

Potential for collaboration between the Netherlands and South Korea on Energy Materials for Hydrogen

Report commissioned by the Embassy of the Kingdom
of the Netherlands in South Korea

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Summary

The main purpose of this report is to evaluate the benefits of a potential cooperation between the Netherlands and South Korea in the field of Energy Materials for hydrogen. The Dutch National Technology Strategy has defined Energy Materials as one of 10 key technology domains for the Netherlands, highlighting hydrogen technology.

Both the Netherlands and South Korea face similar energy transition challenges and have ambitious hydrogen strategies. South Korea focuses on hydrogen use in mobility and power generation, while the Netherlands emphasizes green hydrogen production and industrial use. The report analyzes the two aspects of the hydrogen strategy, stimulating demand for the technology through support of implementation and stimulating technology development directly, for example through subsidies. Because of their different focus in implementation, both countries develop a “home advantage” for their industry in different field. But the need to build supply chains for material, parts and equipment (MPE) is similar.

The report concludes that there is potential for joint RD&D programs and broader cooperation in energy materials can benefiting both countries' green growth ambitions.

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1 Introduction

South Korea and The Netherlands face similar challenges in the energy transition and have many similarities in their economy. Both have a large energy-intensive industry sector which needs to decarbonize. Off-shore wind plays an important role in the plans to make the electricity energy system more sustainable by increasing the share of electricity generated from renewable sources. Both countries rely heavily on the import of energy and consequently ports play an important role in the energy system as energy hubs. Grid congestion is starting to become an issue due to the higher penetration of renewable electricity and electrification in the Netherlands and South Korea.

Hydrogen is an important part of the solution for these challenges for both the Netherlands and South Korea. Both countries were among the first to publish a national hydrogen roadmap and transpose the roadmap into law. Importing hydrogen, for example in the form of ammonia or liquid hydrogen, is set to replace importing fossil fuels such as coal, natural gas and oil in the future and will play an important role in decarbonizing the energy intensive industry. Both countries signed bilateral agreements with potential suppliers of low-carbon hydrogen in regions with good renewable resources. Pipelines are seen as a key part of the hydrogen system and aim to connect ports to user. But hydrogen is not only part of the energy transition, South Korea and the Netherlands, both in the top ten of the Global Innovation Index focus on green growth:¹creating a strong hydrogen technology manufacturing industry that will lead to jobs by exporting technology. Both countries are also considering blue hydrogen, made from natural gas with carbon capture and storage (CCS).

In addition to the similarities, there are striking differences as well. One of the most prominent differences in the hydrogen policy is the emphasis on end-use in South Korea and the emphasis on production of green hydrogen in the Netherlands. South Korean policy has focused on fuel cells for both transport and stationary applications and on gas turbines using hydrogen for power generation. Whereas electrolysis to produce green hydrogen from renewable electricity has a very prominent role in the Dutch hydrogen policy. This report describes the hydrogen strategy of South Korea, makes a comparison with the Dutch Hydrogen Strategy and identifies potential topics for cooperation based on the differences and similarities in challenges and strategy.

¹ [Global Innovation Index 2024. Unlocking the Promise of Social Entrepreneurship](#)

2 The hydrogen ecosystem of South Korea

2.1 The hydrogen strategy

2.1.1 Main drivers and focus

Korea's hydrogen push is driven primarily by three key factors²

- › Economic growth
- › Emissions reduction
- › Energy security.

Economic growth is South Korea's primary driver. Korea has identified the transport and energy sectors as key end markets for H₂ utilisation (particularly fuel cells), and the industries and small to medium enterprises (SMEs) involved in supply chain activities (chemical and mechanical design, materials and components) as key growth areas.

Emissions: South 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. Green hydrogen and blue hydrogen (with carbon capture and storage) are expected to contribute to the climate goals.

Energy security: South Korea reduce their energy dependency on foreign countries by diversify their imports. Importing hydrogen, in liquid form or in the form of energy carrier such as ammonia is an integral part of the strategy.

Korea has set long- term targets through to 2040³ and a strong public funding in the form of research, demonstration and deployment (RD&D) projects and subsidies. The South Korean private sector is active in taking on demonstration and commercialisation activities. There are a wide range of targets defined for different aspects, but 3 main lines can be distinguished: mobility, power generation and developing international supply lines.

1. **Mobility** has been the first area of focus for the Korean hydrogen economy. The country's Hydrogen Roadmap called for the country to have the largest market share of FCEVs and fuel cells in the world. South Korea aims to produce 300,000 FCEV passenger cars and have 21,200 buses in operation by 2030. It also sets a long-term goal of increasing commercial production capacity to 100,000 FCEVs annually. In terms of infrastructure, 70 liquid hydrogen-refuelling stations are planned by 2030. The country has built a track record in large-scale deployment adding 150,000+ BEVs annually over the past few years, and this number is likely to increase in the future⁴.
2. The second focus area is **power generation from hydrogen**. This includes turbines or fuel cells using hydrogen, but also ammonia co-fired in coal power plants, and hydrogen mixtures in natural gas power plants. Contracts for large-scale power generation will be auctioned (see below) and will begin in 2028. At this moment the focus of ongoing project is on technology development and piloting.

² Hydrogen RD&D Collaboration Opportunities: The Republic of Korea, CSIRO, 2022

³ Hydrogen Economy Roadmap, South Korea government, 2019

⁴ [Korea Takes the Lead in Hydrogen Economy Implementation - Asian Insiders](#)

3. Developing the **international supply chain for hydrogen** from locations which have abundant natural resources is a key element of the strategy as Korea lacks resources. Different bilateral agreements have been made with energy rich countries such as Australia and Saudi Arabia. The Korean state-owned gas company KOGAS is preparing to invest almost €40 billion in production capacity abroad to secure hydrogen supply for Korea.

Use of hydrogen to decarbonize energy-intensive industries, such as the steel, petrochemicals, and cement sectors is the third area of application which is not yet as clearly defined as transport and power. Targets for the energy intensive industry will be defined more specifically when challenges in mobility and power generation have been largely addressed.

2.1.2 Policy timeline

In January 2019 Korea published its Hydrogen Economy Roadmap, a strategic plan to promote the hydrogen industry addressing the timeframe until 2040 which sets a hydrogen supply target of 5.26 Mt (175.3 TWh). Subsequently 'Hydrogen Economy Promotion and Hydrogen Safety Management Act' ('Hydrogen Act') was adopted in 2020 providing a legal framework. A year later the "1st Basic Plan for the Implementation of the Hydrogen Economy" was adopted which defines goals and guidelines for the creation of domestic production and import capacities.

Subsequently the Hydrogen Act is amended regularly. The annual meeting of the Hydrogen Committee which includes 8 ministries and is chaired by the Prime Minister plays an important role in decision making. The first amendment made to the Hydrogen Act in May 2022 increases the targets for power generation from low-carbon hydrogen, includes Clean Hydrogen Energy Portfolio Standards [CHPS], and adds the implementation of a clean hydrogen certification scheme as a requirement.

When the same committee convened for the first time under the newly elected administration of President Yoon in November 2022, a growth strategy for the hydrogen sector called "3 Up" was published. It included the build-out of a low-carbon hydrogen supply chain ("Scale-Up"), the setting-up of the necessary infrastructure ("Build-Up"), and the promotion of technological innovations ("Level-Up").

In May 2023, a "Hydrogen Safety Management Roadmap 2.0" was published addressing safety concerns in a hydrogen economy.

Korea's national certification system ("Clean Hydrogen Certification System"), that was introduced in late 2023 during the 6th meeting of the Hydrogen Economy Committee and came into effect in March 2024, establishes a definition of "clean hydrogen" not based on a specific production method but on the carbon emitted during production of the hydrogen. The Korea Energy Economics Institute (KEEI) was designated as the clean hydrogen certification authority.

2.2 Hydrogen ecosystem development

The hydrogen strategy of South Korea is very broad and addresses many different technologies. We will highlight three mayor elements which form the backbone of the hydrogen economy: the development of the refuelling station network, large-scale power generation and the pilot cities.

2.2.1 Building the Refuelling station network

The target of the Hydrogen Roadmap is to have 850,000 FCEVs on the road in 2030. One of the most important elements in the policy, next to subsidizing the buyer of a FCEV, is the creation of an extensive network of refuelling stations. Different consortia committed to building refuelling stations. For example the major contribution comes from HyNet consortium, with KOGAS and Hyundai as main partners, operates around 50 of the approximately 200 refuelling stations⁵.

The development of the infrastructure has not been easy. There are still many technological, organisational and economic challenges and this has led to a large number of issues, ranging from safety incidents⁶, recalled vehicles⁷, fuel shortages⁸ and reliability issues⁹. Although it has come at the cost of owners of FCEV and the stakeholders developing the infrastructure, it also enabled South Korea to follow a steep learning curve.

2.2.2 Clean Hydrogen Auction for the power market

Making electricity from hydrogen is a key priority for Korea. In May 2024 the world's first clean hydrogen power bidding market was launched. "Clean hydrogen" as defined by the Korean government corresponds to the what is more generally named "low-carbon hydrogen". As of 2023, the emission threshold for clean hydrogen is at approx. 33 gCO₂e/MJ, reflective of the carbon intensity of domestic blue hydrogen with a capture rate of 95%. For comparison, the European Union is aiming for a significantly lower clean hydrogen threshold of 28.2 gCO₂e/MJ.

The clean hydrogen power bidding market is a market for supplying and buying electricity produced from hydrogen¹⁰. Participants are allowed to generate power only from hydrogen that fulfils the domestic clean hydrogen certification standards. A certification scheme is in place which allows the supplier to certify the CO₂ emitted unit of H₂ which determines how clean the hydrogen is considered (the certification scheme distinguishes several classes of low-carbon hydrogen). Hydrogen produced with less 33 gCO₂e/MJ¹¹ can qualify for Clean Hydrogen Certification, with four grades based on carbon emission levels. Carbon emissions are calculated based on their entire life cycle, including direct greenhouse gas (GHG) emissions from hydrogen production pathway (Scope 1), as well as indirect GHG emissions from production of electricity or steam by sources external to the hydrogen production pathway (Scope 2 and Scope 3). However, GHG emissions captured for permanent storage such as via CCS will be excluded from the emission calculation, while GHG emissions captured via CCU will be included.

The 2024 bidding volume is 6,500 GWh with a contract period of 15 years. Commercial operation must begin by 2028, following three years of preparation period plus one year of grace period. In December 2025 KOSPO was selected by the South Korean government as the preferred final bidder. Ammonia, produced in Australia using CCS under the CHPS hydrogen certification scheme, will be used for co-firing in a KOSPO coal plant¹².

⁵ There is much confusion about the actual number of stations, with sources quoting widely different numbers.

⁶ [Man seriously injured after faulty Hyundai hydrogen bus explodes at refuelling station in South Korea](#)

⁷ [More than 1,000 fuel-cell vehicles in South Korea failed re-inspection due to hydrogen gas leaks](#)

⁸ [Three quarters of H2 refuelling stations in South Korea closed amid H2 supply crash](#)

⁹ [About half of all hydrogen refuelling stations in South Korea have broken down since start of 2022](#)

¹⁰ [Korea launches world's first clean hydrogen power bidding market - Hydrogen Central](#)

¹¹ This corresponds to 4 kg of carbon dioxide emissions per 1 kg of hydrogen

¹² [Korea Southern Power selected as final bidder in national clean power auction](#)

2.2.3 Developing Pilot cities

South Korea has been actively developing hydrogen “pilot cities” which have the task to integrate hydrogen into daily life, focusing on housing, transport, and industry. According to the definition of a ‘hydrogen city’, the hydrogen gas must be used as a fuel for major urban functions such as cooling, heating, electricity, and transportation.

The initial three hydrogen pilot cities were Ulsan, Ansan, and Jeonju/Wanju. These cities have implemented various hydrogen-related projects, such as hydrogen fuelling stations and pipelines (Ulsan). In 2022 South Korea announced creation of six more hydrogen cities: Pyeongtaek, Namyangju, Dangjin, Boryeong, Gwangyang, and Pohang. These cities receive significant funding to develop hydrogen infrastructure, including fuel cells, hydrogen ports, and pipelines. The cities receive substantial funding from the central government and the cities have distinctive plans, emphasizing different aspects of the use and distribution of hydrogen. Table 1 gives an overview of the main activities of the different hydrogen cities.

Table 1: Hydrogen cities and their specific focus

City	Focus
Ulsan	Use of by-product hydrogen from petrochemical complexes, hydrogen fuelling for ships, building pipelines
Wanju	Regional hydrogen production and supply base, use of hydrogen-electric buses
Ansan	Tidal power generation linked to hydrogen production, hydrogen fuelling stations
Pyeongtaek	Blue hydrogen production, hydrogen port terminal, pipelines, fuel cells for buildings and transport
Namyangju	Self-sufficient hydrogen economy, fuel cells in public housing and facilities, fuelling stations
Dangjin	Hydrogen production from organic waste, fuel cells in public facilities
Boryeong	Hydrogen production from livestock manure, fuel cells in public facilities
Gwangyang	Hydrogen-powered tractors and drones, hydrogen port terminal, fuel cells in public facilities
Pohang	Green hydrogen plant, fuel cells in public housing, pipelines from steelworks

2.3 The electricity system in South Korea

One of aspects which differentiates the South Korean Hydrogen Strategy from many other national strategies, is the limited role of (local) green hydrogen production, which is a key element in many other roadmaps. One of the challenges South Korea faces in this field, is the limited amount of renewable electricity which links to the way in which the electricity system in South Korea is organized. Therefore a brief assessment of the electricity system is in order.

2.3.1 Regulatory framework

Until 2001 the national electricity company KEPCO had a monopoly on generation, distribution and sales of electricity and the electricity market was strictly regulated by the government through the responsible ministry (MOTIE). Due to the liberalised market for

generation, the electricity is now generated by independent parties, including six Generating Companies or GENCOs¹³.

Power generated by the generators is sold through the Korean Power eXchange (KPX) which programs the day-ahead market. A distinctive feature of the South Korean electricity market is that the market price is determined not by price bidding but by summing the increase in actual variable costs for additional electricity supply (the system marginal price, known as SMP) plus a capacity price to cover fixed costs¹⁴.

The electricity market is still strongly regulated by centralized decision making where MOTIE has an important role in regularly publishing a Master Plan for electricity (the biannual Basic Plan) which contains mayor planning decision on generation and transmission of electricity. MOTIE also fulfils many other roles in regulating the electricity market. For example it provides and oversees permits for generators to ensure that they can fulfil their obligation and guarantee supply of electricity.

KEPCO still has a monopoly on transmission and sales of electricity. KEPCO operates the grids and sells the electricity to the consumers. The price of electricity to the consumers is in the end determined by the government of South Korea and is not linked (directly) to the cost of electricity for KEPCO on the KPX. Subsequent governments aim to keep the electricity price for consumers low which has an impact on the financial results of KEPCO.

2.3.2 Renewable electricity

According to the 2024 Korea Energy Agency (KEA) Energy Handbook, the proportion of new and renewable energy (NRE) as share of the total domestic power generation in South Korea increased from 4.99% in 2018 to 5.81% in 2019, 7.44% in 2020, 8.29% in 2021, and 9.22% in 2022.¹⁵ The share of power generation from renewables is set to increase to reach 21.6% in 2030 and 30.6% in 2036 according to the 11th Basic Plan published by MOTIE in 2024. These targets are low in a global perspective¹⁶ leaving South Korea behind other OECD countries.

Furthermore Korea's definition of NRE is broader and includes energy sources that may not be classified as renewable by international standards, such as liquid or gaseous energy carriers from coal or heavy residual oil. Important in this context is that electricity generated from hydrogen by fuel cells or gas turbines is counted towards the NRE share.

Regulatory framework for NRE

The most important element of the legal framework is the Renewable Portfolio Standard (RPS). Large-scale generators such as the GENCO's are "Mandatory Suppliers". This means that the entity is obliged to ensure that a specific share of the electricity production conforms to NRE standards. This can be achieved either by supplying electricity generated from NRE directly, or to purchase renewable energy certificates (RECs). RECs are certificates corresponding to the volume of power generation by NRE and are traded on a market operated by the KPX. The Mandatory Supplier that purchased the REC may be compensated up to the average price of an REC by the regulatory authorities who will in turn be entitled to be paid by KEPCO upon request. To meet the national NRE targets, the mandatory share of NRE increases gradually over the years.

Renewable energy sources

¹³ They operate independently but are fully owned by KEPCO. There is one hydro and nuclear generator, the others are based on thermal generation

¹⁴ [Comparisons | Global Practice Guides | Chambers and Partners](#)

¹⁵ [Renewable Energy 2024 - South Korea | Chambers and Partners](#)

¹⁶ [South Korea's economy risks missing out on global transition to renewables | IEEFA](#)

In 2022 more than 50% of the renewable energy was solar power. However, offshore wind power is expected to become a more important NRE source in South Korea due to its potential for large-scale energy supply.

The Special Act on the Promotion of Offshore Wind Power in South Korea, also known as the Offshore Wind Promotion Act, includes several key points aimed at streamlining and promoting offshore wind energy development:

- › Centralized Site Selection: The government will now handle the selection of offshore wind farm sites, rather than private developers. This involves creating a centralized site information system and conducting inter-ministerial consultations.
- › Streamlined Permitting Process: The Act introduces an integrated permitting process to reduce inefficiencies and uncertainties. This includes environmental impact assessments, maritime safety reviews, and other necessary evaluations.
- › Competitive Bidding: Project developers will be chosen through competitive bidding, ensuring that the most capable and cost-effective projects are selected.
- › Infrastructure Investment: The government will support investments in supply chains, ports, vessels, and grid infrastructure to facilitate the development of offshore wind projects.

Due to the increasing importance of NRE, the South Korean industry is focusing on developing larger wind turbines with expanded rotors and enhanced generator capacities.

2.3.3 Grid congestion

Delays in construction of substations and transmission lines across South Korea are raising concerns that additional power generation may create system instability regionally and nationwide. Increasing electricity demand comes from Artificial Intelligence, the Semiconductor industry and electric vehicles is expected to increase electricity demand. Economic growth and more widespread electrification of the economy in South Korea (Korea) are expected to increase its electricity demand 31% by 2035 and 113% by 2050, compared to 2020 levels¹⁷

Currently, Korea's NRE generation facilities are geographically concentrated, with 75% of capacity coming from the Southern provinces. However, these regions have small industrial complexes. Transmission of the generated energy to areas with high industrial power demand like the Seoul and Busan area is necessary. There is a shortage of grid capacity to support this¹⁸. Additionally, projects to expand the grid and the legislation to support the grid expansion are suffering delays.

¹⁷ Korean Power System Challenges and Opportunities, Berkeley, 2023

¹⁸ [S. Korea's soaring power demand requires urgent grid expansion](#)

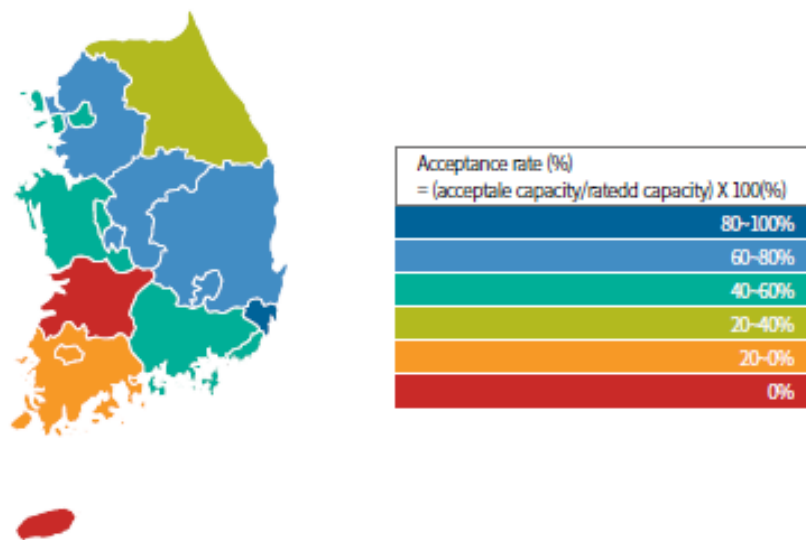


Figure 1: Grid congestion map of South Korea showing the congestion in the Southern provinces where most renewable electricity capacity is located.

2.3.4 Measures to create a more decentralized system.

As indicated, the legislative electricity market framework in South Korea is based on highly centralized production of electricity and is therefore not very conducive to decentralised solutions such as local green hydrogen production. However, because of the increasing role of fuel cells and renewable sin electricity generation, the future electricity system will be based on much more decentralized power production. Driven by the need to introduce more renewable energy into the system and the congested grid, several pieces of legislation have been adopted or are proposed which should create greater flexibility in permitting and operating the market.

For example a regulation is proposed that requires all regions of South Korea to make power grid impact assessments. The regulation gives more control over the permitting of new (larger) electricity users such as datacentres based on the availability of power supply in the grid-connected area, local community acceptance, level of regional underdevelopment, and capacity to maintain proper voltage levels. The regulation is not final, and MOTIE is currently operating a pilot project for the system.

Other regulations give KEPCO more flexibility to permit new generation capacity in congested areas. A substation which has saturated access capacity can now be designated by KEPCO as a System Management Substation. This gives KEPCO more control over granting connections and aims to stimulate that new power generation projects are preferably initiated in areas with available grid capacity. In 2024, KEPCO designated 103 substations in Gwangju and Jeonnam, 61 in Jeonbuk, 25 on the East Coast, and 16 in Jeju as system management substations. A new power generation plant is only permitted to connect to a system management substation when completion of the required power grid reinforcement is finalized and operational.

Legislation on “Distributed energy” was adopted in 2024 to promote a more regionally focused energy supply system and create new industries such as distributed energy businesses. In Dispersed Energy Specialised Areas dispersed energy suppliers installing power can supply electricity directly to electricity users in such zones without having to go

through the electricity market using the transmission and distribution network installed by KEPCO.

The Energy Storage Systems (ESS) market is expected to grow as a solution for storing renewable energy. However, due to fire incidents caused by batteries since late 2017, ensuring safety through technological development is crucial for wider adoption. Hydrogen technology for energy storage does not have a clear role within the strategy.

MOTIE has announced amendments to the Rules on the Operation of the Electricity Market. In several regions, such as Jeju Island and Jeollanam-do province, the share of renewable is high and causing issues. A pilot project for the new Renewable Energy Bidding System launched in Jeju since June 2024. Renewable Energy Generators must participate in the day-ahead Electricity Bidding Market like conventional non-renewable generators. The new rules aim to provide a solution for the lack of a standard for selecting facilities for curtailment, prioritising bidders by bid price. This system is expected to be expanded nationwide in the future.

These examples show that there is a large effort in adapting the regulatory framework to make it more flexible. Hydrogen could play an important role in reducing grid congestion, but needs an established demand for hydrogen or the potential to displace electricity demand. In particular because the (local) demand for hydrogen is developing well. However, this requires a highly coordinated approach to develop technology, business case and legislation enabling the role of hydrogen.

2.4 Private investments aligning with the policy

Setting targets, regulations and mandates has led to large investments from the private sector. A short and far from complete overview is given below.

In commercial hydrogen technology South Korea has a clear leadership in hydrogen **fuel cell vehicles**. Hyundai is worldwide leader in the sales of hydrogen cars. Second car manufacturer Kia is planning to produce hydrogen-fuelled vehicles, with their first hydrogen fuel-cell electric vehicles expected to be released in 2027¹⁹. Hyundai and Kia jointly also developed a hydrogen combustion engine for passenger vehicles²⁰. More than 1000 busses are in operation in South Korea and heavy duty vehicles are commercially available²¹. A recently updated target for hydrogen busses is 21,200 busses in operation in 2030, which corresponds to 25% of all busses²². Hyundai is currently the only provider of fuel cell busses, but Doosan's HiExium Motors is expected to start production soon.

Stationary fuel cells for power generation are a key technology. An important project is the largest hydrogen fuel cell power plant in Gyeongju (between the industrial centers of Ulsan and Pohang), with a capacity of 107.9MW, expected to power 270,000 households annually, is planned for completion by 2028. Doosan has commercialized phosphoric acid fuel cell (PAFC) system and solid oxide fuel cell system (SOFC) and delivers units rated 440 kW and 300 kW respectively. Cumulative sales of PAFC systems have reached 635 MW and 193 MW of capacity is under construction²³.

Another highlight with respect to the stationary fuel cell application is the first "hydrogen apartment" complex, utilizing electricity and heat from hydrogen fuel cells²⁴. The Yuldong Combined Heat and Power Plant located 200m from the apartment complex utilizes by-

¹⁹ [Kia Aims to Release Hydrogen Fuel Cars Starting 2027](#)

²⁰ [Hyundai and Kia Unveil Zero-Emission Hydrogen Engine Set to Disrupt the EV Market](#)

²¹ [Hyundai Motor Unveils the New XCIENT Heavy-Duty Fuel Cell Truck at ACT Expo 2025](#)

²² [South Korea unveils new target for 21,200 hydrogen buses in operation by 2030](#)

²³ [Doosan Fuel Cells - Business Highlights](#)

²⁴ [Korea: Ulsan Unveils World's First Hydrogen Fuel Cell-Powered Apartment Complex](#)

product hydrogen sourced via a 10km pipeline from nearby industrial activities in the oil refining, petrochemical, and steel industries and delivers both heat and electricity to the apartments.

Blue hydrogen produced by steam reforming of liquified natural gas (LNG) with carbon capture is one of the methods for supplying clean hydrogen according to South Korean standards. The Boryeong Blue Hydrogen Project, led by Korea Midland Power Company (KOMIPO) and SK E&S, is currently the world's largest blue hydrogen production initiative. The project aims to produce 250,000 tons of blue hydrogen annually and has a budget of over 5 trillion KRW (approximately €3.4 billion). The hydrogen will be used for power generation (blended with LNG for gas turbines) and for approximately 20% for hydrogen refuelling stations. The consortium entered a bid for the first clean hydrogen power generation auction²⁵. The project has been criticized because the GHG emission reduction could be very minimal²⁶.

As South Korea has a nuclear industry and operates a large number of nuclear plants, **pink hydrogen made from nuclear power** is an interesting option. The technology is being piloted by a large industrial consortium. The first nuclear-powered hydrogen production project is set to begin construction in October 2025, with Korea Hydro & Nuclear Power (KHNP), a subsidiary of the country's largest electricity utility, KEPCO as lead developer²⁷. The demonstration on the outskirts of the port city of Ulsan, will use 10MW of low-temperature water electrolysis and will produce, store and ship more than four tonnes of so-called pink hydrogen a day from March 2027. The electrolyzers will be powered directly by electricity from KHNP's nearby Gori and Saeul nuclear plants, bypassing the grid — a move that will still need special government approval.

Liquid hydrogen is of interest to South Korea, both for the internal distribution of hydrogen to refuelling stations and as an energy carrier for international transport. As example of a project on this technology, Linde and Hyosung Corporation (K) partnered to build, own and operate extensive new liquid hydrogen infrastructure in South Korea. They announced that the Ulsan liquefaction plants is expected to start operations in 2023. Under the partnership, Linde will sell and distribute the liquid hydrogen produced at Ulsan to the growing mobility market in South Korea. To enable this, the joint venture will build, own and operate a nationwide network of hydrogen refueling stations²⁸.

A consortium including Samsung and Hyundai and lead by Pusan National University is developing a hydrogen carrier ship. Targets include development of an insulation technology which reduces boil-off and to integrate the system with onboard fuel cells²⁹.

The early **pipeline infrastructure** projects focus on pipelines bringing industrial by-product hydrogen to users. As of October 2024, 188km of underground pipelines have been laid in Ulsan to connect hydrogen produced as a by-product from petrochemical complexes to the city center.

Amogy is a start-up company which raised close to € 300 million to develop point-of-use **ammonia cracking** technology³⁰. The applications could include maritime as well as

²⁵ [Competition for Korea's first clean hydrogen power projects heats up](#)

²⁶ [Three Unseen Flaws of the Boryeong Blue Hydrogen Project in South Korea](#)

²⁷ [South Korea's first nuclear hydrogen plant set to begin construction in October](#)

²⁸ No recent information could be found on the status of the venture

²⁹ [Development of South Korea's first liquid hydrogen carrier begins, with Samsung and Hyundai on board](#)

³⁰ [Ammonia-to-hydrogen start-up raises \\$56m from Aramco and South Korean investors](#)

providing hydrogen to remote areas. Another innovative approach is the electrochemical separation of hydrogen and nitrogen, as developed by AES Tech ³¹

While the above overview does not give a complete picture of the technologies that are under development, it indicates main development streams. The overview of the key R&D topics based on the Hydrogen Roadmap (2019) in Appendix 1 confirms the wide range of topics of interest to the South Korean strategy.

³¹ [AES Tech Co - About us](#)

3 Comparison with the Dutch Hydrogen Strategy

3.1 Key points of the Dutch hydrogen strategy

Like the South Korean strategy, the hydrogen strategy of the Netherlands combines two elements:

- › The implementation strategy is focussed on providing the societal benefits of the *use* of hydrogen as an energy carrier (decarbonisation heavy industry, improving the business case for offshore hydrogen, etc).
- › Green growth ambition, which focusses on creating future manufacturing jobs and other economic benefits by creating a Dutch green hydrogen technology industry.

An important element is that links both ambitions is the technologies which will be deployed as part of the implementing strategy. As the Korean case shows, deployment can create a home market advantage for developers of technologies.

3.1.1 The hydrogen implementation strategy

Policy Timeline

The hydrogen strategy is based on the *Climate Agreement* which was reached in 2019 with a broad group of societal stakeholders. The National Climate Agreement includes specific targets and measures for hydrogen as part of the broader strategy to reduce greenhouse gas emissions. It highlights the role of hydrogen in industrial decarbonization, transportation, and integration with renewable energy sources.

The *Government Strategy on Hydrogen*, published in April 2020, sets out the Dutch government's vision and policy agenda for hydrogen. It emphasizes the importance of hydrogen in achieving a low-carbon energy system and outlines the necessary steps for scaling up hydrogen production and usage.

The *Hydrogen Program 2021-2025* details the specific projects, funding mechanisms, and timelines for hydrogen development over a five-year period. It focuses on innovation, infrastructure development, and international cooperation.

More recently European directives relevant for hydrogen, such as *RED III* and the *Fuel Quality* directive have been translated into (proposed) legislation and regulation. These directives mandate the use green hydrogen and derivatives in industry and mobility.

Focus

The key points of the hydrogen implementation strategy are the following.

- › The main focus on the shorter term of the policy is replacement of fossil fuels in so-called **hard-to-abate sectors such as steel, refinery and chemicals**. As South Korea, the Netherlands has a very high share of energy-intensive industry³². Hydrogen is seen as an important replacement for fossil fuel used in industry such as coal (steel), oil (refining) and gas (chemicals).
- › While both blue and green hydrogen are part of the hydrogen strategy, **the main policy focus is on green hydrogen**. Explicit objective of the Dutch strategy is to achieve cost

³² Historically the energy-intensive industry came to the Netherlands for its strategic geographic position with Rotterdam as the biggest port of Europe, and the availability of inexpensive natural gas from the Groningen field.

reduction of green hydrogen through demonstration and research and development. According to independent research by Energy Monitor, the Netherlands has the highest subsidies per gigawatt of electrolyser capacity committed in the world – €1.43 billion in total³³.

- › Last year 50% of the Dutch electricity was generated from renewable sources. Remarkably for a country with the solar irradiation of the Netherlands, solar power provided the largest contribution: 20.5% of all electricity production. Onshore and offshore wind and biomass co-firing in coal power plants supplied the remainder. However, because of space limitations onshore the growth of renewable electricity in the coming decade will come mainly from offshore wind parks. The business case for offshore wind power is becoming difficult because periods of low electricity prices correspond with abundant availability of renewable electricity. **Hydrogen is seen as one of the key elements in achieving the growth target of 70 GW offshore wind capacity in 2050.** In the near term the focus is on onshore electrolysis of offshore wind energy. However, in the further future a substantial part of the offshore wind is expected to be converted to hydrogen offshore. A program to develop and scale-up offshore hydrogen production is in place.
- › **The Dutch strategy considers both import of hydrogen and local generation of green hydrogen.** The ports play a very active role, anticipating imported hydrogen transported to the Netherlands in the form of liquid hydrogen or in the form of hydrogen carriers like ammonia, methanol and others. On the longer term (2040) the European backbone will also deliver hydrogen to the Dutch industry, for example from the south of Europe where cheaper renewable electricity is available. The future balance between local production and import is a matter of debate.

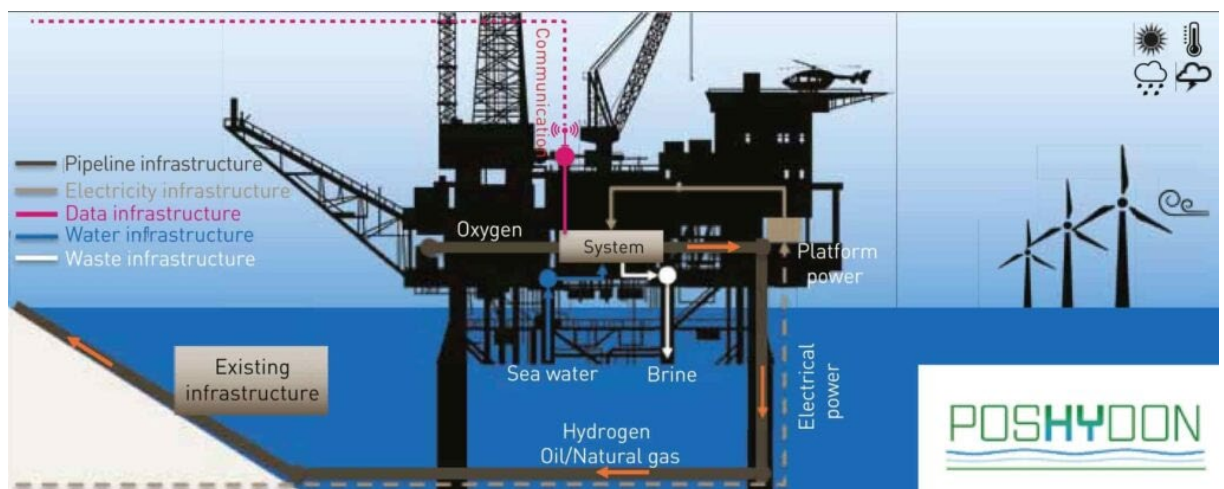


Figure 2: The PosHydon project offers valuable lessons for the Dutch offshore hydrogen program.

- › Natural gas which has been the most important primary energy carrier in the Netherlands over the past 60 years. It is being phased out as gas production from the main Groningen field has been terminated and the Netherlands becomes reliant on more expensive imported natural gas. **The infrastructure, in particular the natural gas transmission network is being partially converted to hydrogen transport** by HyNet. This existing network will be complemented with new dedicated pipelines to form the hydrogen backbone which connects the 5 industrial clusters and the port areas.

³³ [Netherlands | Green Hydrogen Organisation](#)

- In addition to transport infrastructure, **the Netherlands considers underground storage** as an option for the future. A pilot project storing hydrogen in an underground salt cavern is ongoing.

For hydrogen for transport and hydrogen for power generation the national hydrogen strategy has yet to define ambitious targets.



Figure 3: The hydrogen backbone connecting chemical clusters in the Netherlands, Belgium and Germany

3.1.2 Green growth and the National Technology Strategy

The National Technology Strategy (NTS) of the Netherlands focuses on identifying and prioritizing key enabling technologies that can significantly contribute to the country's economic potential, address societal challenges, and enhance national security³⁴. The NTS prioritizes technologies, among which “Energy Materials” is one of the ten key enabling technologies. The ambition in this key technology focusses on the three specific domains: application of energy materials for electrolyzers, batteries and heat storage. The ambitions include investing in research and testing facilities, the attractiveness for talent and an ecosystem embedding SME's.

The National Technology Strategy defines the key enabling technologies are the ones in which the Netherlands has the ambition to excel. Cooperation between the Netherlands and South Korea from the Dutch perspective should strengthen the Dutch position in the Energy Materials domain. It is therefore important to know that South Korea has a similar strategy which highlights areas in which the country has ambitions for global leadership. If a technology is selected as strategic, one important impact is that companies working on developments in the field, receive substantial tax breaks³⁵. Hydrogen technology is one of 12 topics selected³⁶. Although the strategy of the NTS explicitly names electrolysis, here we

³⁴ [National Technology Strategy | Building blocks for strategic technology policy](#)

³⁵ SMEs can receive a tax credit of 40-50%, while mid-sized and large enterprises can receive 30-40%.

³⁶ [Korea to extend support for 'key strategic technologies' of advanced materials, parts, equipment](#)

consider both fuel cells and electrolysis as there is a substantial overlap between material science and technology between the two fields.

3.2 Differences between the Dutch and Korean strategy

The similarities between the two countries and their strategies are very clear:

- › A large energy intensive industry which needs to be decarbonized.
- › Limited space for renewables onshore and reliance on offshore wind as a primary renewable source
- › A strategy based on future import of energy in the form of hydrogen or hydrogen carriers, with liquid hydrogen and ammonia as main transport modes. The ports as energy hubs play an important role.
- › Grid congestion due to rapid increase in electrification is a shared challenge where hydrogen can be a solution.
- › An innovative manufacturing industry and a green growth ambition to develop a hydrogen technology industry creating future jobs and economic growth and export technology.

However, despite the similarities, the hydrogen strategy of both countries is very different.

The main points of difference:

- › South Korea's focus is developing the use of hydrogen. Main targets for the shorter-term being mobility and electricity production from hydrogen. The Dutch focus is on the use of hydrogen in the energy-intensive industries replacing grey hydrogen, which is largely a drop-in solution.
- › South Korea's technology development focusses on a very broad range of technologies. A strong position is held in fuel cells for mobility and for stationary applications. Within mobility passenger cars are the key target, but applications developed and piloted also include tractors, trains, ships, trams, drones, etc. Technology is also developed for the use of hydrogen in turbines and combustion engines, blending hydrogen in the natural gas grid.
- › The "hydrogen pilot city" approach of South Korea creates sandboxes for a very wide range of applications. Although the Netherlands has a number of projects focusing on the use of hydrogen in the built environment, the South Korean approach is much broader and varied.
- › With the focus on the use of hydrogen, the source of hydrogen is, at least in the first phases of the implementation, of less concern in the strategy of South Korea. The definition of "new and renewable energy" therefore includes use hydrogen made from fossil sources, such as natural gas (with carbon capture) and hydrogen by product from industry.
- › In the Netherlands, also based on the European strategy, the focus is much more on green hydrogen, with blue hydrogen as a transitional solution. The vast majority of funding goes towards technology and project development for green hydrogen.
- › While both countries have a strategy considering import of energy in the form of hydrogen or hydrogen carriers, the Dutch approach is based on a balance between local production and import. Here the difference in penetration of renewable electricity is in evidence. Where the Dutch generate more than half of their electricity from renewable sources, Korea is expected to struggle to reach the target of 21.6% in 2030.
- › The difference in the electricity system is striking. Where the Dutch electricity system is highly liberalized and pricing is set by the market, the electricity market in South Korea is very much managed by the government. The high penetration of renewable electricity in

the Netherlands is mainly price driven and achieved by subsidies and regulations stimulating ownership of solar panels and wind turbines. In South Korea renewable energy is mainly stimulated by the Renewable Portfolio Standard mandates. The pathway to a much higher renewable energy penetration is therefore less transparent. This leads to a lack of clear perspective for the business case for green hydrogen in the South Korea.

- › The urgency to develop local production of hydrogen as enabler to increase the use of renewable electricity, is much higher in the Netherlands due to the high share of renewables and the ambitions to increase the share further: for 2030 the target is 70% of the electricity from renewable sources³⁷. To improve the future business case for offshore wind, the Dutch government has defined a strategy for development of offshore green hydrogen production, for which a number of demonstration projects beyond 2030 are planned.
- › Both countries have identified the need to create a pipeline structure to connect the main concentrations of hydrogen use with production and import facilities. In the Netherlands the development of the national backbone infrastructure and the Rhine Delta corridor pipeline connecting the port of Rotterdam to Germany is already underway by Hynetwork, a fully owned subsidiary of Gasunie. In South Korea pipelines to transport hydrogen regionally, from industrial sites to users, are being developed. South Korea in addition also is building a network of refuelling stations which relies on transport of liquid hydrogen.

³⁷ [Renewable Energy and Climate Change | RVO.nl](https://www.rvo.nl/en/renewable-energy-and-climate-change)

4 Focus: energy materials for hydrogen

Does it fit with the Dutch National Technology Strategy to intensify cooperation with South Korea? To assess the potential on energy materials for hydrogen, in this section we focus on fuel cells and electrolyzers. This is in itself a field which is so important that it can be the basis for cooperation. However, it should be noted that the domain of energy materials is broader than fuel cells and electrolyser. Therefore there are more opportunities to contribute to the NTS than the field of electrochemical materials.

4.1 Industrial activities in South Korea on fuel cells and electrolyzers.

In the fuel cell field Korea is a clear global leader. Hyundai's sustainable strategy encompasses a very broad range of technologies³⁸, but the company is perhaps best-known for being global leader in hydrogen vehicle with over 30,000 fuel cell vehicles delivered globally. Although the market lift-off is not there yet Hyundai has strengthened its strategy on fuel cells and recently announced the construction of a new fuel cell manufacturing facility in Ulsan³⁹. The fuel cell strategy of Hyundai focusses on providing the proton exchange membranes (PEM) fuel cell for the vehicle market, but also explicitly address the wider markets of mobility (drones, trains, etc.) and stationary applications. Another leading company is Doosan, which focuses on the stationary market with products based on phosphoric acid fuel cells (PAFC) and solid oxide fuel cells. Standard containerized products in the 300-500 kW range⁴⁰. While there are many more companies developing products for the fuel cell market, Doosan and Hyundai are at the forefront and representative of the achievements of Korea in field of fuel cells.

Water electrolysis is a much less advanced field, and therefore products are much less commercialized. Several companies in South Korea are actively developing electrolyzers.

- › Bloom Energy Korea develops high-temperature solid oxide electrolyzers, which are highly efficient and suitable for large-scale hydrogen production and have delivered electrolyzers to several Korean consortia.
- › WESPE is actively involved in hydrogen technology. They specialize in developing and producing PEM water electrolysis systems and their core components and deliver stacks with an active area up to 330 cm².
- › Techcross Water & Energy is a manufacturer of electrodes for water management (electrochemical disinfection) involved in projects related to electrolysis and hydrogen production
- › Other companies developing electrolyser technology include for example Light Bridge and Arco Labs. However, there primary products are focussing on the lab-scale, such as test stations and small stacks.

³⁸ [Hyundai E&C Achieves CDP Korea Award Honor Roll for 7th Straight Year](#)

³⁹ [Hyundai announces new hydrogen fuel cell factory in South Korea](#)

⁴⁰ [Technology & Products - Doosan Fuel Cell Technology](#)

Furthermore there are Korean companies who buy the core technology abroad and focus on system integration. For example, Valmax Technology Corporation collaborates with Elogen, a French PEM electrolyser manufacture for the supply of electrolysers for various projects, including mobility and energy solutions, where Valmax is the system integrator. Samsung has a strategic cooperation with NEL to develop electrolyser systems for the Korean market⁴¹. Other system integrators include Hyundai Engineering & Construction, Kwanshan and others.

All in all the situation is very different in the fuel cell market where Korea is internationally leading. The market for electrolysers globally is much less mature. But also the position of Korea in manufacturing components and stacks is not yet very developed. However, it is important to note that South Korea is open to invest in local manufacturing of technology from other parts of the world, for example through licensing, co-development, etc.

4.2 Academic activities on materials for electrolysis

The amount of academic work focused on material development for hydrogen technology in South Korea is very broad and aligns well with the technologies listed in Appendix 1. Therefore we focus here on catalyst development for electrolysis, as this is a direct interest in the framework of the NTS. In South Korea there are quite a few universities and institutes working in the field. A short overview of some of the research topics shows quite some interesting work:

- › Researchers at Kumoh National Institute of Technology have reviewed recent efforts to reduce catalyst loading in PEM water electrolysis⁴². They explored core-shell nanostructures where precious metal catalysts form a shell around heteroatoms, significantly reducing catalyst loading while maintaining catalytic activity
- › Seoul National University, Yonsei University and KIST have developed a highly efficient electrochemical catalyst using a ruthenium-based nanocluster with a core-shell structure⁴³. This AEM catalyst uses only a small amount of precious metal but achieves outstanding performance and stability, showing strong potential for commercial use
- › Korea Institute of Science and Technology (KIST) together with Yonsei and POSTECH have developed technology to improve the reversibility and durability of bifunctional catalysts for an⁴⁴AEM reversible cell.
- › Researchers at UNIST have developed ultrahigh-current-density niobium disulfide catalysts for hydrogen evolution⁴⁵. This new catalyst can produce hydrogen at a large scale, offering a high current density and efficiency compared to existing catalysts
- › UNIST has developed a technology for improved water electrolysis using a platinum group metal-free benchmark anode catalyst⁴⁶. This technology has demonstrated remarkable performance superiority over its MEA counterparts.
- › A joint research team from Chung-Ang University and Georgia Institute of Technology developed a hybrid electrochemical catalyst using cobalt transition metal nanoparticles and pyrochlore oxides⁴⁷. This catalyst significantly enhances the oxygen evolution reaction (OER) in water electrolysis, showing 78 times greater activity compared to

⁴¹ [Nel ASA: Signs collaboration agreement and conducts private placement with SAMSUNG E&A | Nel Hydrogen](#)

⁴² [Recent Advances in Catalyst Materials for PEM Water Electrolysis](#)

⁴³ [Korean Scientists Develop World's Most Efficient Hydrogen Catalyst Using 1/3 the Precious Metal.](#)

⁴⁴ [Developing bifunctional catalyst performance enhancement technology](#)

⁴⁵ [Ultrahigh-current-density Niobium Disulfide Catalysts for Hydrogen Evolution](#)

⁴⁶ [Groundbreaking Technology Developed for Improved Water Electrolysis Performance and Stability](#)

⁴⁷ [CAU-GIT Joint Research Team Develops High-Performance OER Electrocatalyst for Water Electrolysis](#)

conventional cobalt nanoparticles and 11 times greater activity compared to IrO₂ catalysts.

- › Researchers at Hanyang University are focusing on the commercialization of alkaline electrolysis technology⁴⁸. Their work aims to develop efficient and durable electrocatalysts capable of operating at high current densities while ensuring safety, focusing on factors such as charge transfer, mass transport, and intrinsic activity.

Although this is not an exhaustive overview, it already shows a focus on the essential issues such as replacement of scarce materials and lifetime which are highly relevant in the NTS strategy.

⁴⁸ [Critical challenges and opportunities for the commercialization of alkaline electrolysis](#)

5 Potential cooperation between the Netherlands and South Korea

Same challenges and different approach: this characterizes the hydrogen strategies for both countries. Based on the differences and similarities described above, benefits may lie in identifying shared interest and consider the how cooperation might help compensate a lack of home market advantage.

5.1 Shared interest

The strategies of both countries overlap strongly in the field of importing and transporting hydrogen. Shared interest includes a wide range of research topics on transport and storage, such as material behaviour under hydrogen atmosphere, (measuring) leakage of hydrogen, sensing, infrastructure planning, underground storage, etc. In addition to handling hydrogen, handling hydrogen carriers such as ammonia, and the cracking of ammonia to hydrogen and ammonia combustion.

Grid congestion map: load connection (left) and generation connection (right)

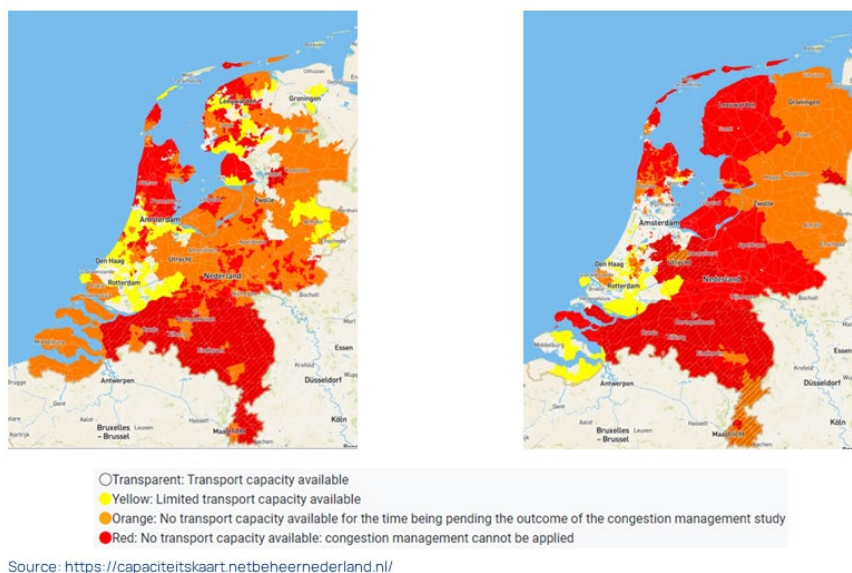


Figure 4: Grid congestion map of the Netherlands

Safety protocols and regulations for hydrogen are a shared interest. There have been quite a number of incidents in South Korea with hydrogen leakages and more serious incidents. While incidents should obviously be avoided, once they occur, the lessons which can be

drawn from them are very valuable. The Dutch focus is mainly on safety of green hydrogen production, transport and storage. However, sharing analysis of incidents will benefit both countries.

Grid congestion is a shared challenge in both countries. Where Korea is successfully developing the local hydrogen demand, the Netherlands has a more ambitious timeline for developing the hydrogen transport pipeline network. Both are needed to effectively reduce the pressure on the electricity network. A common strategy on the role of hydrogen in reducing grid congestion could combine both strengths and lead to development of technology to reduce grid congestion.

5.2 Complementarity in markets

South Korea does not yet have a specifically defined strategy towards large-scale implementation of green hydrogen and the electricity market organization does not appear to benefit a rapid introduction of electrolysis on a large scale. Nonetheless, a substantial part of the funding for hydrogen projects (over the period 2017-2021 approximately 25%) to green hydrogen projects⁴⁹. It demonstrates the willingness to invest in electrolyser technology.

The Dutch strategy is coherent on a scope which is much narrower: a focus on large-scale hydrogen production, transport and storage to connect to the industrial clusters and import of hydrogen through the ports. Green hydrogen is the main focus of the government funding for technology development. The Netherlands is part of the European market where high investment in green hydrogen are expected the coming decade. This makes cooperation attractive for Korean companies willing to invest in electrolysis.

Hydrogen for transport is not prominent in the policy in the Netherlands. Public perception may also currently not be favourable because of lower well-to-wheel⁵⁰ efficiency of fuel cell compared to electric vehicles which use electricity directly, the limited availability of refuelling stations and the limited choice in fuel cell vehicle. In this field South Korea is a global leader, in particular with respect to building an infrastructure for refuelling.

The same is true for stationary fuel cells. While there are some projects on the use of hydrogen in the built environment, the scale of those projects is very small compared to the pilot city approach which is prominent in South Korea. For Dutch companies there is a lack of home country advantage in these fields which could be partly compensated by intensifying cooperation.

By focussing on the use in fuel cells (South Korea) or on the electrochemical production of hydrogen (Netherlands), interestingly both countries do not yet fully profit from the synergy between the two technologies. Many manufacturing technologies may be useful for both fields and the benefit of intensified cooperation will also lie in realizing the synergy by being able to address both markets.

5.2.1 The opportunities for cooperation are broad(er)

It should be emphasized that although fuel cells and electrolyzers are the core technologies for a hydrogen economy, there are more opportunities in the field of hydrogen technology. Based on the key R&D priority areas in Appendix 1, fields of interest to Dutch SMEs could include:

⁴⁹ Approximately 25%

⁵⁰ Well-to-wheel efficiency refers to the whole supply chain from the sources of energy to the energy conversion in the vehicle.

- › Hydrogen and hydrogen carrier transport requires corrosion resistant and mechanically strong and stable materials. Developments to reduce costs and enhance safety are highly relevant.
- › Hydrogen storage: (materials for) large-scale hydrogen gas storage and transportation (450 bar) and high-pressure vessels for hydrogen fuelling (900 bar), ultra-high pressure tube trailers (450, 900 bar).
- › Liquid hydrogen: designs and core parts related to liquefied hydrogen storage and transportation, transportation of low-pressure liquid hydrogen (3 bar) and fuelling technology, liquid hydrogen carriers utilising LNG carrier building technology.
- › Other key R&D topics of interest to South Korea include manufacturing of hydrogen gas turbine technology, power electronics such as (high-voltage) inverters and converters.
- › Equipment specifically suitable for use in technologies for hydrogen production and use such as valves, fuelling technology, sensors, sealing, etc.
- › Based on the synergy between fuel cells and electrolyzers, potential exploitation of Dutch know-how in the area of fuel cells for both stationary and mobile applications where South Korea has built a unique position, cooperation can create opportunities for Dutch SME's in for example in the field of advance materials and automated manufacturing.

6 Conclusions

The Netherlands and South Korea both have high ambitions with respect to hydrogen and an innovative manufacturing sector. They share many similar challenges based on their economic and geographical situations. And yet, they have chosen highly different strategies, with South Korea focusing broadly on the use of hydrogen with mobility and power generation key sectors, and the Netherlands with a focussed strategy on the supply chain for (green) hydrogen and its use in industry. For importing and transporting hydrogen their strategies largely overlap.

Within the National Technology Strategy (NTS) of the Netherlands, Energy Materials, with a specific focus on electrolyzers is a key technology. South Korea on the other hand has a well developed technology position in fuel cells. Cooperation with South Korea has several benefits for Dutch companies. Intensifying cooperation could make it possible to capture the synergy between fuel cell and electrolyser manufacturing which require similar materials and equipment and knowledge, both in terms of market and innovations. Furthermore the South Korean academic institutes are quite active in material development for the electrolyser technology. These factors together create a strong incentive for cooperation in the field of Energy Materials.

Supply chains for these fuel cell and electrolyzer technologies are complex and extensive. While competition might occur on one specific component or material, it is the strength of the whole supply chain which determines competitiveness. Rather than competing, both countries can profit from intensified cooperation. A joint RD&D program would be a good way to “catalyse” such a cooperation.

At the same time it needs to be emphasized that the domain of energy materials offers more potentially beneficial cooperations than just on fuel cells and electrolyzers. There are other opportunities for Dutch industry, in particular SME's, in the field of energy materials in South Korea. A too narrow scope of joint program should be avoided.

Signature

TNO Energy & Materials Transition Petten, 9 July 2025

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Appendix A

Korea's key RD&D priorities

Based on the Government of Korea (2019) Hydrogen Economy Roadmap of Korea⁵¹

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

⁵¹ Hydrogen RD&D Collaboration Opportunities: The Republic of Korea, 28 January 2022, Australia's National Science Agency

Supply chain area	Sub-technology areas	Korea's key RD&D priorities
		By 2022, establish hydrogen pipelines near sources of by-product hydrogen production. Short distance piping infrastructure (within 10km).
		By 2025 demonstrate hydrogen supply to adjacent areas by installing pipelines at import bases.
		By 2030 high-pressure hydrogen pipelines to service high-demand areas nationwide. This includes improved materials.
	Transportation (ships)	Develop liquid hydrogen carriers utilising LNG carrier building technology. Construct a liquid hydrogen storage and acquisition base.
	Transportation (tank lorries and tube trailers)	Develop transportation (tank lorry) low-pressure liquid hydrogen (3 bar) and fuelling technology. Develop ultra-high pressure tube trailers (450, 900 bar).
Supply chain area	Sub-technology areas	Korea's key RD&D priorities
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
	Hydrogen vehicles	Develop metropolitan hydrogen bus technology (including design, motor, vessel etc.). Launch 5-10 ton hydrogen trucks by 2021, and 30 ton trucks by 2024. Establish local manufacture of hydrogen truck parts by 2030. Develop and demonstrate 5-10 ton public special freight vehicles by 2023. This includes garbage trucks, honey wagons, sprinkler trucks and others. Secure high pressure hydrogen vessels and high-voltage converters for buses. Demonstrate hydrogen taxis to analyse and improve durability of parts. Develop technology for localising electric parts (inverters and converters). Localise, scale-up and reduce cost of production for core parts (compression valves, storage containers) and fuelling technology. Improve hydrogen storage density/gravimetric capacity (wt%).
	Fuelling stations	Develop 1 to 2-ton per day hydrogen refuelling technology. Develop liquid hydrogen refuelling station technology. Develop high-pressure complex vessel for hydrogen fuelling stations (900 bar).
		Develop technology for high-power fuel cells.

Supply chain area	Sub-technology areas	Korea's key RD&D priorities
	Fuel cells (power generation)	Standardise and localise all parts of fuel cells for power generation. Improve lifespan and efficiency of parts for homes and buildings.
		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.

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