, Daewoo Shipbuilding & Marine Engineering, LG Chem, Kia, Dongwoo Fine-Chem	KAIST, KIST, Korea Basic Science Institute Korea University, Hanyang University, Agency for Defense Development
Utilisation	Gas blending	4.7%	Samsung Electronics, Hanwha Chemical Corporation	KIER, KIST, Sungkyunkwan University, Korea Research Institute of Chemical Technology, Hanyang University
	Transport	6.7%	Hyundai, Daewoo Shipbuilding & Marine Engineering, Kia, Hyundai Heavy Industries, MH Technologie	KIMM, Kookmin University Industry Academy Cooperation Foundation, KIST
	Electricity generation	8.7%	Daewoo Shipbuilding & Marine Engineering, Hyundai Construction, Samsung Heavy Industries, Samsung SDI Co. Ltd., LG Chem	KIER, KIMM, Seoul National University, KIST, Gwangju Institute of Science and Technology, Pusan National University

Technology area		IP output (% of global)	Leading companies	Leading non-profits and universities
	Industrial processes	2.7%	RIST, Fereco, POSCO, Hyundai	KIER, Korea Research Institute of Chemical Technology, Korea Institute of Ocean Science & Technology Industry Academic Cooperation Foundation, Keimyung University, KIMM, KIST

IP Australia patent analytics on hydrogen technology

IP Australia has developed an interactive visualisation tool to provide hydrogen insights to researchers, academics, business and policy sectors. For more hydrogen IP statistics including key destination markets, origin profiles, applicant profiles, collaborations and specific patent searches, refer to IP Australia's Hydrogen Patent Landscape tool:

- <https://www.ipaustralia.gov.au/tools-resources/publications-reports/patent-analytics-hydrogen-technology>

1.6.3 Project data

Data from the IEA Hydrogen Projects Database (as at October 2021)¹⁷⁴ provides insight on clean hydrogen technology value chains deployed at pilot and commercial scale across Korea. Note that the following limitations should be taken into account:

- The database does not indicate whether the technologies used are indigenous or purchased from an overseas provider. While many countries often deploy their own technologies at scale, many countries purchase technologies from overseas to deploy locally. As such the database indicates deployment activity, but not necessarily the ability to translate indigenous R&D into commercial scale-up.
- This dataset counts only low-carbon hydrogen projects and their associated value chains. As such hydrogen production projects from gas, coal and oil without CCS are not included. Similarly, utilisation projects not related to a clean hydrogen project source are not included.
- The dataset reflects only projects occurring domestically, and therefore does not count projects undertaken by Korean companies outside of Korea. As such, the table may understate Korea's activity, particularly its contribution to international supply chain development. This data should therefore be considered holistically with the rest of this report.
- Any limitations stated in the data collection methodology, definitions and assumptions should be taken into account (see IEA Hydrogen Projects Database for details).

For the purposes of this report, the dataset has been filtered to include only projects from 2010 through to projects expected to be operational by 2030 as this timespan best reflects current activities. Projects without a specified date have been excluded from the table below. Further, only projects that are at feasibility study, final investment decision, demonstration, or operational stage are included. Projects at

¹⁷⁴ IEA (2021) Hydrogen Projects Database. Available at <https://www.iea.org/data-and-statistics/data-product/hydrogen-projects-database>

the 'concept' stage are not included. It should be noted that the majority of projects listed span production, storage and multiple end-uses, and as such can be counted in more than one technology category.

Table 14: Korea's domestic clean hydrogen project data

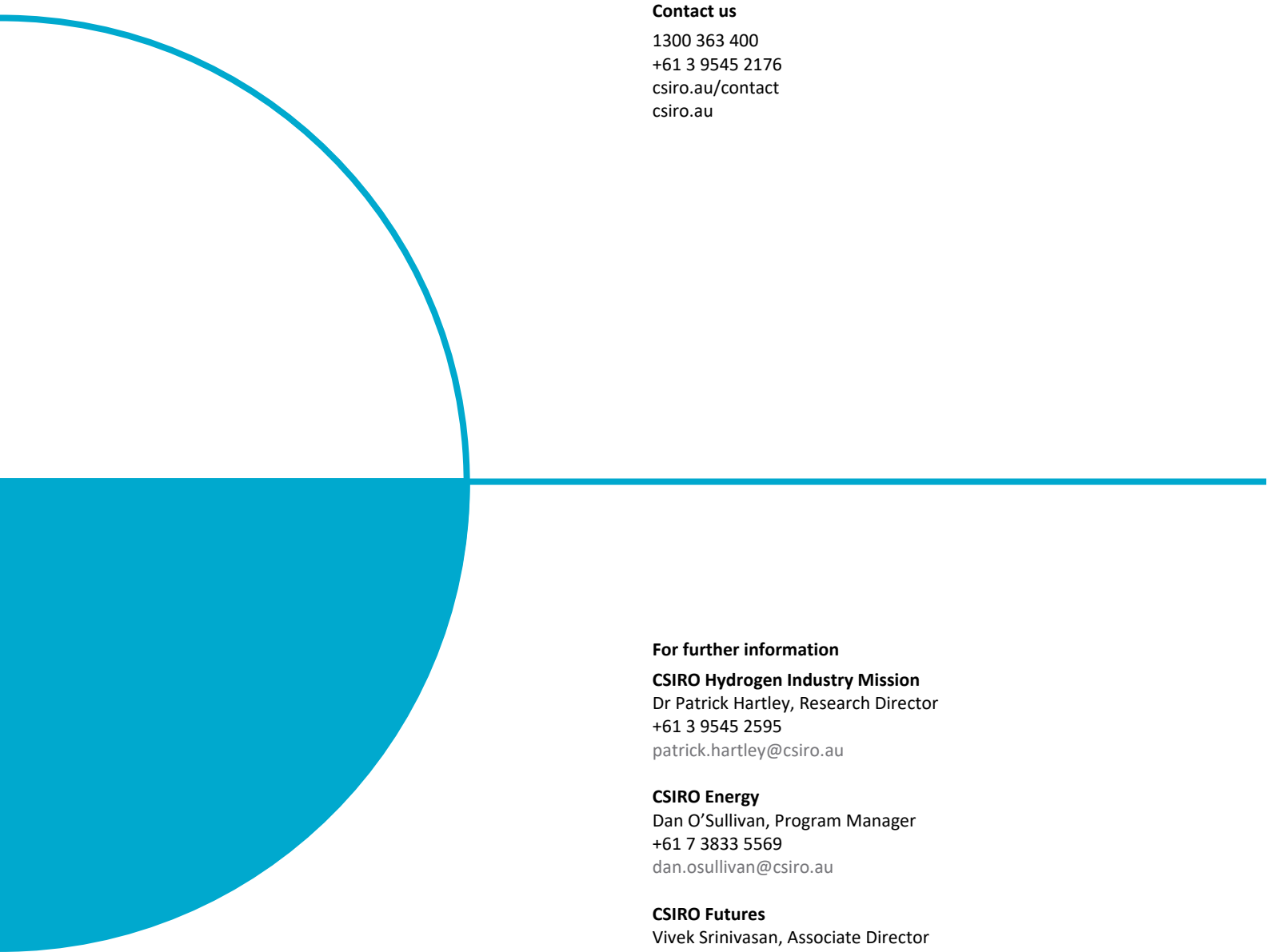
Technology	Sub-technology		Domestic project Count	% of global
Production	Electrolysis	PEM	-	-
		Alkaline	-	-
		SOE	1	3.6
		Other or unspecified	1	0.4
	Fossil fuel conversion	Coal gasification with CCS	-	-
		Natural gas with CCS	2	5.6
		Oil with CCS	-	-
		Methane pyrolysis	-	-
	Biomass and waste conversion		-	-
	Photochemical and photocatalytic		-	-
	Biological		-	-
	Thermal water splitting		-	-
Storage and distribution	Compression and liquefaction		4	0.8
	Chemical carriers	Ammonia	-	-
		Methane	-	-
		Methanol	-	-
		Synfuels	-	-
Utilisation	Gas blending		-	-
	Transport		1	0.4
	Electricity generation		2	1.5
	Industrial processes	Refining	-	-
		Ammonia	-	-
		Methane	-	-

Technology	Sub-technology		Domestic project Count	% of global
		Iron and steel	-	-
		Biofuels	-	-
		Synfuel	-	-
		Other industry	-	-

IEA Hydrogen Projects Database

The latest version of the IEA Hydrogen Projects Database can be found at:

- <https://www.iea.org/data-and-statistics/data-product/hydrogen-projects-database>



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