



# ▶ HYDROGEN: POWERING SOUTH KOREA'S FUTURE

South Korea's vision of becoming a hydrogen-based economy will not only decarbonise the environment, but also sustain the country's future economic growth. Whilst the automotive industry is undoubtedly a beneficiary of this eco-friendly initiative, there is also plenty of potential for heavy industrial players to embrace the hydrogen technology to grow their business.

In January 2019, President Moon Jae-in laid out an ambitious roadmap for the country to develop the technology and infrastructure needed for a hydrogen economy (see Fig. 1). The roadmap focuses on three key areas:

- ▶ More hydrogen-powered vehicles on the roads.
- ▶ More fuel cells (hydrogen batteries) for household and industrial use.
- ▶ Build an infrastructure for the distribution, storage and production of hydrogen.

Based on the roadmap, the nation targets to achieve an annual production of 5.26 million tonnes of hydrogen by 2040 (up from 130,000 tonnes in 2018); thereby, halving the average hydrogen cost to KRW 3,000 (USD2.59) per kilogramme<sup>2</sup>. This is one of the most challenging



**Darren Choi**  
Equity Portfolio Senior Manager  
Eastspring Investments Korea



**Dylan CH Lim**  
Equity Portfolio Manager  
Eastspring Investments Korea

**Fig. 1: Roadmap for hydrogen economy by 2040<sup>1</sup>**

| Year  | Hydrogen vehicles (Units) | Fuelling stations (Units) | Fuel cells for            |                          |
|-------|---------------------------|---------------------------|---------------------------|--------------------------|
|       |                           |                           | industrial use (Gigawatt) | household use (Megawatt) |
| 2040F | 6,200,000                 | 1,200                     | 15.0                      | 2,100                    |
| 2022F | 81,000                    | 310                       | 1.5                       | 50                       |
| 2018  | 2,000                     | 14                        | 0.3                       | 7                        |

aspects of the initiative, since the storage and production facilities of hydrogen are not yet well developed.

What is the reason for such an ambition? What holds the key to success? Where do we see investment opportunities?

## DECARBONISING THE ENVIRONMENT

South Korea faces a chronic problem with dirty air. The country is ranked 119 out of 180 for air quality in the 2018 Environmental Performance Index (see Fig. 2). The poor air quality, together with its heavy greenhouse gas (CO<sub>2</sub>) emissions, is undermining the health of the Korean population.

Emissions from cars and trucks are one major source of air pollution; industrial solvents are another<sup>4</sup>. To tackle the issue, South Korea has partnered with the US National Aeronautics and Space Administration (NASA) to accurately locate the sources of air pollution<sup>5</sup>.

In the meantime, however, the South Korean government needs to find an alternative source of energy to help reduce pollutants and greenhouse gas emissions. This is also an integral part to South Korea achieving the targets set at the 2015 Conference of the Parties (COP21), which, together with other countries, aims to keep global warming well below 2°C.

## SUSTAINABLE GROWTH

Besides reducing pollutants and greenhouse gases, the transition to a 'hydrogen economy' could create a new domestic market and sustain the growth of the country's advanced industries.

According to research by McKinsey & Company, a hydrogen industry this large will trigger strong employment demand; just to meet the demand for the domestic market alone, Korea's hydrogen industry can potentially employ 600,000 people in 2050, largely in the automotive industry.

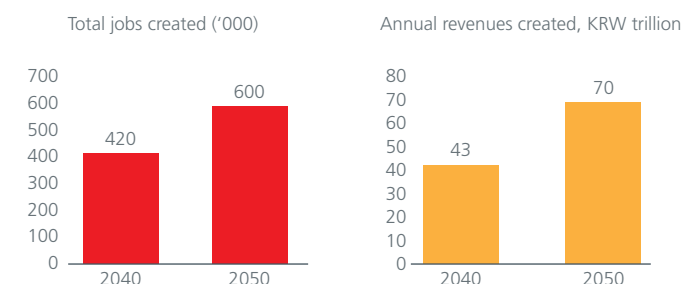
Domestic revenues across the energy value chain, from hydrogen generation through distribution to end-user applications such as

hydrogen vehicles, can reach KRW 70 trillion (USD60.47 billion) per year by 2050, the same research shows (see Fig. 3).

**Fig. 2: Air quality and greenhouse gas emissions in Korea, 2018<sup>3</sup>**

| Environmental Performance Index, 2018 | Current rank | Current score | Baseline rank | Baseline score |
|---------------------------------------|--------------|---------------|---------------|----------------|
| Air quality                           | 119/180      | 61.19         | 82            | 67.86          |
| PM2.5 exposure                        | 174/180      | 30.21         | 173           | 42.71          |
| CO <sub>2</sub> emission intensity    | 138/180      | 32.40         | 62            | 57.43          |

**Fig. 3: A hydrogen economy will create new jobs and add revenues for South Korea<sup>6</sup>**



## A CLEAN ENERGY CARRIER

Hydrogen is one of the most abundant substances in the universe. It is a clean and safe energy carrier (not an energy source) that can be used directly as a fuel, or converted to heat and electricity in a hydrogen battery called a 'fuel cell'.

Small fuel cells, such as those installed in the Hyundai Nexo SUV (sports utility vehicle), only take a few minutes to refill and power an electric car, while large fuel cells can provide electricity to buildings in remote areas with no power lines.

Hydrogen-powered cars, for example, correspond to more than a 50% reduction in fuel consumption compared to their gasoline-powered counterparts<sup>7</sup>.

Such low-carbon hydrogen is therefore the key to decarbonising South Korea.

## EN ROUTE TO LESS EMISSIONS

South Korea plans to introduce 2,000 public buses and 820 police vans powered by hydrogen, as well as providing subsidies for hydrogen-powered taxis to reduce further environmental degradation and greenhouse gas emissions, according to President Moon's plans<sup>7</sup>.

The switch would reduce an estimated 30,000 tonnes of fine dust pollutants – in other words, 10% of the amount currently produced – if 1.8 million hydrogen-powered cars were on the streets by 2030<sup>8</sup>.

Combined with more hydrogen being used for heating systems, industry feedstocks (unprocessed materials) and power systems, the increase in hydrogen usage could help close the remaining gap towards the required greenhouse gas reduction targets by 40% (see Fig. 4).

## BUT IT WON'T BE PLAIN SAILING

Despite the positive impacts, however, there are a host of challenges; notably, the high construction costs of fuel cell systems relative to other technologies.

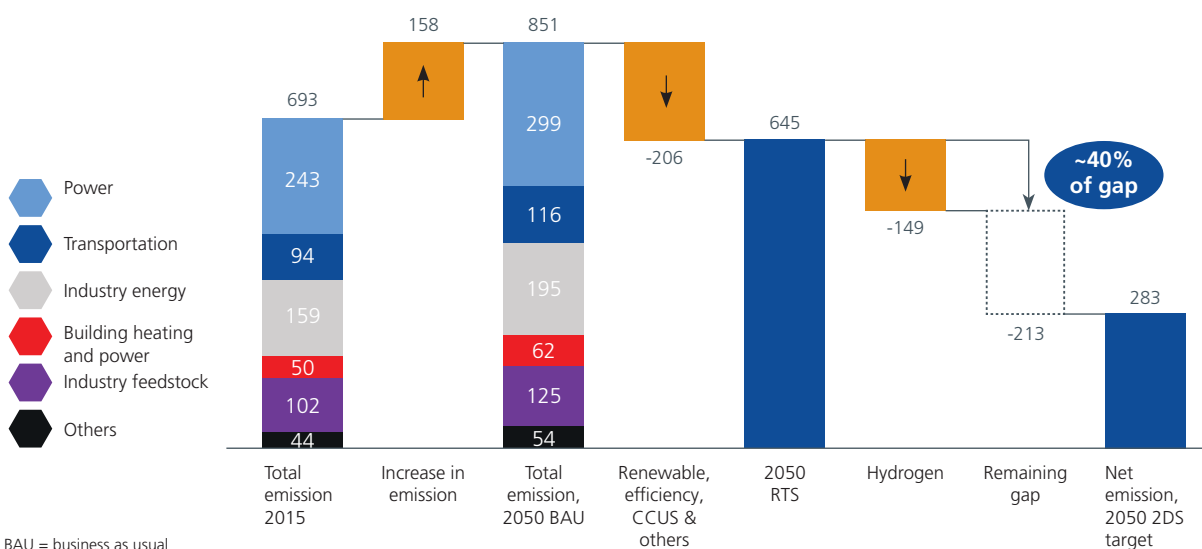
Production scale holds the key to reducing these construction costs.

As Korea's hydrogen-vehicle production increases and scales up to 100,000 per year – the government's 2025 target – the cost of a fuel-cell system should decrease as much as 77% to around USD3,160<sup>10</sup>. In addition, technological advancement should help reduce the usage of platinum in fuel cells, thus further lowering production costs.

In the interim, the government is offering purchase subsidy incentives. A Hyundai Nexo SUV currently priced at USD63,000, for example, can now be purchased at USD32,000 after government subsidy.

**Fig. 4: Hydrogen can help close the greenhouse gas reduction gap<sup>9</sup>**

CO<sub>2</sub>e avoidance potential by segment in 2050 (In Mt, hydrogen potential vis-à-vis business as usual)



BAU = business as usual  
 CCUS = carbon capture, use and storage  
 RTS = International Energy Agency Reference Technology Scenario  
 2DS = 2-degree Celsius Target

In our opinion, if the average sale price drops to about USD30,000 (without subsidy), then it will help push hydrogen-powered cars into the mainstream automotive industry.

### THE MISSING JIGSAW

The take up of hydrogen vehicles would, however, be dependent on having an established hydrogen mobile infrastructure.

In 2018, South Korea only had 14 hydrogen fuelling stations for 2,000 hydrogen vehicles on the roads. Japan, in contrast, has more than 100 fuelling stations, outnumbering those in both Germany and the United States<sup>11</sup>.

To catch up, the government has established a special purpose corporation called Hydrogen Energy Network (HyNet) to partner with industrial companies, such as Korea Gas Corporation and Hyundai, to build its hydrogen-fuelling infrastructure (1,200 stations) across the country<sup>12</sup>.

Adding to the challenges is the development of up-stream hydrogen technologies. Production and storage technologies for hydrogen, for example, are not yet core competencies, as seen in South Korea's lagging position in Fig. 5. This contrasts with the country's commendable performance in hydrogen down-stream technologies, such as fuel-cells for heating applications and hydrogen cars.

### SOME GOOD NEWS

Despite the challenges, South Korea's key industrial companies, such as the automotive, shipbuilding and petrochemicals companies, are already equipped with world-class technology for hydrogen utilisation, especially in the mobile (e.g. vehicles), stationary (e.g. fuel cells) heating and industrial applications (see Fig. 6).

With a global market share of 50%, South Korea is the first country to succeed in mass-producing hydrogen-powered cars<sup>15</sup>. In Ulsan, the country's industrial powerhouse, large-scale petrochemical plants are already capable of producing enough hydrogen to expand the use of

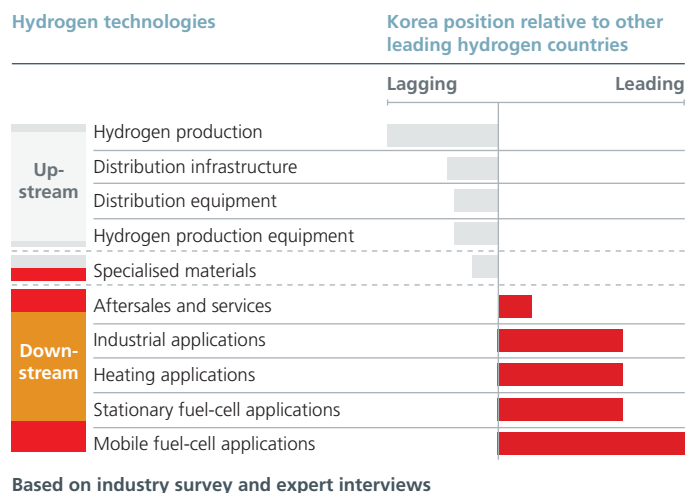
hydrogen-powered vehicles.

### BEYOND THE DOMESTIC MARKET

Given this head start, fuel-cell application leaders who are able to capture both the domestic and export markets' demand are poised to create sustainable value over time.

For example, the South Korean automotive industry, including original equipment manufacturers (OEM) and fuel-cell suppliers, can generate more than KRW 25 trillion (USD21.6 billion) in annual revenues by 2050<sup>16</sup> as they

**Fig.7: Hydrogen fuel cell trucks are more efficient than battery trucks<sup>18</sup>**



**Fig. 6: Rankings: Industry development of hydrogen applications<sup>14</sup>**

| Ranking | Mobile (Eg. Cars)  | Stationary (Eg. Fuel cells) |
|---------|--------------------|-----------------------------|
| 1       | Japan              | Japan                       |
| 2       | Germany            | Germany                     |
| 3       | <b>South Korea</b> | United States               |
| 4       | United States      | <b>South Korea</b>          |
| 5       | China              | China                       |
| 6       | Norway             | Norway                      |
| 7       | Denmark            | France                      |
| 8       | France             | Denmark                     |
| 9       | Canada             | Canada                      |
| 10      | Netherlands        | United Kingdom              |
| 11      | United Kingdom     | Netherlands                 |
| 12      | Sweden             | Sweden                      |

expand their reach to overseas markets.

Hyundai Motor's recent joint venture with Swiss-based H2 Energy is exemplary.

From 2019 to 2025, the Korean automaker has promised to deliver 1,600 hydrogen-powered heavy-duty trucks<sup>17</sup>; H2 Mobility Switzerland will then lease a large portion of these more energy-efficient trucks (see Fig. 7).

### EMERGING OPPORTUNITIES

Hydrogen storage, distribution and production, though currently a developed area, represent significant potential for heavy industrial companies to capture new business opportunities. What they need to do is to move away from the status quo:

- ▶ **Steel and petrochemical companies.** Upgrade their existing facilities to produce more hydrogen for future use.
- ▶ **Shipbuilders.** New business from liquefied natural gas (LNG) carriers and build hydrogen-powered vessels to replace diesel vessels in the future.
- ▶ **Gasoline companies.** Leverage the existing storage and distribution network to tap into the hydrogen fuelling station infrastructure development.

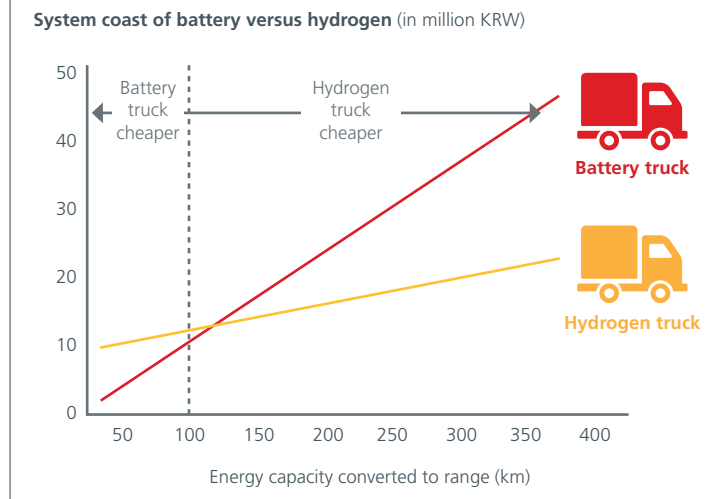
On balance, there is a strong incentive for these industrial players to participate in the hydrogen infrastructure investments, given the potential to generate sustainable earnings.

### THE DAWN OF THE SHIFTING TREND

That said, there must be systematic research and development, together with a clear governmental policy framework and funding mechanisms to incentivise private companies to participate.

State-funded think tank H2Korea was set up to bridge the gap between the government and private sectors on hydrogen technologies. In addition, the Ministry of Trade, Industry and Energy (MOTIE) has earmarked an investment outlay of KRW2.6 trillion (USD2.23 billion)<sup>20</sup> for a joint venture with private sector companies to speed up

**Fig.7: Hydrogen fuel cell trucks are more efficient than battery trucks<sup>18</sup>**



the development of the hydrogen infrastructure.

Such partnerships between government and business are powerful because they increase the amount of funding and result in better vetting of the projects, thereby yielding greater economic benefits.

In view of this, the outlook for Korea's hydrogen industry and the associated responsible investment opportunities should remain positive.

Only asset managers who can understand the implications of this shifting trend and identify emerging leaders within this space can fully tap into the potential of South Korea's emerging hydrogen industry.

---

Sources: <sup>1</sup>Ministry of Trade, Industry and Energy, January 2019. As a reference, the planned 15 gigawatts of hydrogen fuel cells are equivalent to 15 nuclear reactors. [https://www.ucsusa.org/clean\\_energy/our-energy-choices/how-is-electricity-measured.html](https://www.ucsusa.org/clean_energy/our-energy-choices/how-is-electricity-measured.html) <sup>2</sup>Korean government news release, January 2019. <sup>3</sup>Wendling, Z. A., Emerson, J. W., Esty, D. C., Levy, M. A., de Sherbinin, A., et al. (2018). 2018 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. <https://epi.envirocenter.yale.edu/epi-indicator-report/AIR>. <sup>4</sup>National Aeronautics and Space Administration (NASA), July 2017: <https://www.nasa.gov/feature/early-airborne-results-address-south-korean-air-quality> <sup>5</sup>The Korea Herald: <http://www.koreaherald.com/view.php?ud=20190317000085> <sup>6</sup>The South Korea government, January 2019, and McKinsey & Company, November 2018. <sup>7</sup>US Department of Energy Hydrogen Program. [https://www.californiahydrogen.org/wp-content/uploads/files/doe\\_fuelcell\\_factsheet.pdf](https://www.californiahydrogen.org/wp-content/uploads/files/doe_fuelcell_factsheet.pdf) <sup>8</sup>The Republic of Korea: Cheong Wa Dae, 17 January 2019. <https://english1.president.go.kr/briefingspeeches/speeches/110> <sup>9</sup>McKinsey & Company, Hydrogen Roadmap — Korea, P. 14, November 2018. Exhibit 1, citing data from Ministry of Environment; Ministry of Trade, Industry and Energy, (MOTIE); Hydrogen Coalition Members' Study; Hydrogen Korea Study team. <sup>10</sup>Eastspring Investments, based on the cost estimate from the US Department of Energy. Mass Production Cost Estimation of Direct H<sub>2</sub> PEM fuel Cell Systems for Transportation Applications: 2017 Update. <sup>11</sup>Office of Energy Efficiency & Renewable Energy, United States had 39 publicly available hydrogen stations for fuelling fuel cell electric vehicles in January 2018. In Germany, there were 60 stations. <https://www.tuev-sued.de/company/press/press-archive/highest-increase-of-hydrogen-refuelling-stations-in-germany-worldwide-in-2018-again> <sup>12</sup>Ministry of Trade, Industry and Energy (MOTIE), March 2019: <https://www.gov.kr/portal/ntnadmNews/1798821>. <sup>13</sup>Coalition members' feedback, 38 indicators from benchmarking, expert interviews; Hydrogen Coalition Members' Study; Hydrogen Korea Study team, McKinsey & Company, Hydrogen Roadmap — Korea, November 2018. <sup>14</sup>Hydrogen Coalition Members' Study; Hydrogen Korea Study team, November 2018. Index of 38 indicators in current uptake of hydrogen applications, market potential, industry strength, infrastructure (current and planned) and regulatory environment <sup>15</sup>The Republic of Korea: Cheong Wa Dae, 17 January 2019. <https://english1.president.go.kr/briefingspeeches/speeches/110> <sup>16</sup>McKinsey & Company, Hydrogen Roadmap — Korea, P. 15, November 2018. <sup>17</sup>Gasworld, as at 15 April 2019: <https://www.gasworld.com/hyundai-motor-and-h2-energy-sign-joint-venture-/2017011.article> <sup>18</sup>Department of Energy, Tesla Semi, Nikola One, and McKinsey. Assumptions: Component weight for diesel powertrain, in kg: ICE system 1,000; fuel system 1,050; transmission 200; exhaust 200; Component weight for BEV powertrain, in kg: transmission 50; E-motors 100; power electric 300; battery 4500; Component weight for FCEV powertrain, in kg: transmission 50; E-motors 100; power electric 300; battery 600; fuel cell 150; H<sub>2</sub> tank 800. Reference truck: 40 t semi-truck with 18 t GVW truck tractor 4x2; FCEV truck with 120 kWh battery; BEV truck with 900kWh battery; FCEV and BEV battery with 5kg/kWh; FCEV and BEV with two electric motors; FCEV truck with 300 kW fuel cell weighing 150kg (2 kW/ kg). <sup>19</sup>Petrol Plaza, June 2018: <https://www.petroplaza.com/news/8875?nl=1>



---

## Disclaimer

**This document is produced by Eastspring Investments (Singapore) Limited and issued in:**

**Singapore and Australia (for wholesale clients only)** by Eastspring Investments (Singapore) Limited (UEN: 199407631H), which is incorporated in Singapore, is exempt from the requirement to hold an Australian financial services licence and is licensed and regulated by the Monetary Authority of Singapore under Singapore laws which differ from Australian laws.

**Hong Kong** by Eastspring Investments (Hong Kong) Limited and has not been reviewed by the Securities and Futures Commission of Hong Kong.

**Indonesia** by PT Eastspring Investments Indonesia, an investment manager that is licensed, registered and supervised by the Indonesia Financial Services Authority (OJK).

**Malaysia** by Eastspring Investments Berhad (531241-U).

**United States of America (for institutional clients only)** by Eastspring Investments (Singapore) Limited (UEN: 199407631H), which is incorporated in Singapore and is registered with the U.S Securities and Exchange Commission as a registered investment adviser.

**European Economic Area (for professional clients only) and Switzerland (for qualified investors only)** by Eastspring Investments (Luxembourg) S.A., 26, Boulevard Royal, 2449 Luxembourg, Grand-Duchy of Luxembourg, registered with the Registre de Commerce et des Sociétés (Luxembourg), Register No B 173737.

**United Kingdom (for professional clients only)** by Eastspring Investments (Luxembourg) S.A. - UK Branch, 125 Old Broad Street, London EC2N 1AR.

**Chile (for institutional clients only)** by Eastspring Investments (Singapore) Limited (UEN: 199407631H), which is incorporated in Singapore and is licensed and regulated by the Monetary Authority of Singapore under Singapore laws which differ from Chilean laws.

The afore-mentioned entities are hereinafter collectively referred to as **Eastspring Investments**.

The views and opinions contained herein are those of the author on this page, and may not necessarily represent views expressed or reflected in other Eastspring Investments' communications. This document is solely for information purposes and does not have any regard to the specific investment objective, financial situation and/or particular needs of any specific persons who may receive this document. This document is not intended as an offer, a solicitation of offer or a recommendation, to deal in shares of securities or any financial instruments. It may not be published, circulated, reproduced or distributed without the prior written consent of Eastspring Investments. Reliance upon information in this posting is at the sole discretion of the reader. Please consult your own professional adviser before investing.

Investment involves risk. Past performance and the predictions, projections, or forecasts on the economy, securities markets or the economic trends of the markets are not necessarily indicative of the future or likely performance of Eastspring Investments or any of the funds managed by Eastspring Investments.

Information herein is believed to be reliable at time of publication. Data from third party sources may have been used in the preparation of this material and Eastspring Investments has not independently verified, validated or audited such data. Where lawfully permitted, Eastspring Investments does not warrant its completeness or accuracy and is not responsible for error of facts or opinion nor shall be liable for damages arising out of any person's reliance upon this information. Any opinion or estimate contained in this document may subject to change without notice.

Eastspring Investments (excluding JV companies) companies are ultimately wholly-owned/indirect subsidiaries/associate of Prudential plc of the United Kingdom. Eastspring Investments companies (including JV's) and Prudential plc are not affiliated in any manner with Prudential Financial, Inc., a company whose principal place of business is in the United States of America.



A member of Prudential plc (UK) 