Hydrogen Governance and Sustainability in the Asia-Pacific

Approaches in Japan, South Korea, and India

Authors
Wakako Ito, Tomohiko Adachi, Fang-Ting Cheng, Tomoko Ishikawa, Youhyun Lee, Seong Bin Pak, Rajesh Sharma, Kentaro Tamura, Maximilian Rischer, Rainer Quitzow

RIFS Study
Potsdam
November 2025

Supported by

This study was funded by the Federal Foreign Office within the Project "Geopolitics of the Energy Transformation: Sustainability Governance in the Hydrogen Sector" Responsibility for the content of the report lies exclusively with the authors and does not necessarily reflect the views of the Federal Foreign Office.

Federal Foreign Office

Executive Summary

This study provides a comparative analysis of hydrogen governance in India, Japan, and South Korea, with a particular focus on sustainability considerations within national strategies, policy frameworks, and implementation mechanisms. The latter covers public funding schemes, commercial financing of hydrogen, as well as relevant standards and certification schemes. Recognizing the critical role of hydrogen in achieving decarbonization goals, the study examines how these three key Asia-Pacific economies are approaching sustainable hydrogen development, highlighting both strengths and areas for improvement.

The study is structured around the following five key areas:

1. Sustainability ambitions and compliance mechanisms,
2. The role of sustainability standards and certification,
3. Sustainability criteria in public funding schemes,
4. Sustainability considerations in commercial finance, and
5. Promoting sustainable hydrogen: challenges, commonalities, international partnerships.

Building on these five areas, this study examines the extent to which sustainability is embedded within the hydrogen policy frameworks of each country. It further identifies distinctive features, policy innovations, institutional challenges, and existing gaps in their respective approaches. The report begins with an analysis of Japan, followed by South Korea and India (Chapters 2–4). Chapter 5 presents a synthesis and comparative analysis of the three countries.

Sustainability in Hydrogen Governance: Japan

Japan's hydrogen governance framework is anchored in a carbon intensity threshold of 3.4 kg CO_2-equivalent per kg of hydrogen, applicable across all production pathways. This benchmark determines eligibility for public funding and serves as a central reference for investment decisions, even though Japan has not yet established a dedicated national certification system. The country's hydrogen strategy anticipates significant reliance on imports and promotes the use of hydrogen and ammonia for power generation. However, the carbon intensity threshold does not account for all lifecycle GHG emissions, including those associated with transport, distribution, and it does not consider energy losses due to conversion and reconversion along the value chain.

Japan's approach offers limited consideration of broader environmental and social dimensions within its contracts-for-difference-style public funding mechanism, which supports domestic and international projects alike. While domestic projects are subject to general environmental regulations, overseas projects—also eligible for funding—are not required to meet sustainability criteria beyond those set by host countries. Development finance institutions, such as the Japan Bank for International Cooperation (JBIC), apply detailed due diligence procedures in project financing that are aligned with internationally recognized ESG standards and approaches. However, no hydrogen-specific sustainability guidelines have been established to date.

Sustainability in Hydrogen Governance: South Korea

South Korea's sustainability framework is built around quantifiable emissions thresholds under the Clean Hydrogen Certification System (a maximum of 4 kg CO_2 eq/kg H_2 across four grades). The Clean Hydrogen Certification Scheme is pathway-neutral, allowing any production method, provided that the resulting hydrogen meets the defined carbon intensity limits. By 2050, hydrogen imports are projected to account for up to 80% of total national consumption.

In addition, the government has developed pursuing the Clean Hydrogen Portfolio Standard (CHPS) as its central funding program to support the hydrogen sector. This contracts-for-difference-style public funding scheme is designed to support electricity generation

projects rather than hydrogen production directly. It requires a minimum of 20% hydrogen or ammonia co-firing (measured by gross heating value) to be certified under the Clean Hydrogen Certification System. Hydrogen imports are also eligible. Beyond these requirements, the tender evaluation considers not only price but also sustainability-related factors. According to the scheme, hydrogen is graded according to its carbon intensity, based on four certification levels. Social aspects are also considered within the criterium of resident acceptance. However, this only applies to the power generation project and does not extend to hydrogen production. Other broader environmental and social criteria are absent. It should be noted that in mid-October 2025 the second tender under the scheme was cancelled, and it remains uncertain whether the program will continue. Media reports have speculated that the government is concerned about impact on its planned coal phase-out.

General environmental regulations apply to hydrogen projects, but they do not include hydrogen-specific guidance. In parallel, the national K-Taxonomy aims to promote sustainable economic activities—including hydrogen—in alignment with international ESG norms, though participation remains voluntary. Furthermore, Korean development banks, such as the Korea Development Bank, apply the Equator Principles to advance sustainable financing.

Sustainability in Hydrogen Governance: India

India, as an emerging player in both domestic hydrogen consumption and exports, has established its primary sustainability governance framework for hydrogen through the Green Hydrogen Certification of India (GHCI), which provides detailed definitions, compliance mechanisms, and verification procedures. The framework places a strong emphasis on renewable hydrogen - referred to as green hydrogen in public documents - and explicitly allows only hydrogen produced using renewable energy for electrolysis or biomass-based energy sources. These requirements, together with an emission threshold of 2 kg CO2 eq/kg H2, distinguish India's approach from those of Japan and South Korea.

Compliance with the GHCI is a prerequisite for eligibility under India's public hydrogen funding program, ensuring both climate integrity and verifiable origin. While general environmental regulations also apply to these hydrogen projects, they do not provide hydrogen-specific guidance. Overall, India's governance system demonstrates a strong commitment to renewable hydrogen and national decarbonization goals, though it remains primarily focused on emissions performance rather than comprehensive sustainability integration.

Comparative Analysis of Sustainability Governance in Japan, South Korea and India

Divergent National Approaches towards Terminologies and Hydrogen Sourcing (Domestic, Import, and Export): While all three countries prioritize hydrogen as a central component of their energy transition, their strategies differ markedly. India emphasizes domestic production of green hydrogen from renewable energy, targeting 5 million tonnes annually by 2030, with export potential. Japan focuses on both domestic production and imports, aiming for 20 million tonnes of low-carbon hydrogen. South Korea anticipates that approximately 80% of its projected 27.9 million tonnes of clean hydrogen consumption by 2050 will be imported.

Carbon Intensity as the Primary Sustainability Metric: Carbon intensity currently serves as the principal sustainability criterion in all three countries, although India complements this with a requirement to utilize renewable resources, i.e., renewable electricity or biomass. All schemes focus on "well-to-gate" emissions. In the case of Japan and South Korea - where hydrogen imports are expected to play a major role - potentially relevant emissions from transportation, conversion or reconversion processes, and hydrogen or energy losses are not accounted for. Broader environmental and social impacts, though recognized, are generally addressed only through national environmental permitting processes.

Certification and Standards Landscape: South Korea has established a tiered Clean Hydrogen Certification System based on carbon intensity thresholds, ranging from 0 to 4 kg CO2eq/kg H2. India's Green Hydrogen Certification Scheme (GHCI) mandates renewable- and biomass-based production with a GHG limits of 2 kg CO2eq/kg H2. Japan does not yet have a formal certification system, but has defined a GHG emission threshold of 3.4 kg CO2eq/kg H2. All these thresholds account for emissions associated with input materials and production processes within well-to-gate system boundaries. They may be applied when hydrogen is to be certified under the different national classifications and their respective thresholds (i.e., Low-Carbon Hydrogen in Japan, Clean Hydrogen in South Korea, and Green Hydrogen in India) or to establish eligibility within government funding schemes.

Import Orientation and Use-Phase Considerations: Both Japan and South Korea plan to use hydrogen and ammonia for power generation, including co-firing with fossil fuels. This is combined with a potential reliance on imported hydrogen. Moreover, existing certification schemes utilize system boundaries that exclude emissions from storage and transport. This raises concerns about the overall greenhouse gas reduction potential of hydrogen use.

Funding Mechanisms and Sustainability Linkages: Public funding in all three countries is tied to compliance with carbon intensity standards. In Korea, project eligibility (hydrogen or ammonia-based power generation) is also assessed to some extent against social criteria, and large-scale projects are required to undergo an Environmental Impact Assessment. Additional hydrogen-specific environmental and social requirements - beyond general national regulations - are not imposed. While national environmental regulations apply to domestic projects, there are no additional safeguards for hydrogen imports.

Governance Gaps and Challenges: While all three nations acknowledge the importance of broader environmental and social considerations, existing policy frameworks do not explicitly integrate these criteria. While domestic environmental regulation may be sufficient for mitigating certain adverse environmental impacts, this may not be the case for imported hydrogen. Given the importance of imported hydrogen for both Japan's and South Korea's hydrogen strategies, this represents, in terms of sustainability governance and climate aspects, a gap in their respective governance systems.

Contents

1 INTRODUCTION	**8**
2 JAPAN	**10**
2.1 Sustainability Ambitions and Compliance Mechanisms	10
2.2 The Role of Sustainability Standards and Certifications	13
2.3 Sustainability Criteria in Public Funding Schemes	14
2.4 Sustainability Considerations in Commercial Finance	17
2.5 International Partnerships	17
3 SOUTH KOREA	**19**
3.1 Sustainability Ambitions and Compliance Mechanisms	19
3.2 The Role of Sustainability Standards and Certifications	21
3.3 Sustainability Criteria in Public Funding Schemes	23
3.4 Sustainability Considerations in Commercial Finance	26
3.5 International Partnerships	27
4 INDIA	**28**
4.1 Sustainability Ambitions and Compliance Mechanisms	28
4.2 The Role of Sustainability Standards and Certifications	29
4.3 Integration of Sustainability Criteria in Public Funding Schemes	31
4.4 Sustainability Considerations in Commercial Finance	32
4.5 International Partnerships	32
5 COMPARATIVE ANALYSIS: SUSTAINABILITY IN HYDROGEN GOVERNANCE IN JAPAN, SOUTH KOREA AND INDIA	**34**
5.1 Synthesis of Country Analyses	34
5.2 Comparative Analysis and Conclusions	37
Literature	**39**
Authors	**45**

Tables

Table 1: Areas for Promotion of Low-Carbon Hydrogen and Other Uses	12
Table 2: Requirements for Carbon Intensity of Low-Carbon Hydrogen and Other Substances	13
Table 3: Evaluation Criteria of the Price-Difference Support Mechanism in Japan	16
Table 4: Evaluation Criteria for Low-Carbon Hydrogen Hub Development in Japan	16
Table 5: Key Goals and Strategies of the Hydrogen-related Plans in South Korea	20
Table 6: South Korea's Hydrogen Standards	23
Table 7: Social Sustainability Criteria and Proof of Compliance under the Korean CHPS	24
Table 8: Comparative Analysis of Sustainability Governance Aproaches in Japan, South Korea, and India	38

1 Introduction

Hydrogen has gained global prominence as a versatile energy carrier with the potential to decarbonize hard-to-abate sectors, enhance energy security, and support industrial transformation (IEA, 2024). As countries strive to meet their climate targets and diversify their energy sources, hydrogen offers a pathway to reduce dependence on fossil fuels while enabling the integration of renewables and driving green (IRENA, 2022). Its role is particularly critical in achieving net-zero goals in sectors such as transportation, heavy industry, and power generation (Staffell et al., 2019).

In the Asia-Pacific region, Japan, India, and South Korea are expected to become key players in the hydrogen market through technological advancement, investments, and active strategies (Lee & Pak, 2025). They have actively shaped the global hydrogen landscape. Japan was the first country to publish a national hydrogen strategy (2020) and remains a pioneer in hydrogen technology and international partnerships. South Korea has embedded hydrogen in its national growth agenda through strong government coordination and regulatory frameworks (Cho et al., 2024). India, at an earlier stage, is pursuing ambitious hydrogen development to support both energy transition and industrial growth, with a strong emphasis on international collaboration (Barman et al., 2025). The distinct policy approaches and institutional capacities of these countries offer valuable insights into maintaining sustainability in hydrogen governance.

These countries have adopted various approaches to integrate sustainability into their hydrogen economy strategies. This study reviews the efforts of these three countries to address sustainability concerns in the context of hydrogen governance. It covers sustainability considerations in hydrogen policy and regulation, public funding schemes, commercial financing of hydrogen, as well as relevant standards and certification schemes.

For this study, the term “sustainability” is defined comprehensively, encompassing not only the aim of reducing greenhouse gas (GHG) emissions but also other environmental, social, and economic dimensions. These dimensions include factors such as water stress, land use, land-use change, potential land-use conflicts, and resettlement. More specifically, sustainability is conceptualized along three interrelated dimensions—environmental and energy, economic, and social—each of which contains specific elements particularly relevant to hydrogen governance.

1. Environmental and energy dimension

This dimension focuses on the environmental integrity of hydrogen production and use, including:

- System-wide GHG emissions: whether specific emission thresholds are defined, emission scopes and system boundaries are applied, and grid-connected production follows criteria such as renewable energy additionality, temporal correlation, and geographical correlation.
- Energy access: the extent to which local access to clean energy is considered;
- Resource and ecosystem impacts: whether hydrogen strategies address water resource availability and quality as well as biodiversity and ecosystem conservation

2. Economic dimension

This dimension considers the contribution of hydrogen strategies to local economic development and employment creation, including whether local value chains are strengthened and economic benefits are equally distributed.

3. Social dimension

This dimension addresses both rights-based and participatory aspects of sustainability, including:

- People’s rights: whether strategies account for human rights, labor rights, and (indigenous) land and land use rights.
- Social acceptance and stakeholder engagement: the extent to which social and cultural acceptance is assessed and whether stakeholders are meaningfully involved in policymaking and project implementation processes.

By adopting this multidimensional approach, this study evaluates not only the environmental performance of hydrogen strategies in Japan, India, and South Korea but also their broader social legitimacy and economic inclusiveness. Building on this framework, the study examines how the three countries have integrated sustainability into their hydrogen strategies. The analysis is structured around five key areas, which are presented in the same order for each country:

1. Sustainability ambitions and compliance
2. Role of sustainability standards and certifications,
3. Integration of sustainability criteria in public funding schemes,
4. Sustainability considerations in commercial finance for hydrogen, and
5. Promoting sustainable hydrogen: challenges, commonalities, and international partnerships.

Building on these five areas, this study examines the extent to which sustainability is embedded within the hydrogen policy frameworks of each country. It further identifies distinctive features, policy innovations, institutional challenges, and existing gaps in their respective approaches.

The report begins with an analysis of Japan, followed by South Korea and India (Chapters 2–4). Chapter 5 presents a synthesis and comparative analysis of the three countries.

.

2 Japan

2.1 Sustainability Ambitions and Compliance Mechanisms

Sustainability Ambitions in the Hydrogen Sector

Japan was the first country to formulate a hydrogen strategy at the national level. The Basic Hydrogen Strategy, announced in December 2017, set out a vision for a future hydrogen society towards 2050 and included an action plan for its realization, from hydrogen production to utilization, including technology development, infrastructure development, and regulatory reforms (The Ministerial Council on Renewable Energy, Hydrogen and Related Issues, 2017).

The strategy also aims to establish hydrogen technologies, such as fuel cells, in which Japan has a competitive edge, and to develop a domestic hydrogen market ahead of the world. Following the 2050 Carbon Neutral Declaration of October 2020, the Basic Policy for the Realisation of Green Transformation (GX Basic Policy) was approved by the Cabinet in February 2023 (Cabinet Secretariat, 2023). The GX Basic Policy sets out a policy direction to achieve carbon neutrality while realizing a stable and inexpensive energy supply and strengthening the international competitiveness of Japanese industry. Hydrogen is regarded in the GX Basic Policy as an important energy carrier for which Japan has the highest level of technological capability internationally, which contributes to the diversification of energy supply and decarbonisation of various sectors. In view of the growing international interest in hydrogen and the commercialization of low-carbon hydrogen technology, the Basic Hydrogen Strategy was revised in June 2023 to become more closely aligned with the industrial strategy (The Ministerial Council on Renewable Energy, Hydrogen and Related Issues, 2023). The Hydrogen Society Promotion Act was enacted in May 2024 (METI, 2024d). Under this Act, relevant regulations and support will be provided in an integrated manner to promote the deployment of low-carbon hydrogen and its derivatives.

In Japan, the hydrogen policy is positioned within the energy and green industrial policy (GX policy). Therefore, the perspectives of the basic energy policy `S + 3Es` (which emphasizes the balance between energy security/stable supply, environmental compatibility, and economic efficiency with safety as a fundamental prerequisite) and the GX policy (which emphasizes the compatibility between decarbonization and strengthening industrial competitiveness and economic growth) are the basic principles for hydrogen policy in Japan.

The sustainability criteria in Japan's hydrogen policy are limited under these basic principles. From an environmental perspective, the revised Basic Hydrogen Strategy incorporates a carbon intensity-based assessment, and the regulation under the Hydrogen Society Promotion Act specifies low-carbon hydrogen having a carbon-intensity threshold of 3.4 kg CO_2 eq/kg-H_2 with a Well-to-Gate boundary. The revised Basic Hydrogen Strategy emphasizes the importance of the economic aspects that contribute to the region and communities where low-carbon hydrogen projects will be located (contribution to the local economy, specific scale of investment, and job creation) and the pursuit of cost reductions. No criteria have been set for environmental aspects other than GHG emissions (such as impacts on biodiversity and water resources) or cultural aspects (human and labour rights and land use rights). Thus, Japan does not have comprehensive sustainability criteria for low-carbon hydrogen; only a carbon intensity threshold is applied, irrespective of whether hydrogen is produced domestically or imported.

In terms of energy security/stable supply, and economic efficiency of the “S + 3Es” principles, the Japanese government pursues an affordable and large-scale, stable supply of low-carbon hydrogen. As discussed in the “Integration of Sustainability Criteria in Public Funding Schemes” section, while domestic production of low-carbon hydrogen is promoted, imports are considered an important option for Japan because of various constraints on domestic production. The Basic Hydrogen Strategy sets supply cost targets for low-carbon hydrogen (30 yen/Nm3 (approximately 334 yen/kg) by 2030 and 20 yen/Nm3 (approximately 222 yen/kg) by 2050), as well as supply volume targets for low-carbon hydrogen, including ammonia (3 million tons per year by 2030, 12 million tons of hydrogen/year by 2040, and 20 million tons/year by 2050). (The Ministerial Council on Renewable Energy, Hydrogen and Related Issues, 2023). The government aims to achieve these targets regardless of whether hydrogen is produced domestically or imported.

Linkage between National Hydrogen Policy and National Climate Policy

Hydrogen is a clean energy carrier that is key to achieving carbon neutrality by 2050 and is expected to contribute widely to the decarbonization of domestic electricity and industrial sectors. The policy objective is to use Japan's technological capabilities to promote new industries and strengthen its industrial competitiveness by capturing the global market. The Basic Policy on Promotion of Supply and Utilization of Low-Carbon Hydrogen (the "Hydrogen Basic Policy"), a Ministerial Notice issued under the Hydrogen Society Promotion Act, lists hard-to-abate sectors such as steel, chemicals, and transport as sectors where hydrogen use should be promoted, based on the recognition that hydrogen is a scarce commodity in the context of its high price compared to fossil fuels (METI, 2024b).

However, the Hydrogen Basic Policy also recognizes that the hard-to-abate sectors alone may not be able to create sufficient low-carbon hydrogen demand under current conditions, which can lead to the establishment of a large-scale supply chain. There is also a need for thermal power generation as a flexible means of adjusting to the variability of renewable energy. In light of this, the Hydrogen Basic Policy states that by promoting the use of low-carbon hydrogen and its derivatives in power generation, the electricity sector will be decarbonized, while ensuring sufficient and stable demand that will lead to the construction of large-scale supply chains.

Specifically, the Sixth Strategic Energy Plan (2021) states that approximately 1% of the total electricity generated in 2030 (approximately 0.934 trillion kWh) will come from combusting hydrogen and ammonia, either 100% hydrogen or ammonia (single) firing or co-firing with gas (in the case of hydrogen) and coal (in the case of ammonia), at thermal power plants, and the Hydrogen Basic Policy appears to have acknowledged this target (METI, 2021). However, the most recent Seventh Strategic Energy Plan (2025) does not set such a specific numerical target but only states that "decarbonization of thermal power will be promoted through the use of hydrogen, ammonia, and carbon capture, use and storage (CCUS)" (Agency of Natural Resources and Energy, 2025). Historically, the government funded the technological development of turbines or burners that are capable of using hydrogen or ammonia fully or partially as fuel, and also assisted the demonstration projects to establish technology for using hydrogen or ammonia as fuel at thermal power plants. The government has also implemented a long-term subsidy scheme to assist the construction of thermal power plants which are capable of 100% hydrogen or ammonia firing, or co-fire hydrogen or ammonia with fossil fuels, on condition that (in the case of co-firing) the developer must demonstrate that it satisfies the annual minimum co-firing rate set by the government, and it commits itself to its own roadmap to switch to 100% hydrogen or ammonia firing by 2050.

With regard to the use of hydrogen and its derivatives for the power sector, some concerns have been raised in terms of the cost, energy conversion effectiveness, and level of energy consumption on a life-cycle assessment basis, particularly in the case of product imports (Shibata, 2022). Expected reductions in life-cycle GHG emissions also significantly varies depending on the hydrogen and its derivatives production technology as well as types of hydrogen energy carriers (e.g., liquid hydrogen, methylcyclohexane (MCH) and ammonia)[1]. However, the government considers starting with co-firing as a realistic option for reducing GHG emissions from thermal power plants while maintaining a stable supply of electricity, and, as discussed in Section 2.3, the government set carbon-intensity requirements for the price-difference support mechanism. See Table 1 for a synthesis.

[1] See, for example, the following studies: Abeynaike, A., & Barbenel, Y. (2025), Ozawa et. al. (2019), Stocks et al. (2022), and Sun et al. (2024).

TABLE 1: AREAS FOR PROMOTION OF LOW-CARBON HYDROGEN AND OTHER USES

	2030	2040	2050
Iron and steel	Demonstration of COURSE 50* Partial commercial use of hydrogen for hydrogen reduction	Wider deployment of the Super COURSE 50** Wider deployment of direct hydrogen reduction technology	Expanding the introduction of Super COURSE 50 and direct hydrogen reduction technologies
Chemistry	Research and development and, in part, commercial applications for fuel conversion of naphtha cracking furnace heat sources. Research and development and, in part, commercial application of feedstock conversion from petroleum-derived naphtha	Wider deployment of fuel conversion of naphtha cracking furnace heat sources. Wider deployment of feedstock conversion from petroleum-based naphtha.	-
Transportation	Prioritised introduction of FCV fleets Development of hydrogen stations	Expanding the use of FCV fleets Expansion of hydrogen use to railways, ships, etc. Large-scale hydrogen stations	-
Generation (e.g., power)	Ammonia co-firing of around 20% Hydrogen co-firing of about 10% Deployment of ammonia co-firing power generation in Asia	Establishment of technology for dedicated ammonia-fired power generation (or co-firing of more than 50%) Accelerating the development of ammonia-fired power generation in Asia	Expanding the introduction of hydrogen and ammonia dedicated combustion

* Technology to reduce CO2 emissions by 10% by blowing by-product hydrogen into a blast furnace. Further information is available at https://www.greins.jp/course50/en/

** Technology to reduce CO2 emissions by up to 50% by blowing large quantities of hydrogen from external sources into a blast furnace. Further information is available at https://www.greins.jp/course50/en/

Compliance Mechanisms

The Hydrogen Society Promotion Act obliges companies that supplied more than 1,000 tons of hydrogen or 100,000 tons of ammonia in the previous financial year to prepare and publish an action plan to convert the so-called grey hydrogen (unabated, fossil fuel-based hydrogen) into low-carbon hydrogen, allowing the Ministry of Economy, Trade, and Industry (METI) to provide advice, recommendations, and orders for its implementation. This mechanism was newly introduced in late 2024, and at the time of this report, no action had been taken by the METI.

The implementation of domestic hydrogen projects does not require environmental assessments specific to hydrogen beyond general environmental assessments and safety regulations under the Environmental Impact Assessment Act (Government of Japan, n.d.-b). Infrastructure development of certain scale (for example, in the case of solar power development, assessment is compulsory in respect of the project whose size is 40,000 kW or larger, and case-by-case 30,000 kW or larger) must have an environmental impact assessment in accordance with the Act (requirement at the national level) as well as regulations (if applicable) which may be set up by the relevant local authorities before commencing any construction work. The developer must conduct the environmental impact assessments from the various perspectives, such as air, water, soil, biodiversity, animals, scenery, community space, waste, GHG emission and radiation level. The developer must report and reflect the result to its business plan, and the authorities will consider them in determining whether or not they will grant licenses and permissions to commence the project (and the authority will continue to monitor the project). At present, in the absence of hydrogen-specific requirements, these general environmental assessment frameworks govern the hydrogen project development from a sustainability point of view.

The revised Energy Conservation Act (2022) obliges large energy consumers to prepare medium- and long-term plans for conversion to non-fossil energy sources and to regularly report on their use of non-fossil energy sources, including hydrogen and ammonia (Government of Japan, n.d.-a). Additionally, businesses in the five industries for which the METI sets guidelines (steel, chemical, cement, paper, and automobile manufacturing) are required to set targets and report on the status of their efforts in relation to these guidelines. METI provides guidance and advice where necessary. Recommendations or public announcements are issued if it is inadequate. However, the revised Basic Hydrogen Strategy states that the possible measures related to the conversion to non-fossil energy based on the Energy Conservation Act will be examined after 2030, based on carbon intensity and other relevant criteria.

Gaps and Weaknesses in Ensuring Adherence to the Broader Sustainability Criteria

As noted above, Japan's hydrogen policy currently lacks broader sustainability criteria beyond carbon intensity, such as those addressing social and cultural aspects. Domestically, this would likely be considered in the context of revising and updating the general environmental impact assessment criteria, which are not necessarily specific to hydrogen projects. For now, it is unclear how broader sustainability considerations would be addressed in the context of imported hydrogen, which is supposed to be the predominant source of hydrogen in the future.

2.2 The Role of Sustainability Standards and Certifications

Definitions and Standards

The Hydrogen Society Promotion Act defines low-carbon hydrogen and its derivatives as products that satisfy the following requirements: (1) CO2 emissions below a certain threshold during production, regardless of the production pathway; (2) contribution to CO2 emission reduction in Japan, in line with internationally agreed methods of calculating CO2 emissions (such as ISO14067 and ISO/TS 19870); and (3) other requirements specified by the Order of the METI.

A ministerial order issued by the METI under the Hydrogen Society Promotion Act states that hydrogen and its derivatives include ammonia, synthetic fuels, and synthetic methane (METI, 2024b). The requirements for low-carbon hydrogen and its derivatives have also been established and are listed in Table 2. Note that there are no requirements other than carbon intensity. Emissions associated with the storage and transportation of hydrogen and hydrogen derivatives are not considered, nor are hydrogen and energy losses during processes such as conversion to ammonia or re-conversion to hydrogen. It should be noted that these unaccounted losses can significantly influence the overall assessment of hydrogen's carbon intensity. This approach may be revised in the future, considering relevant international discussions.

TABLE 2: REQUIREMENTS FOR CARBON INTENSITY OF LOW-CARBON HYDROGEN AND OTHER SUBSTANCES

	Carbon intensity thresholds	Scope of calculation	Additional requirements for synthetic fuels and synthetic methane
Hydrogen	3.4 kg CO2 eq/kg-H2 or lower	Well to Gate	-
Ammonia	0.87 kg CO2 eq/kg-NH3 or lower	Well to Gate	-
Synthetic fuels *	39.9 g CO2 eq/MJ or lower	Well to Wheel**	Hydrogen used as feedstock must meet the hydrogen requirement above Double-counting with exporting countries on CO2 capture during production should be avoided
Synthetic methane *	49.3 g CO2 eq/MJ or lower	Well to Wheel***	(see above)

* This requirement applies to imported synthetic fuels and synthetic methane.

** CO2 emitted from the production, transport, storage, and utilisation of synthetic fuels; less CO2 recovered for the feedstock of such synthetic fuels.

*** CO2 emitted from the production, liquefaction, transport, storage, and utilisation of synthetic methane; less CO2 recovered for the feedstock of such synthetic methane.

GHG and Sustainability Standards

Under the Hydrogen Society Promotion Act, companies that supply more than 1,000 tons of hydrogen or 100,000 tons of ammonia in the previous financial year are obliged to prepare action plans for converting gray hydrogen into low-carbon hydrogen, even though there are no statutory mandatory targets in terms of the volume or percentage of introducing low-carbon hydrogen. In addition, having a carbon intensity below the threshold is a mandatory requirement for approval under the financial support schemes enforced under the Act as referred to in Section 2.3 below.

The Government of Japan recognizes the need for an organization to certify “low-carbon” hydrogen. However, discussions on whether it should be a public or private organization and how international mutual recognition should be achieved are still in their early stage. The structure and type of certification scheme remain to be determined.

Broader Sustainability Aspects

There is no particular awareness of sustainability criteria other than low-carbon. In addition to the national government, several local governments (Tokyo Metropolis, Yamanashi Prefecture, and three Chubu prefectures (Aichi, Gifu, and Mie) have introduced their own green hydrogen certification systems. Businesses that produce and/or use renewable hydrogen in these prefectures may apply for a specific green hydrogen business certification, and in the case of Tokyo, they may receive subsidies to promote its deployment. In these cases, businesses must satisfy the conditions using renewable power sources (non-fossil certificates can also be used). However, there are no specific criteria for broader sustainability aspects (Tokyo Metropolitan Center for Climate Change Actions, 2025). It should be noted that there are no requirements for grid-connected green hydrogen production, such as “additionality,” “temporal correlation,” or “geographical correlation,” at either the national or local level in Japan.

2.3 Sustainability Criteria in Public Funding Schemes

Sustainability Criteria in Public Funding Programs

The Hydrogen Society Promotion Act provides two types of public support for low-carbon hydrogen projects: a contract-for-difference-style support scheme, applicable to both domestic and overseas production projects, and a support scheme for hydrogen hub development. The former is aimed at providing revenue support to the low-carbon hydrogen producer for 15 years by funding the price gap between the production and delivery costs of hydrogen and the sales price (which is considered to be the counterfactual fossil fuel price). The government has budgeted three trillion Yen (~ US$21 Bn) for a period of 15 years for this support scheme. The latter is to provide CAPEX funding support to hydrogen hub developers who will construct shared facilities at a specific location (hub), such as tanks and pipelines. The government has not yet clarified the size of the budget. Eligibility for these support programs will be assessed from the perspectives of both energy policy (i.e., the S + 3Es principle) and GX policy, i.e., compatibility between decarbonization and industrial competitiveness/economic growth (see Tables 3 and 4 below).

Other than these broader evaluation criteria, there are no sustainability criteria per se that are tied to the planned overseas projects. The government expects that the developer would comply with the sustainability criteria of the country (if any) in which the business operates its hydrogen project, but does not set its own sustainability criteria generally. It should be noted that these evaluation criteria do not apply to any other government-funded demonstration projects or studies generally, which mainly focus on technological development.

Additionally, leading government-affiliated financial institutions in the GX investment sector have established voluntary investment policies that typically include sustainability criteria such as environmental, social, and governance considerations, and compliance with international standards, such as World Bank standards. For example, the GX Acceleration Agency states that when deciding whether to provide financial support, the agency will consider not only the business sustainability of the project, but also a comprehensive range of factors, including impacts on industrial competitiveness, economic growth, and environmental improvements; impacts on society, such as the accumulation of human capital and the creation of quality jobs. In this way, the agency takes sustainability considerations into account in its investment assessment.

In addition to these direct funding programs, Japan also supports development financing, for example, through the Japan Bank for International Cooperation (JBIC). JBIC is strongly involved in promoting hydrogen projects both in Japan and overseas. This includes loans for importing strategically important goods (such as hydrogen and ammonia), overseas investment loans to support Japanese foreign direct investments, and other instruments applicable to hydrogen development. One example is a recently announced loan agreement of up to USD 626 million to enable the Mitsui & Co. Ltd. conglomerate to invest in a company in the USA aiming to develop a hydrogen supply chain, which will also involve substantial offtake by JBIC (JBIC, 2025). JBIC's engagement is further reflected in its numerous partnerships and MoUs.

In 2015, JBIC promulgated the Guidelines for Confirmation of Environmental and Social Considerations, which aim to contribute "to the sound development of the international economy and society through environmental and social considerations in all projects" (with "project" defined as any undertaking subject to JBIC lending, equity participation, or guarantees) (JBIC, 2022).

Under these guidelines, JBIC evaluates environmental and social considerations for each project through a structured screening and categorization process, classifying projects as Category A, B, C, or FI (Financial Intermediary) based on potential environmental impact and sensitivity. For Categories A and B, JBIC conducts detailed environmental reviews, assessing measures to prevent, mitigate, or compensate for negative impacts, including human rights, resettlement, and indigenous peoples' concerns. Category C projects require screening only, while Category FI relies on oversight via the financial intermediaries to which JBIC provides capital. JBIC also monitors projects after approval, requiring borrowers to report on environmental and social measures and intervening when necessary to ensure compliance, up to suspending funding if issues are not properly addressed (ibid.).

Ultimately, JBIC requires that projects meet either the World Bank Environmental and Social Standards (ESS) or the IFC Performance Standards (ibid.). JBIC also maintains sector-specific checklists for various areas such as oil and natural gas development, iron and steel, and others (though not yet for hydrogen) (JBIC, n.d.). In summary, JBIC is active in promoting hydrogen developments through various financing approaches and relies on established frameworks to safeguard environmental and social considerations in its operations.

Specific Sustainability Requirements

The specific evaluation criteria for projects eligible for the price-difference mechanism are presented in Table 3 (METI, 2024a).

Safety is essential from the perspective of the S+3Es principles. Business operators must obtain all relevant licenses and approvals under the applicable laws and regulations. In terms of stable supply, the evaluation criteria included a supply volume of more than 1,000 tons per year (hydrogen equivalent), domestic production, contributions to the diversification of supply sources, production regions, technologies, and fuels, and a high participation ratio of Japanese companies. For environmental compatibility, the evaluation criterion is that the carbon intensity must be below the criteria listed in Table 2 above. The evaluation criteria for economic efficiency include the reduction of supply costs to a level where a self-sustaining supply is possible after the support period ends.

In terms of the GX policy, the criteria include supply to hard-to-abate sectors such as steel, chemicals, and transport; contribution to domestic emission reductions; significant domestic economic spill-over effects contributing to strengthening the international competitiveness of the Japanese industry; and future supply and use of low-carbon hydrogen and other resources in the region where the low-carbon hydrogen project is located.

Of the above evaluation criteria, safety, supply of at least 1,000 tons per year, and supply to hard-to-abate sectors are mandatory requirements for eligibility.

TABLE 3: EVALUATION CRITERIA OF THE PRICE-DIFFERENCE SUPPORT MECHANISM IN JAPAN

S+ 3Es principles	Green Transformation (GX) policy
Safety • **Mandatory: Acquisition of all relevant licenses and approvals under the applicable laws and regulations** Stable Supply (Energy Security) • **Mandatory: A supply volume of more than 10,000 tons per year (hydrogen equivalent)** • Domestic production • Contribution to the diversification of supply sources, production regions, technologies, and fuels • A high participation ratio of Japanese companies in the upstream interests Environmental Compatibility • **Mandatory: The carbon intensity must be below the criteria listed in Table 2 (e.g., hydrogen: 3.4 kg CO2 eq/kg-H2 or lower, Well-to-Gate)** Economic Efficiency • The reduction of supply costs to a level where a self-sustaining supply is possible after the support period ends	Strengthening industrial competitiveness and economic growth • **Mandatory: Supply to hard-to-abate sectors such as steel, chemicals, and transport** • Significant domestic economic spill-over effects and scalability • Contribution to strengthening the international competitiveness of the Japanese industry • Supply to sectors and applications where the promotion of low-carbon hydrogen, etc. is difficult • Early investment decisions and the start of the supply chain • Large-scale investment and job creation • Measures for self-sustaining supply after the end of support • Technological innovation and competitive advantage. • A plan for wide-area supply and use is being developed in cooperation with local businesses and governments. Decarbonisation Contribution to domestic emission reductions

Note: Bold font indicates mandatory requirements. The more non-mandatory requirements the applicant meets, the higher the likelihood of being awarded the subsidy

Evaluation criteria were also set for projects eligible to support hub development (see Table 4) (METI, 2024a). Mandatory requirements include safety, a supply volume of more than 10,000 tons of hydrogen equivalent per year, supply to the hard-to-abate sector, preparation of a hub development plan with a medium- to long-term outlook for contribution to the local economy, and creation of potential hydrogen demand in the surrounding area.

TABLE 4: EVALUATION CRITERIA FOR LOW-CARBON HYDROGEN HUB DEVELOPMENT IN JAPAN

S+ 3Es principles	**Green Transformation (GX) policy**
Safety • **Mandatory: Acquisition of all relevant licenses and approvals under the applicable laws and regulations** Stable Supply (Energy Security) • **Mandatory: A supply volume of more than 10,000 tons per year (hydrogen equivalent)** Environmental Compatibility • The carbon intensity must be below the criteria listed in Table 2 (e.g., hydrogen: 3.4 kg CO2 eq/kg-H2 or lower (Well-to-Gate) Economic Efficiency • The reduction of supply costs to a level where a self-sustaining supply is possible after the support period ends. • Utilisation of resources that contribute to decarbonisation in an economically and rationally sound manner. • High project efficiency in terms of supply volume per amount of support, CO2 reduction volume, or low total amount of support.	Strengthening industrial competitiveness and economic growth • **Mandatory: Supply to hard-to-abate sectors such as steel, chemicals, and transport** • Significant domestic economic spill-over effects and scalability • Contribution to strengthening the international competitiveness of the Japanese industry • Supply to sectors and applications where the promotion of low-carbon hydrogen, etc. is difficult • Measures for self-sustaining supply after the end of support • Technological innovation and competitive advantage. • **Mandatory: Contribution to local economy** • Future visions reflecting local industrial structure • Concrete scale of investment and job creation at the local level • A plan for wide-area supply and use is being developed in cooperation with local businesses and governments • Preparation of a hub development plan with a medium- to long-term outlook for the contribution to the local economy and creation of potential hydrogen demand in the surrounding area • Securing land for facility expansion to meet increased demand in surrounding areas • Possibility of interregional collaboration and expansion of supply and use to later-developing regions Decarbonisation Contribution to domestic emission reductions

Note: Bold font indicates mandatory requirements. The more non-mandatory requirements the applicant meets, the higher the likelihood of being awarded the subsidy.

Monitoring and Enforcement Mechanisms

Under the support schemes of the Hydrogen Society Promotion Act, qualified operators are eligible for subsidies, but are required to regularly report on the status of project implementation to the supervising body (the METI) and subsidy executing body (Japan Organization for Metals and Energy Security, JOGMEC). In particular, they are required to report to JOGMEC in order to demonstrate that they meet the emissions threshold on an annual and quarterly basis, subject to the verification by a third party that is sufficiently capable of conducting such verification. If the project is deemed not to be implemented in accordance with the approved plan, for example, if the carbon intensity standard continues to be missed because of the project operator, approval may be cancelled, and operators may be ordered to refund the subsidy received.

Green Innovation Fund projects have been supported for over ten years. During this period, progress is checked and evaluated annually through dialogue with the management of each project-implementing company and other companies in sector-specific working groups consisting of external experts. In addition, regular stage-gate evaluations and monitoring are conducted by the fund's executive body (the New Energy and Industrial Technology Development Organization, NEDO) several times a year. In certain cases where the project has repeatedly missed a budget, timetable, and other conditions and demonstrated no credible prospect of success, the NEDO may terminate the project at a stage-gate evaluation.

2.4 Sustainability Considerations in Commercial Finance

Sustainability Criteria for Financing

Since large-scale, commercialized hydrogen project developments are still in the early days, with limited involvement of financial institutions yet, there are no governance mechanisms specifically tailored to hydrogen projects that consider broader sustainability issues. Instead, at present, the financial institutions, both public and private, consider and apply their investment policies generally applicable to energy and infrastructure projects (including renewables projects) to the emerging hydrogen projects.

Likewise, private financial institutions such as major banks have made similar environmental and social considerations key to their investment policies[2]. As one of the most recent examples, the Japan Hydrogen Fund was launched in September 2024 as a private fund specializing in investments in hydrogen-related sectors. It has raised USD 400 million in the banking, energy, and automotive sectors, and has executed three investments by March 2025. According to the fund manager, financial and non-financial information, such as sustainability, is an important factor in gaining insight into the medium- to long-term stability and sustainability of each business, and the fund will be managed with enough consideration of sustainability aspects, such as environment, social, and governance considerations, through their sustainable investment evaluation processes (Sumitomo Mitsui Financial Group, 2024). However, detailed information about such sustainability criteria is not publicly available.

In general, Japanese financial institutions—both public and private—state that they adhere to international practices, including sustainability considerations, when formulating their investment policies, although these policies are not publicly disclosed.

2.5 International Partnerships

International cooperation is essential for creating a hydrogen society. The Japanese Government is a founding member of the IPHE, an intergovernmental consultative body established in 2003 to promote the development of hydrogen and fuel cell technologies, standards, and information exchange. Notably, the IPHE published a hydrogen certification paper in October 2024 taking the position to developing a mutual recognition and certification scheme of clean hydrogen (International Partnership for Hydrogen and Fuel Cells in the Economy, 2024). In 2018, the Japanese Government hosted a ministerial meeting on hydrogen energy in Tokyo. This was the first conference in the world to invite ministers from

[2] Such as JBIC, DBJ, GX Acceleration Agency, SMBC, and Sumitomo Mitsui SA Asset Management

abroad to hold policy dialogues and exchange views on the realization of a hydrogen society. The conference has been held six times so far to discuss the hydrogen initiatives of each country, share the latest knowledge, the possibility of international collaboration, and the direction of policies for global hydrogen utilization. In the 2023 Chair summary, the importance of developing international standards and certification schemes was recognized for carbon-intensity-based tradability, transparency, trustworthiness, and sustainability in the context of promoting hydrogen trade and fostering a hydrogen market (METI, 2023).

In addition to these multilateral frameworks, hydrogen-related policy dialogue and cooperation are also being promoted in bilateral frameworks, such as those with the EU (METI, 2024c), Republic of Korea (METI, 2025) and Germany (The Japanese-German Energy Partnership, 2025). Under these frameworks, the governments recognized the importance of building a resilient and sustainable supply chain of hydrogen, and in the case of Japan and Korea, the governments agreed to jointly enrich the methodology for measuring greenhouse gas emissions in the production process of hydrogen.

As previously discussed, the Japanese government established a policy to support the formation of a large-scale hydrogen supply chain using the aforementioned support schemes under the Hydrogen Society Promotion Act. Given the geological constraints to substantially increase renewables capacity in Japan and resultant limited domestic renewables hydrogen production potential, the government would need to consider imports as an option for a large-scale, cost-competitive clean hydrogen supply from the regions where hydrogen can be produced using cheap surplus renewables energy or hydrogen can be produced by reforming natural gas at a relatively stable price with reliable CCS technology.

That said, increased costs due to recent global inflation and depreciation of the yen, as well as volatile natural gas prices, have cast doubt on whether hydrogen can be produced and imported at an affordable cost in the near future. METI plans to announce a small number of candidate projects that will be eligible to receive subsidies under the Act around March 2026, and sustainability elements will be considered in the selection process, as discussed in the “Integration of Sustainability Criteria in Public Funding Schemes” section. However, it remains to be seen to what extent sustainability elements will gain importance during the selection process, because they are merely part of the various assessment criteria.

3 South Korea

3.1 Sustainability Ambitions and Compliance Mechanisms

Sustainability Ambitions in the Hydrogen Sector

The Korean government has been promoting a hydrogen policy since the early 2000s, recognizing hydrogen as a critical energy source and an essential tool for combating climate change. In 2005, the government established a Comprehensive Master Plan for Hydrogen Economy Response to Build a Foundation for the Hydrogen Economy. Prior to this, the second electricity supply and demand plan, finalized in December 2004, had already incorporated fuel cell distribution, a commitment reiterated in the current 10th Basic Plan for Electricity Supply and Demand. Despite the lack of policy emphasis for over a decade following the 2005 plan, hydrogen re-emerged as a key focus in the Innovation Growth Strategy Investment Direction in August 2018 (J. Yoo, 2024), because of former President Moon's political direction of implementing a nuclear power phase-out. Subsequently, the government unveiled a Roadmap for the Promotion of the Hydrogen Economy in January 2019, followed by the enactment of the Act on the Promotion of the Hydrogen Economy and the Safety Management of Hydrogen in February 2020, which formalized the hydrogen economy. In line with this law, the Hydrogen Economy Committee, a representative entity of the integrated hydrogen-related policy, was established in July 2020 (Lee, Kim, et al., 2024).

Considering that clean hydrogen (including both renewable and fossil-based hydrogen with CCS) constitutes less than 0.7% of Korea's total domestic hydrogen production, and renewable hydrogen accounts for less than 0.1%, its contribution to greenhouse gas reduction remains negligible (KEEI, 2023a; Tae-kyung, 2025). Although official national statistics are unavailable for imported hydrogen, the share of renewable hydrogen is presumed to be minimal. According to the Korean government's 2050 hydrogen supply scenario, imported hydrogen is expected to account for approximately 80% of the total supply (MOFA, 2021; Tae-kyung, 2025). Consequently, greater emphasis is expected on importing clean hydrogen, with a clear focus on promoting procurement cooperation with countries and regions such as Australia, the Middle East, and North Africa.

Linkage between National Hydrogen Policy and National Climate Policy

The South Korean government regards hydrogen as a vital contributor to GHG emission reduction. In 2020, the role of hydrogen in South Korea's energy sector expanded when the government announced its commitment to achieve carbon neutrality by 2050 (Lee et al., 2024) Hydrogen has been identified as one of the core technologies in South Korea's Carbon Neutrality and Green Growth Basic Plan (2023), and it is also included as a key sector for emission reduction in the country's 2030 Nationally Determined Contribution (NDC), underscoring its pivotal role in national climate policy and in achieving carbon neutrality by 2050. The government's efforts to transition towards eco-friendly energy sources, expand renewable energy, and increase the use of carbon-free power have brought hydrogen to the forefront of the national energy strategy. These initiatives focus on replacing fossil fuels with hydrogen in power generation and industrial sectors to mitigate GHG emissions. To emphasize the evolution of hydrogen, the government introduced the 1st Hydrogen Economy Implementation Master Plan in November 2021. This plan presents a broader vision of the hydrogen economy than the Roadmap for the Promotion of the Hydrogen Economy in 2019. The Masterplan aims to supply 3.9 million tons of clean hydrogen by 2030 and 27.9 million tons by 2050, contributing to the realization of both the 2030 NDC and the 2050 carbon neutrality target (Lee et al., 2024).

South Korea is undertaking various initiatives to meet the sustainability goals of its hydrogen sector. In particular, South Korea's 1st Hydrogen Economy Implementation Master Plan (2021) identifies the realization of a hydrogen economy as a key strategy for achieving carbon neutrality. While reducing GHG emissions remains a core objective, the country is focusing on research and development in hydrogen production and utilization, infrastructure expansion, and international collaboration, outlined in the 3rd Basic Energy Plan (2019-2040). Therein, South Korea intends to harness renewable energy to produce clean hydrogen, advance fuel-cell technologies, and promote the commercialization of hydrogen vehicles and related industries. These efforts are considered integral to achieving carbon neutrality and laying the foundation for a robust hydrogen economy.

TABLE 5: KEY GOALS AND STRATEGIES OF THE HYDROGEN-RELATED PLANS IN SOUTH KOREA

Category	3rd Basic Energy Plan (2019–2040)	1st Hydrogen Economy Implementation Master Plan (announced in November 2021)
Basic Direction	Foster hydrogen as a future energy industry	Build a full-cycle hydrogen ecosystem (production–distribution–utilization). Foster the hydrogen industry and create jobs. Contribute to carbon neutrality.
Goal	By 2040: Deploy 6.2 million hydrogen vehicles and establish 1,200 hydrogen refuelling stations Expand hydrogen's share in power generation	By 2030: Deploy 2 million hydrogen vehicles (including passenger cars, buses, trucks) Install 450 hydrogen refuelling stations Introduce 8 GW of fuel cells for power generation Secure annual clean hydrogen supply of 3.9 million tons by 2050: Deploy 6 million hydrogen vehicles Install 1,200 hydrogen refuelling stations Hydrogen to account for more than 5% of power generation Secure annual hydrogen supply of 27 million tons
Hydrogen Production / Supply	Expand hydrogen production infrastructure (starting with by-product and reforming hydrogen → shift to water electrolysis and overseas production in the long term) Promote import of clean hydrogen from abroad	Shift toward clean hydrogen supply (including water electrolysis and overseas imports) Build 40 hydrogen production hubs by 2030 Establish liquefied hydrogen plants and storage/transport systems
Hydrogen Utilization / Infrastructure	Expand adoption of hydrogen vehicles Commercialize hydrogen buses and trucks Actively utilize hydrogen in power generation (e.g., fuel cells) Expand nationwide hydrogen refueling infrastructure Review development of hydrogen pipeline and distribution networks	Transportation: expand use in passenger/commercial vehicles, ships, drones, etc. Industry: use hydrogen to decarbonize sectors like steel and chemicals Construct 2,000 km of national hydrogen pipeline by 2050
Safety / Regulatory Framework	Establish safety standards and certification systems for hydrogen	Designate a dedicated hydrogen safety agency and build an integrated management system Introduce a clean hydrogen certification system
Other	Strengthen R&D across the full hydrogen value chain: production, storage, transport, and utilization Increase investment in core technologies (e.g., electrolysis, liquefied hydrogen)	Secure clean hydrogen production technologies (e.g., electrolysis, CCUS) Develop efficient hydrogen transport and storage technologies Promote future promising technologies (e.g., ammonia, liquefied hydrogen

Sources: 3rd Basic Energy Plan (2019-2040; MOTIE, 2019); 1st Hydrogen Economy Implementation Master Plan (MOTIE, 2021), of which a summary is available at Government of Korea (2021)

Compliance Mechanisms

To ensure sustainability, achieve carbon neutrality, and reduce GHG emissions, as indicated in the first Hydrogen Economy Implementation Master Plan, multiple institutions and mechanisms have been established within the hydrogen sector according to the Hydrogen Act. With this act, South Korea has established a legal basis for promoting the hydrogen economy through the Hydrogen Act in 2020, which is the first law of its kind in the world. Key agencies, including the Korea Energy Economics Institute, the Ministry of Trade, Industry, and Energy, and the Ministry of Environment, are responsible for shaping hydrogen-related policies (Lee et al., 2024). These agencies regulate hydrogen production and consumption, and support the development and dissemination of relevant technologies. Additionally, private organizations such as the Korea Hydrogen Association collaborate with industry stakeholders to promote the advancement of hydrogen technologies. Monitoring processes of GHG reduction involve regular reporting and data collection, along with the establishment of evaluation criteria to ensure the sustainable use of hydrogen. South Korea certifies hydrogen as "clean" if its production emits less than 4 kg CO2e per kg, on a well-to-gate basis, making it eligible for government support (see also section 3.2). This system reduces uncertainty for hydrogen production projects in practice, shall help to cut emissions within the hydrogen ecosystem, strengthen the reliability of the domestic certification system, and respond to international environmental regulations, ultimately driving investment in clean hydrogen and supporting carbon neutrality goals. From a governance perspective, the Hydrogen Economy Committee under Article 6 of the Hydrogen Law[3], chaired by the Prime Minister, coordinates interministerial policies and sets strategic directions for funding allocation, serving as a central governance body.

Gaps and Weaknesses in Ensuring Adherence to the Broader Sustainability Criteria

However, these systems exhibit several shortcomings and limitations, as the environmental impacts of hydrogen production processes - particularly regarding GHG reduction - have often been insufficiently considered (Lee et al., 2025). While the Korean government aims to expand renewable hydrogen, the anticipated approximate 80% reliance on imported hydrogen in 2050 means that the carbon reduction impact will largely depend on the robustness of emission tracking systems for imports and may thus remain limited. Additionally, the current certification schemes (see above and the following chapter) apply a well-to-gate system boundary approach, which excludes significant emissions from processes such as conditioning, (re)conversion, and transport, thus likely increasing the overall carbon footprint if hydrogen is being imported from overseas. Finally, while South Korean environmental regulation will ensure that key environmental impacts are considered during domestic project development, there is no policy in place to ensure the consideration of environmental impacts for imported hydrogen (see also section 3.3. below).

3.2 The Role of Sustainability Standards and Certifications

Definitions and Standards

The Korean legal framework classifies hydrogen as a "new energy" under Article 2 of the Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy[4]. Under the Hydrogen Economy Promotion Act ('Hydrogen Act') article 25-2 and the accompanying notice on the operation of the Clean Hydrogen Certification System (MOTIE, 2024), the Korean government classifies clean hydrogen into four grades based on the level of greenhouse gas emissions per kilogram of hydrogen produced at the facility level: Grade 1: 0.00–0.10 kg CO2 eq/kg-H2, Grade 2: 0.11–1.00 kg CO2 eq/kg-H2, Grade 3: 1.01–2.00 kg CO2 e/kg-H2, Grade 4: 2.01–4.00 kg CO2 eq/kg-H2. Accordingly, the legal definition of clean hydrogen in Korea is strictly based on its quantified emissions intensity (no more than 4kg CO2 eq/kg-H2, well-to-gate), rather than the method of production.

GHG and Sustainability Standards

Korea's national hydrogen policy places strong emphasis on reducing GHG emissions through the production and utilization of hydrogen, and this focus is reflected across various institutional and policy frameworks. A key example is the Clean Hydrogen Certification System, legally established in 2023 under Article 25-2 of the Hydrogen Act, which certifies hydrogen based on quantified GHG emissions per kilogram (see box 1 on following page).

---

[3] Article 6 (Hydrogen Economy Committee). (1) the Hydrogen Economy Committee (hereinafter referred to as the "Committee") shall be established under the control of the Prime Minister to deliberate on each of the following matters concerning major policies and plans for implementing the hydrogen economy: 1. Matters concerning formulating and executing master plans and reviewing and evaluating the implementation results thereof; 2. Matters concerning recommendations for improving statutes and regulations pertaining the implementation of the hydrogen economy; 3. Matters concerning policy coordination, cooperation, and support related to the hydrogen economy by relevant central administrative agencies and local governments; 4. Matters concerning cooperation between countries, establishment of a hydrogen industry ecosystem, and handling of grievances of enterprises in relation to the hydrogen economy; 5. Matters required to undergo deliberation of the Committee under other statutes; 6. Other matters deemed necessary by the Chairperson of the Committee in relation to the hydrogen economy.

[4] Article 2 (Definitions). The terms used in this Act are defined as follows: 1. The term "new energy" means any of the following energy that is either converted from existing fossil fuels or uses electricity or heat generated through the chemical reaction of hydrogen, oxygen, etc.: (a) Hydrogen energy; (b) Fuel cells; (c) Energy from liquefied or gasified coal and energy from gasified heavy residual oil which fall within the criteria and scope prescribed by Presidential Decree; (d) Other energy prescribed by Presidential Decree, other than petroleum, coal, nuclear power, or natural gas;

Under Article 25-2 of the Hydrogen Act, hydrogen may be certified as "clean" if its greenhouse gas emissions during production and supply remain below the threshold of 4kg CO2e per kg of hydrogen, based on a well-to-gate boundary assessment. Certification is issued across four distinct grades, as outlined above. While certification is generally voluntary, it becomes mandatory for hydrogen to be labeled as "clean," to qualify for the Clean Hydrogen Portfolio Standard (CHPS; see Chapter 3.3 for further details), and is likely required for eligibility in other current or future public funding programs.

The certification system is overseen by the Ministry of Trade, Industry and Energy (MOTIE) by Public Notice by the Ministry of Trade, Industry and Energy No. 2024-39. As part of the recent government reorganization, all energy-, climate-, and hydrogen-related responsibilities, including the operation of the Clean Hydrogen Certification System, have been transferred to the newly established Ministry of Climate, Energy and Environment of Korea (SHIN & KIM LLC, 2025). The Korea Energy Economics Institute (KEEI) is in charge of the overall certification process, including receiving applications, deliberation, and issuing certificates, while the Korea Testing & Certification (KTC) and the Korea Research Institute of Chemical Technology (KTR) are responsible for technical verification, including on-site inspections and data review (S. Yoo, 2024).

BOX 1: CLEAN HYDROGEN CERTIFICATION UNDER THE SOUTH KOREA H2 ACT

Article 25-2 of the Hydrogen Act establishes the Clean Hydrogen Certification system, setting out the legal framework for certifying, supporting, labelling, inspecting, and revoking clean hydrogen. Under this system:

- The Minister of Trade, Industry, and Energy may certify hydrogen or hydrogen compounds as clean hydrogen by grade if they meet the certification standards established by Presidential Decree, including criteria such as carbon dioxide emissions during production or import, to promote the use of clean hydrogen.
- The Minister may provide administrative and financial support to producers or users of certified clean hydrogen, which may be differentiated according to the hydrogen grade.
- Clean hydrogen certified under Paragraph 1 may be labelled with the official certification mark, as prescribed by the Ordinance of the Ministry of Trade, Industry, and Energy.
- Hydrogen or hydrogen compounds not certified under Paragraph 1 may not be labelled with the clean hydrogen certification mark or similar designations.
- The Minister may revoke certification or order the suspension or improvement of the certification mark if standards are unmet, certification was obtained improperly, operations are not conducted as required, inspections are obstructed, notifications are not submitted, or previous orders are ignored.
- In cases of revocation, suspension, or required improvement under Paragraph 5, the Minister shall publicly announce the action in accordance with Presidential Decree.
- The Minister may conduct inspections pursuant to Presidential Decree to ensure that certified entities continue to meet the certification standards.
- Additional matters necessary for the certification and revocation of clean hydrogen certification shall be prescribed by Presidential Decree.

The Operational Rules for the Clean Hydrogen Certification, issued by the KEEI (2025) outline specific provisions if hydrogen is produced via electrolysis. In this case, hydrogen production may either be fully self-sufficient using dedicated low-carbon electricity or rely on grid electricity (ibid., p. 26), provided that the overall GHG emission intensity does not exceed the specified threshold; mixed approaches are also allowed. When grid electricity is used, electricity-related data are only considered eligible for verifying the carbon intensity of electrolytic hydrogen if the amount of electricity generated from low-carbon power sources matches, on a monthly basis, the electricity consumed by the hydrogen production facility and if the low-carbon power source is connected to the same electricity grid as the hydrogen plant (Article 9.1).

In practice, such electricity supply can be arranged through Power Purchase Agreements (PPAs) (ibid., p.26). In addition, the use of Renewable Energy Certificates (RECs) is permitted, but the amount of hydrogen production electricity accounted for via RECs is limited to a maximum of 10% of the total monthly electricity used by the facility (ibid., Article 9.4). To summarise, South Korea's clean hydrogen certification framework primarily relies on a mass-balancing approach, with a limited allowance (up to 10%) for book-and-claim accounting via RECs to provide flexibility while ensuring credible carbon intensity verification.

Generally, in South Korea, hydrogen-related standards, including the Clean Hydrogen Certification Scheme, are classified as either mandatory (legal) or voluntary (administrative or technical). Legal mandatory standards are grounded in laws, such as the Hydrogen Economy Promotion Act and the Hydrogen Safety Management Act. For instance, hydrogen producers and importers are encouraged to comply with the Clean Hydrogen Certification System, which classifies hydrogen into four grades based on greenhouse gas emissions intensity (4 kg CO2eq per kg H2). The Clean Hydrogen Certification is, as of 2025, only mandatory when electricity producers aim to benefit from the financial incentives of the Clean Hydrogen Portfolio Standards (CHPS, see next section). Safety regulations enforced by the Korea Gas Safety Corporation (KGS) also mandate strict licensing and approval procedures for hydrogen production, storage, transport, and refueling facilities (Gogger, 2025; KEEI, 2023b; MPR Korea Certification, n.d.).

In contrast, voluntary standards are used primarily for administrative guidance and industry harmonization but are not legally binding. One example is the color-based classification of hydrogen into green, blue, or gray, which is widely used in policy documents and planning strategies to distinguish production methods. However, these color terms have no legal standing and do not replace the emission-based classification required by law. Similarly, several technical standards for equipment, pipelines, and hydrogen fuel systems (e.g., KGS codes such as AH171 or FU671) are based on international norms such as the IEC or SAE standards and are applied flexibly, especially during the early implementation phases. Table 6 provides an overview of some of the voluntary and mandatory standards.

TABLE 6: SOUTH KOREA'S HYDROGEN STANDARDS

Legal Mandatory Standards	Contents
Clean Hydrogen Certification	Emission-based standards: all hydrogen producers/importers may obtain certification defining grades 1–4 (≤4 kg CO_2 eq/kg-H2). Mandatory to qualify for the Clean Hydrogen Portfolio Standards or likely to other bidding markets
KGS Safety Standards & Licensing	Manufacturing licenses and safety approvals are required for producers, fuel-cell/mobile units, pipelines, and refuelling stations.

Broader Sustainability Aspects

South Korea enforces legally binding standards for clean hydrogen certification in case of certain public funding schemes, emission thresholds, electricity procurement obligations, and safety management through hydrogen laws and KGS regulations. Simultaneously, it utilizes non legally binding but widely referenced administrative and technical standards to support sectoral coordination, technological alignment, and international interoperability. This dual system helps balance regulatory compliance with practical policy implementation and industrial development.

Broader sustainability factors, such as water use, land use change, biodiversity, and social impacts (e.g., labor conditions and community effects), have not been addressed in hydrogen-specific policy or regulations. As Korea seeks to strengthen its role in international hydrogen supply chains and respond to ESG-driven industrial policies, there is a growing need to adopt more comprehensive sustainability criteria that encompass both the environmental and socioeconomic dimensions.

3.3 Sustainability Criteria in Public Funding Schemes

Sustainability Criteria in Public Funding Programs

Korea's hydrogen funding programs are increasingly incorporating climate-related criteria into their design and implementation. Key initiatives include support for clean hydrogen production facilities and hydrogen power generation bidding systems, which demonstrate greenhouse gas (GHG) reduction benefits when certified under the Clean Hydrogen Certification Scheme, as reflected in the Clean Hydrogen Portfolio Standard (CHPS), established under the amended Hydrogen Economy Promotion and Hydrogen Safety Management Act.

The CHPS is designed to facilitate the growth of Korea's emerging hydrogen economy by providing financial incentives to electricity producers that utilize hydrogen or ammonia, either through co-firing with other energy sources in their power generation. The financial incentive is implemented through competitive auctions with 15-year power purchase agreements to ensure investment stability (Majumder-Russell & Lee, 2024). Precisely, the government pays the difference between the agreed price for hydrogen-based electricity (contracted price) and the market price (System Marginal Price) on the Korea Power Exchange (KPX). Electricity generators seeking government support under the scheme must demonstrate that a portion of their electricity is produced from certified clean hydrogen (4kg CO2eq/kg-H2).

Initial pilot auctions began in 2023 to test the bidding framework, culminating in the world's first hydrogen-based power generation auction in May 2024, which offered 6,500 GWh. Although only 750 GWh was awarded, the auction marked a significant step toward market-based clean hydrogen deployment (Sang-won, 2025; Tam, 2023).

In May 2025, the government announced the second CHPS tender providing governmental support for a total 3,000 GWh of electricity, which was subsequently cancelled in mid-October 2025. It remains uncertain in what form the scheme will continue. Although no official explanation was provided, Korean media reports suggested that the decision might be related to potential conflicts with the national coal phase-out strategy, as co-firing ammonia with coal could delay this transition. The government indicated that the scheme would be replaced, though no timeline or details of the revised program were disclosed (Collins, 2025). The following section outlines selected requirements and evaluation criteria from the second tender.

The evaluation procedure allocates 60% weight to price factors and 40% to non-price factors. A key element of the non-price assessment - accounting for 35% of the non-price score - is the hydrogen grade, classified from Grade 1 to Grade 4 under the Clean Hydrogen Certification Scheme (see Definitions and Standards above). As a social sustainability criterion, the evaluation further considers "Resident Acceptance and Project Progress," (Poten & Partners, 2025). According to the 2025 Submission Manual of the Korea Power Exchange (KPX, 2024), resident acceptance is verified through either the results of local consultations or a signed consent form from residents. Project permitting progress is also evaluated, requiring submission of relevant permits (see Table 7). However, it should be noted that all the described requirements only apply to the power generation project in Korea and do not extend to the production of hydrogen.

TABLE 7: SOCIAL SUSTAINABILITY CRITERIA AND PROOF OF COMPLIANCE UNDER THE KOREAN CHPS

Specific Proof Of Compliance	Evaluation Criteria: Resident Acceptance
Official Opinion of Local Governments	• A letter of intent, a formal recommendation for licensing, or a positive opinion from the local municipal government (e.g., city, county, or district) where the project is located is a key evaluation document. Proceeding with a project is virtually impossible without the support of the relevant local authority.
Public Hearings and Information Sessions	• The evaluation considers the extent to which the project developer has held information sessions for local residents and how feedback gathered during these sessions has been incorporated into the project plan.
Resident Consent Rate and Agreements	For some projects, developers may be required to submit objective data showing the consent rate of residents or households within a certain radius of the proposed site. Securing a "coexistence agreement" that outlines benefits for the local community—such as local hiring, development support projects, or profit-sharing models—is highly valued in the evaluation.
Civil Complaints and Resolution Efforts	The number and nature of civil complaints filed during the project's development, along with the developer's demonstrated efforts to resolve these issues, are also taken into account.

Additionally, Korea's Ministry of the Environment is currently exploring the introduction of a carbon pricing support mechanism (Korean carbon contracts for difference, K-CCfd) (Choi, 2024), a policy mechanism already implemented in Europe and other major economies, to facilitate the transition to clean hydrogen and other low-carbon technologies. In 2024, the Ministry of Environment formulated a Korean-style carbon offsetting system, the details of which are outlined in the Fourth Basic Plan for the Emissions Trading System announced in December 2024. Consequently, the Korean government is expected to implement a carbon-offsetting system at the earliest possible date[5]; however, its implementation has been postponed because of the government's change in 2025. Currently, in South Korea, the design of the K-CCfD system has been delayed due to a change in administration, making CHPS the primary government-led policy based on economic incentives related to hydrogen.

In addition to these measures, Korea's public financial institutions, including the Export-Import Bank of Korea (KEXIM), Korea Development Bank, Industrial Bank of Korea, and Korea Credit Guarantee Fund, are implementing policy finance programs for hydrogen through the Climate Response Fund and their own resources. Among these, KEXIM provides financial support in the form of interest rate reductions, expanded loan limits, and preferential credit guarantee fees for various sectors within the hydrogen value chain, hydrogen energy, and fuel cell electric vehicles (FCEVs) from the perspective of ESG investment and advanced strategic industries. For example, KEXIM views hydrogen energy as a crucial green energy source alongside solar and wind energy and considers FCEVs, FCEV infrastructure, and related services as advanced strategic industries, thus offering financial support.

When public institutions provide grants and loans for hydrogen projects, they are tied to specific sustainability requirements beyond GHG emission reduction (KDB, n.d.). Korean public financial institutions implement comprehensive sustainability requirements when providing grants and loans for hydrogen projects. The Korea Development Bank (KDB) applies the Equator Principles, internationally recognized environmental and social risk management standards, categorizing projects into three risk levels based on their environmental and social impacts (ibid.; KDB, 2025). KDB prohibits financing for new coal-fired power plants while supporting transition finance for clean energy projects (KDB, n.d.). The Export-Import Bank of Korea (KEXIM) operates under a sustainable finance framework updated in 2023 to meet global ESG standards (KangaNews, 2024). Both institutions ensure that financed projects contribute to UN Sustainable Development Goals and undergo comprehensive environmental and social due diligence covering climate change mitigation, biodiversity protection, human rights, and community impact assessment (Equator Principles Association, 2017; KDB, n.d., 2025).

Specific Sustainability Requirements

To qualify for the CHPS, the following (sustainability-related) requirements must be fulfilled: Electricity must be generated using a minimum co-firing ratio of 20% derived from clean hydrogen or ammonia (measured in Gross Heating Value). Clean hydrogen or ammonia must comply with the Clean Hydrogen Certification Scheme and maintain an emission intensity below 4kg CO2e per kg of hydrogen (Poten & Partners, 2025). As described above, a social sustainability criterion (Resident Acceptance and Project Progress) is part of the evaluation process to qualify for funding, but only applies power generation projects in Korea and does not extend to hydrogen production. Additionally, hydrogen sourced from abroad is eligible, provided it meets the same GHG emission criteria and certification requirements. For large-scale hydrogen infrastructure or hub projects, compliance with environmental impact assessments under Articles 22–24 of the Environmental Impact Assessment Act, administered by the Ministry of Environment, is additionally required. Projects failing to meet these criteria—particularly those relying solely on gray hydrogen without carbon capture or lacking verified emissions data—are ineligible for clean hydrogen funding programs.

However, in the context of hydrogen imports, South Korea has yet to develop legally binding and comprehensive sustainability criteria governing overseas hydrogen projects in which its entities provide financial support.

Monitoring and Enforcement Mechanisms

The Clean Hydrogen Portfolio Standard (CHPS), introduced by the Ministry of Trade, Industry and Energy (MOTIE) establishes mandatory requirements for the use of low-carbon hydrogen in electricity generation. Only hydrogen certified under the national Clean

[5] The proposed carbon offsetting system, as specified in the Basic Plan for the Emissions Trading System, takes into account Korea's unique carbon emissions landscape. Given the country's high dependence on fossil fuel-based power generation and manufacturing, the system aims to provide effective support beyond existing initiatives such as research and development (R&D) funding and equipment subsidies. Key considerations in designing the system include: Challenges Faced by Domestic Companies; High investment risks due to the limited economic feasibility of emission reduction technologies; The inability of businesses to make preemptive investments in decarbonization measures; Corporate requirements for government support; Expansion of financial support to facilitate corporate investments in R&D and equipment; Simultaneous support for the development and demonstration of breakthrough technologies; Innovations aimed at achieving carbon neutrality beyond current technological limits; Demonstration and industrialization of emerging climate technologies, such as Carbon Capture and Storage (CCS), Carbon Capture and Utilization (CCU), and Direct Air Capture (DAC).

Hydrogen Certification System - verifying a life-cycle carbon intensity below the defined threshold (currently 4 kg CO2-eq/kg H2) - is eligible for participation.

According to the Notice on the Operation of the Clean Hydrogen Certification System (enforced on March 4, 2024), the Ministry of Trade, Industry and Energy (MOTIE) is authorized under Articles 18, 20, and 21 to conduct inspections, impose sanctions and penalties such as improvement orders, and revoke or suspend the use of certificates (MOTIE, 2024). The framework further defines qualification and traceability requirements (Article 12, ibid.) to ensure that only hydrogen produced within defined emission limits qualifies. Emission accounting follows a Well-to-Gate approach, covering greenhouse gas emissions up to the production stage. Emissions from transportation and storage are currently excluded, as are the effects of hydrogen and energy losses during processes as conversion to and from ammonia, which can influence the overall carbon intensity of hydrogen. Certification is conducted through the Korea Energy Economics Institute (KEEI). Operational safety is maintained through the oversight of the KGS under the Gas Business Act (Articles 29–35), which enforces licensing and regular safety inspections of hydrogen infrastructure.

3.4 Sustainability Considerations in Commercial Finance

The activation of climate finance is essential for sustainable development. In this context, concepts such as climate and green finance have been previously utilized. If climate finance can be regarded as an academic concept, the “green taxonomy” represents its institutionalization as a legal concept. Specifically, a green taxonomy provides criteria for determining whether economic activities, investment assets, or project characteristics qualify as climate-aligned, making it highly relevant for private financial actors. In South Korea, this framework is implemented through the K-Taxonomy (Korean Ministry of Environment, 2022; Song, 2023)[6].

In December 2021, the Ministry of Environment in Korea announced the draft of the “K-Taxonomy Guidelines” to prevent greenwashing. K-taxonomy provides clear principles and criteria for eco-friendly economic activities that contribute to achieving six environmental goals, such as greenhouse gas emission reduction, adaptation to climate change, sustainable water conservation, circular economy (recycling), pollution prevention and management, and biodiversity protection. Under the K-taxonomy framework, hydrogen-related activities are primarily classified as contributing to the greenhouse gas reduction objective. Similar to the EU Taxonomy approach, hydrogen activities must demonstrate substantial contribution to at least one of the six environmental objectives while ensuring compliance with the "Do No Significant Harm" principle for the remaining environmental goals (Korean Ministry of Environment, 2022).The K-taxonomy was first enacted in December 2021, defining 69 economic activities, comprising 64 green economic activities and five transitional economic activities. In December 2022, the Ministry of Environment announced a revision that added nuclear power generation activities, resulting in 74 economic activities, comprising 67 green economic activities and seven transitional economic activities (Oh et al., 2024).

Under the K-taxonomy framework, proper green economic activities must satisfy three fundamental criteria: (i) contribute to the achievement of one or more of the six environmental goals (recognition standard), (ii) not cause any serious damage to other environmental goals in the process of achieving the set environmental goal (do no significant harm standard), and (iii) comply with all laws and regulations related to human rights, labor, safety, anti-corruption, and destruction of cultural properties (Oh et al., 2024). It categorizes key areas, such as hydrogen energy production and storage, the establishment and operation of hydrogen transportation infrastructure, and LNG-based blue hydrogen production, as significant elements of green taxonomy (ibid.). However, inclusion in these categories does not automatically qualify activities as "green," as all hydrogen-related activities (in addition to the other requirements described) must satisfy stringent technical screening criteria, including clean hydrogen certification requirements (4 kg CO2 eq/kg-H2) (Korean Ministry of Environment, 2022). K-taxonomy applies to both corporations and financial

---

[6] Existing studies tend to use terms such as climate finance, green finance, low-carbon finance, and sustainable finance interchangeably. According to UNEP (2016), climate finance can be defined as financing aimed at reducing GHG emissions within environmental finance, and it can be divided into mitigation finance and adaptation finance. The former is sometimes referred to as 'low-carbon finance,' which involves financing for the purposes of reducing, avoiding, and storing GHG emissions as well as establishing sinks. On the other hand, adaptation finance refers to financing aimed at building resilience to mitigate the ecological impacts (vulnerability) caused by climate change. Green finance is a broader concept than climate finance, and it refers to financing for not only reducing GHGs but also addressing overall environmental issues such as water management and pollution.

institutions as a voluntary reference guideline to determine whether their economic activities, assets, projects, or activities are suitable for green classification. Although the guidelines are not legally binding, they provide principles and standards for the types of economic activities that are considered green activities (Oh et al., 2024).

K-taxonomy is considered to align with the EU Taxonomy (Jang, 2022; Oh et al., 2024); however, it has several shortcomings compared to its European counterpart. First, the six environmental goals established by the EU are explicitly stated in Article 9 of the Taxonomy Regulation, whereas K-Taxonomy defines them only through guidelines concerning the Ministry of the Environment's responsibilities, which compromises its legal strength. The legal basis for K-Taxonomy was provided by the amended “Environmental Technology and Industry Support Act” enacted in April 2021. Article 10-4 states that “financial institutions should strive to incorporate environmental factors into investment decisions,” referred to as “environmental responsible investment.” This indicates that K-taxonomy lacks the necessary enforcement mechanisms to ensure compliance.

Second, K-taxonomy has limitations in terms of usability. In Korea, only companies issuing green bonds verify their compatibility with green taxonomy, resulting in limited utilization of K-taxonomy among companies (Oh et al., 2024). This limited utilization reflects K-taxonomy's narrow scope as a voluntary guideline primarily targeting green bond issuers and financial institutions, though it also applies to large corporations seeking ESG credentials and listed companies under emerging disclosure pressures. The limited scope affects broader market adoption, as potential users including hydrogen producers, infrastructure developers, and equipment manufacturers lack clear incentives to align with K-taxonomy standards. As of 2022, only six banks and companies have issued K-taxonomy-aligned green bonds worth KRW 640 billion (Korean Ministry of Environment, 2022). For hydrogen companies, K-taxonomy is directly relevant as it includes hydrogen production, storage, and transportation infrastructure in the green sector, with blue hydrogen temporarily included until 2030. Unlike the EU CSRD's mandatory taxonomy alignment disclosure requirements, Korea's K-taxonomy operates as a non-binding guideline without equivalent mandatory disclosure obligations, creating a significant regulatory gap compared to European standards.

Third, climate finance in Korea is primarily centered on public climate finance. Based on the “Framework Act on Carbon Neutrality and Green Growth for Coping with Climate Crisis” enacted in 2021, the Climate Response Fund was established in 2022, with a projected size of 2.62 trillion KRW (approximately USD 1.96 billion) according to the 2025 budget plan. The Climate Response Fund was designed primarily for public institutions and state-owned enterprises with limited direct access to private companies, including private hydrogen producers. Private entities must typically partner with public institutions or utilize indirect financing mechanisms to access these funds (Song, 2023).

The landscape of how private investments apply to sustainability criteria remains fragmented. Private financial institutions in Korea do not systematically follow the K-taxonomy guidelines because of their non-mandatory nature. Instead, so far, major private investors rely on international frameworks such as the Equator Principles and IFC Performance Standards or develop internal ESG frameworks independently (Jang, 2022; Oh et al., 2024).

3.5 International Partnerships

Korea is actively engaged in international partnerships to address these issues and to foster a sustainable hydrogen ecosystem. The country is collaborating with nations such as Australia, the UAE, Japan, and Saudi Arabia on clean hydrogen initiatives and is also participating in global platforms such as the ISO and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). While these collaborations have begun to address sustainability aspects through carbon intensity certification and safety standards, the development of truly comprehensive sustainability criteria remains an ongoing challenge. For instance, the Korea-Japan Hydrogen Cooperation Dialogue established specific working groups on carbon intensity certification and safety standards, with both countries confirming that clean hydrogen cooperation is essential for achieving their respective NDCs. Domestically, the Hydrogen Economy Committee, chaired by the Prime Minister, coordinates policies across ministries with agencies such as the Ministry of Trade, Industry, and Energy, the Ministry of Environment, and the Ministry of Land, Infrastructure, and Transport, which play key roles in implementation.

4 India

4.1 Sustainability Ambitions and Compliance Mechanisms

While India does not have a legal definition for sustainability, it is practiced through environmental laws, biodiversity laws, and the Constitution. For example, the precautionary and polluter-pays principles are used to enforce the sustainability principle. The National Green Tribunal helps promote sustainability concepts through judicial pronouncements. To encourage the general public to practice a sustainable lifestyle, the Prime Minister often invokes ancient literature and scriptures to emphasize the importance of protecting nature and living in harmony with nature. He affirms that “For India, One Earth, One Family, One Future is a commitment.” This commitment is also reflected in national initiatives such as “One Earth, One Health” and “One Sun, One World, One Grid” (DD News, 2024).

During COP 26, 2021, India expressed to intensify its climate action by announcing five key targets, referred to as the Panchamrit (five nectar elements):

1. To achieve 500 GW of non-fossil energy capacity by 2030.
2. To meet 50 percent of its renewable energy requirements by 2030.
3. To reduce its total projected carbon emissions by one billion tonnes by 2030 (compared to 2022).
4. To reduce the carbon intensity of its economy by more than 45 percent by 2030.
5. To achieve the target of net-zero emissions by 2070.

The Prime Minister of India asserted that “these ‘Panchamrits’ will be an unprecedented contribution of India to climate action.” These five points chart a pathway for India to advance toward the decarbonization of domestic industries by reducing the use of fossil fuels, increasing the adoption of renewable or non-fossil energy sources, creating domestic demands for hydrogen, and ultimately achieving the goal of net zero emissions (Ministry of External Affairs, n.d.). Green hydrogen is expected to play a significant role in achieving these targets, as outlined in the following.

Linkage between National Hydrogen Policy and National Climate Policy

India launched its National Green Hydrogen Mission (NGHM) in August 2021 and, following several months of preparatory work, issued a Green Hydrogen/Green Ammonia Policy. The policy aims to achieve the goal of producing 5 million tonnes of green hydrogen by 2030. With this policy, India announced the use of green hydrogen and green ammonia as a future fuel to replace fossil fuels. The production of green hydrogen and ammonia using power from renewable energy is “one of the major requirements towards environmentally sustainable energy security” in India (PIB Delhi, 2022).

Additionally, the NGHM, now situated within the Ministry of New and Renewable Energy (MNRE), aims to position India as the global hub for the production, usage, and export of green hydrogen and its derivatives. This aligns with India’s aim to become Aatmanirbhar (self-reliant) through clean energy and serves as an inspiration for the global clean energy transition. The mission is expected to contribute significantly to the decarbonization of the economy, reduce reliance on fossil fuel imports, and enable India to assume technology and market leadership in green hydrogen (MNRE, 2023a). With the implementation of the NGHM, India is expected to avoid 50 million metric tons (MMT) of CO2 emissions per annum by 2030 (ibid.). By the same year, the production capacity of green hydrogen is targeted to reach at least 5 MMT per annum, respectively 15 GW electrolysis capacity. Green hydrogen is expected to replace “fossil fuel-derived feedstocks in petroleum refining, fertilizer production, and steel manufacturing” (ibid., p. 2). Currently, India consumes a total of 5 MMT of grey hydrogen, which is expected to be substituted by green hydrogen, in turn substantially reducing the country’s carbon footprint.

Compliance Mechanisms

The MNRE is responsible for overseeing the implementation of the NGHM and coordinating with various ministries and public and private stakeholders as a part of the “Whole Government” approach (MNRE, 2023a). A so-called Empowered Group (EG), comprising key government officials under the NGHM, will set a target for replacing fossil fuels with green hydrogen through a step-by-step approach. The MNRE will then develop guidelines and monitoring mechanisms in coordination with the Ministry of Petroleum and Natural Gas, Department of Fertilizers, and other sectoral ministries to ensure progress across various sectors relevant for decarbonisation. The public or corporate sector must submit regular progress reports to a designated monitoring agency. Certain obligations have already been planned. For example, the Shipping Corporation of India, a public sector unit (PSU), must deploy at least two ships to run on green hydrogen or its derivative by 2027. Indian Oil and Gas, another PSU that charters approximately 40 vessels, must charter at least one ship powered by green hydrogen by 2027 and at least one ship per year thereafter (MNRE, 2023a).

The Energy Conservation Act (EC) prescribes legal provisions to enforce consumption targets for green hydrogen, thereby aiding the government in enforcing a minimum share of energy and feedstock consumption from non-fossil fuels. The recent amendment to the Energy Conservation Act introduces key provisions (Articles 14 and 14AA) for that, including the establishment of a carbon credit trading system, mandatory consumption of a minimum share of non-fossil fuels, and the issuance of energy savings certificates. It also allows for the voluntary purchase of carbon credits or energy savings certificates under the carbon trading framework. The Act also provides penalties for violations, where both the user of the vessel and the manufacturer are liable for monetary fines. The fine is calculated based on the consumption of oil and the vehicle unit (ibid.).

The Green Hydrogen Certification Scheme of India (GHCI), issued in 2025, governs the issuance of green hydrogen certification, compliance monitoring, and imposes penalties for violations. The GHCI represents the first legal and policy framework in India that directly addresses the production and use of hydrogen. In a country as large and diverse as India, with multiple states and provincial governments, the establishment of a centralized hydrogen policy is crucial to ensuring coordinated efforts toward achieving the national target of 5 MMT of green hydrogen and 500 GW of non-fossil fuel capacity by 2030. Twelve states of India (Andhra Pradesh, Gujrat, Haryana, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, and West Bengal) have also issued green hydrogen policies in support of realizing the aim of India to achieve Net Zero by 2070 (Pal et al., 2025). These state policies also support investment in green hydrogen projects, and grant several direct and indirect financial supports for those projects. For further details, see the “Role of Sustainability Standards and Certifications” section.

Gaps and Weaknesses in Ensuring Adherence to the Broader Sustainability Criteria

In terms of hydrogen, the GHCI serves as the implementing framework for green hydrogen certification, compliance, and the consequences of violation. It is assumed that any permission granted to establish a hydrogen production facility under the GHCI will be subject to compliance with additional applicable environmental laws and regulations governing construction and industrial activities. As such, the GHCI does not explicitly incorporate broader sustainability criteria; however, adherence to these standards remains essential.

4.2 The Role of Sustainability Standards and Certifications

Definitions and Standards

In 2023, India defined green hydrogen as hydrogen produced from renewable energy sources, either through electrolysis or by the conversion of biomass (MNRE, 2023c). If hydrogen is produced through electrolysis, then to qualify as green hydrogen, “the non-biogenic gas emissions arising from water treatment, electrolysis, gas purification, drying and compression of hydrogen shall not be greater than 2 kg of carbon dioxide equivalent per 1 kg of hydrogen (kg CO2 eq/kg-H2), taken as an average over 12-month period.” The same applies for green hydrogen produced from biomass feedstocks, where “greenhouse gas emissions arising from biomass processing, heat/steam generation, conversion of biomass to hydrogen, gas purification, and drying and compression of hydrogen” must be taken into account. The Indian government further explains that “renewable energy” used for the production of hydrogen may also “include such electricity generated from renewable sources which is stored (“banked”) in an energy storage system, or stored with the grid in accordance with the applicable regulations” (MNRE, 2025). Notably, stakeholders may propose alternative production pathways, which will be assessed by a technical committee for potential future considerations (Point 6.3 of the scheme).

For green hydrogen producers seeking to access government incentives or to market their hydrogen as “green” within India, obtaining a final Certificate under the certification scheme (see below) is mandatory. This requirement also applies in cases where the production facility supplies both domestic and export markets (final certificate for both required). Certification is not required when the entire production is set to be exported. Producers with an annual green hydrogen production capacity of less than 10 tonnes are exempt from the aforementioned certification requirements.

GHG and Sustainability Standards

To specify all these requirements, India issued a draft of the Green Hydrogen Certification Scheme of India (GHCI) in 2024. Following a public consultation period, the GHCI was launched in April 2025 and now serves as the central regulatory framework for hydrogen, covering all aspects of its production, including processes such as compression and purification, within a well-to-gate system boundary (MNRE, 2025). The overall purpose of the Green Hydrogen Certification scheme is to establish a ‘Guarantee of Origin’ (GO) system, ensuring transparency and authenticity of the production process of green hydrogen. The issued certificate will generally contain ‘a unique identification for each 100 kg of hydrogen produced, specifying project details, production year, and emission intensity values’ (MNRE, 2025). This certificate is both non-transferable and non-tradable, and cannot be used to claim emission-reduction credits (ibid.). However, this certificate can be used to demonstrate the replacement of fossil fuels with green hydrogen, such as in the steel industry.

Enforcement and Compliance Mechanisms

According to the GHCI, two types of certificates may be issued: a provisional and a final certificate. The provisional certificate is voluntary and automatically generated when a green hydrogen producer applies through a Green Hydrogen Portal. The provisional certificate will only “report” that the hydrogen produced during a specified period is “green.” It is to be noted that the product’s overall carbon footprint will not be mentioned on the provisional certificate. However, if a claim is being made that the green hydrogen shall be labelled as such and produced in India, such a final certificate is mandatory. Accordingly, the final certificate confirms two key aspects: (1) the hydrogen qualifies as green, and (2) it is produced within India. If an applicant wishes to claim the use of renewable energy for the production of green hydrogen, carbon credits or renewable energy certificates[7] will not be considered as valid proof for the GHCI. However, electricity may be counted as fully renewable if Power Purchasing Agreements with RE producers have been concluded. If electricity from sources other than renewable energy is used for electrolysis in hydrogen production, the associated GHG emissions will be included in the total GHG emission intensity boundary (MNRE, 2025). The final certificate also indicates that, according to the definition of green hydrogen, renewable energy sources and the CO2 emissions were within the approved limit of 2 kg equivalent.

Compliance with the requirements is verified through an annual audit conducted by Accredited Carbon Verifiers, who are accredited by the Bureau of Energy Efficiency (Byrtus, 2025). The MNRE reserves the right to conduct additional random audits. As part of the monitoring process, a green hydrogen producer must prepare a comprehensive plan for GHG emission quantification and monitoring. All data from the production to the consumption of green hydrogen must be maintained by the producer. For transparency, green hydrogen producers should maintain data on the final use of hydrogen produced, sold, or even converted into hydrogen carriers for further use or transportation purposes. The GHCI initially proposed imposing substantial monetary penalties for violations of its requirements; however, these were removed in the final certification documentation. Instead, other measures for enforcing compliance with the certification scheme have been introduced. For a first violation, a green hydrogen producer’s certificate may be withdrawn. If a second violation occurs within three years of the first, the producer will be ineligible to apply for the certificate in the next cycle. In the event of a third violation, the producer may be barred from applying for the certificate for a specified period, and additional measures may be implemented through a future executive order (MNRE, 2025; section 15.3). While monetary penalties have been removed for the time being, their initial inclusion underscores the government’s commitment to strictly enforce the conditions of the green hydrogen certificate.

---

[7] Renewable Energy Certificates are tradable instruments issued to renewable energy generators for each 1 MWh of electricity delivered to the grid. They represent the environmental attribute of renewable power, independent of its physical consumption, and provide verifiable proof that renewable energy has been produced. Unlike Power Purchase Agreements, which are contracts for the actual supply of renewable electricity, RECs convey only the attribute, not the power itself.

Broader Sustainability Aspects

In India, current hydrogen-related rules, regulations, and policies primarily focus on greenhouse gas emissions and do not comprehensively address broader sustainability considerations. For example, the possession of a certificate under the GHCI does not constitute statutory clearance for the establishment of a green hydrogen plant. However, indirect references to such aspects can be observed within other existing frameworks.

For establishing a green hydrogen plant, obtaining other statutory approvals—such as environmental clearances—is mandatory, as the green hydrogen certificate alone is insufficient. As a part of environmental impact assessment, socio-economic impact on local community and health risk assessment of the surrounding population are important factors to consider (HECS, 2025). Compliance with applicable environmental regulations remains essential, reflecting the government's effort to incorporate sustainability considerations through environmental law. For instance, financial institutions assessing green hydrogen project loans require evidence of water procurement certificates and operational clearances from state pollution control boards.

While these requirements address certain sustainability elements, broader aspects—such as social impacts on local communities—have yet to be considered comprehensively.

4.3 Integration of Sustainability Criteria in Public Funding Schemes

Sustainability Criteria in Public Funding Programs

According to the NGHM, two types of public (government) funding schemes have been launched under the Strategic Interventions for Green Hydrogen Transition (SIGHT). The first category supports the domestic production of electrolyzers, while the second (which will be focused on in the following) provides incentives to support the production of green hydrogen. The incentive-based funding targets early-stage innovators and provides risk-free incentives to early movers in the sector. The initial budget for green hydrogen production is allocated at 13,050 crore (~$1.47 billion USD) (MNRE, 2023b). Funds are disbursed through a transparent bidding process. The MNRE delegated the implementation of this funding scheme to the Solar Energy Corporation of India (SECI; ibid.). This funding scheme prescribes conditions and eligibility for bidders. Accordingly, compliance with the National Green Hydrogen Standard and thus the above-mentioned GHG emission threshold (no more than 2 kg CO_2e per kg H_2) is required (MNRE, 2023b, section 5.2). The Green Hydrogen Certification Scheme of India (GHCI, see Chapter 4.2) will serve as the mechanism for demonstrating compliance (MNRE, 2023b; section 5.2; MNRE 2025; section 14.6.1). Besides that, both funding schemes do not include any broader sustainability requirements for eligibility or winning of bids. However, the scheme requires obtaining clearances and approvals from relevant Government departments and local bodies, including those related to environmental matters, along with the submission of quarterly progress reports on project development (SECI, 2023).

At present, India has not introduced any tax policy specifically targeted at hydrogen projects. However, the NGHM has ensured that some incentives could be provided for the power purchase agreement to use energy from renewable sources and the inter-state transmission of such energy (electricity). Some stakeholders have suggested some measures akin to US hydrogen tax credits, and a reduction in the Goods and Services Tax and import duties. However, the official notifications have not yet been issued on these fronts (Pal et al., 2025). Currently, the government's focus is to support the green hydrogen industry and production by providing subsidies rather than generating revenue from this industry and business. Financing from Indian development finance institutions has not yet been widely adopted; however, India has attracted significant attention and support from international institutions such as the World Bank and the European Investment Bank (EIB).

Generally, as of mid-October 2025, two companies manufacture electrolyzers, while four projects are under construction or expansion. Sixteen additional projects have been announced so far. Concurrently, fourteen green hydrogen production projects have been approved and commissioned, while there is one demonstration project and four projects currently under construction. An additional 137 projects have been announced or are in the planning phase, according to the Project Database of the Government of India (MNRE, n.d.).

Monitoring and Enforcement Mechanisms

According to the GHCI, the SMC was established to oversee all projects related to green hydrogen, including the Green Hydrogen Certification Scheme. This monitoring committee is led under the chairmanship of the Secretary from MNRE, and comprises representatives from the MNRE, MOP, MoPNG, and experts from other organizations, as may be required for this purpose. The SCM is required to periodically review the implementation status of the scheme. The committee will further facilitate and recommend measures to resolve difficulties observed during the implementation of the scheme. As the scheme is still in its early stages, further insights into the committee's functioning and its impact on implementation will emerge over time.

4.4 Sustainability Considerations in Commercial Finance

Similar to the Government of India, its related ministries, and other stakeholders, private financial institutions—including commercial and investment banks—are increasingly adopting policies to promote the sustainability of hydrogen. In the following section, however, the focus will be on the approaches of two major public sector banks. These institutions are particularly influential in setting benchmarks for the sector, not only because of their policy alignment but also due to their scale and market presence.

The State Bank of India (SBI), one of India's largest commercial banks (publicly owned by the Government of India), adopts an Environmental, Social, and Governance (ESG) framework for its financial activities (SBI, 2023). Although the bank does not have a hydrogen-specific loan scheme, it contributes to the Sustainable Development Goals by financing initiatives under its broader ESG framework, including support for sectors such as biofuel projects, green car loans, solar photovoltaic pump sets, and grid-connected rooftop PV projects. While granting loans, the SBI evaluates its borrowers based on the ESG criteria as a mandatory part of the loan approval process. Eligible renewable energy projects include solar power on the ground or roof connected to a grid, hydro energy, wind energy, waste-to-energy projects with direct emissions below 100 g CO2 eq/kWh, and bioenergy for electricity generation, with life-cycle emissions of less than 100 g CO2 eq/kWh). Clean transportation projects support vehicles running on hydrogen or EV (SBI, 2023). The SBI monitors projects throughout the loan lifecycle. If a project fails to meet the ESG criteria or a fund is divested into another area, the project is removed from the designated category, and the remaining available funds may be allocated to other eligible projects. Each project must demonstrate its impact—for example, by showing annual GHG emissions are reduced or avoided (tCO2 eq p.a.), the annual generation of renewable energy, and the capacity of renewable energy plants constructed (SBI, 2023). As of the writing of this paper, no hydrogen-specific criteria within SBI were identified.

4.5 International Partnerships

Since the inception of the NGHM, India has been active at the domestic and international levels to showcase its prowess and learn from the experiences of other countries. The NGHM has coordinated with the Ministry of Foreign Affairs to forge partnerships with international organizations and foreign countries with similar interests. India selected Germany as its first partner for growth in the green hydrogen sector. This message was unequivocally stated by the Prime Minister of India and the German Chancellor in their joint statements. The motto of this friendship and cooperation is “Growing Together with Innovation, Mobility, and Sustainability,” and with a particular focus on “climate action and sustainable development,” which will be the driving force of this cooperation among other things (PIB Delhi, 2024). For example, India set up the Indo-German Green Hydrogen Task Force, supported by the Indo-German Energy Forum, to develop an Indo-German Green Hydrogen Roadmap, released in October 2024 (MNRE & The Federal Government of Germany, 2024). The roadmap includes cooperation on sharing knowledge and experiences in regulations, standards, and safety procedures, as well as sustainability criteria and certification schemes for green hydrogen and for green hydrogen among other things (Indo-German GHR, 2024). The SECI and H2Global Stiftung signed an MOU to promote green hydrogen initiatives (SECI-H2, 2024). This MOU will provide India with market-based insights to position itself as a green hydrogen exporter by working together to design joint-tender concepts. India also organized the International Conference on Green Hydrogen in 2023 and 2024, bringing together global stakeholders to exchange knowledge, innovations, and advancements (MNRE, 2024). At the World Hydrogen Summit 2024, the NGHM established the largest pavilion to showcase India's mission towards green hydrogen. India celebrates World Hydrogen and Fuel Cell Day (October 8) to promote the boundless possibilities of hydrogen as a source of green and sustainable energy by organizing an event that brings together experts from academia, industry, and government on the eve of the day. India takes pride in having spearheaded the establishment of the International Solar Alliance, a global alliance comprising 105 countries.

India has adopted a comprehensive approach towards realizing the goal of the Green Hydrogen Mission. Significant progress has been made in this regard in the short term. The true test will lie in the successful implementation of the approved projects and their ability to meet the long-term goals. However, the cost of producing green hydrogen remains high, making it currently unaffordable for India's industrial sectors. Therefore, as technology advances, the Indian government must actively pursue strategies to reduce costs, making this new energy source accessible and affordable for the broader population.

5 Comparative Analysis: Sustainability in Hydrogen Governance in Japan, South Korea and India

This section provides a comparative analysis of hydrogen governance in India, South Korea, and Japan, reviewing similarities and differences and highlighting key strengths as well as gaps in the governance frameworks.

5.1 Synthesis of Country Analyses

Japan

Japan's approach to hydrogen sustainability is characterized by a comprehensive, long-term vision that emphasizes both domestic production, imports, and international collaboration. The country's hydrogen strategy is driven by the aim of reducing its reliance on fossil fuels, enhancing its energy security, and becoming a global leader in hydrogen technology. Among other things, hydrogen and ammonia co-firing with fossil fuels is being targeted as a transitional approach to reducing GHG emissions in the domestic power sector.

Policy Drivers: Energy security, industrial competitiveness, decarbonization, and international leadership are the primary drivers of Japan's hydrogen strategy.

Specific Hydrogen Targets and Focus: Japan was the first country to publish a national hydrogen strategy (2017). Current supply targets for low-carbon hydrogen are 3 Mt/year by 2030, 12 Mt/year by 2040, and 20 Mt/year by 2050. The Hydrogen Society Promotion Act (May 2024) provides an integrated legal framework to advance low-carbon hydrogen and its derivatives. Japan's approach combines domestic efforts with an emphasis on hydrogen and derivative imports. Recognizing its limited domestic renewable energy capacity, Japan emphasizes the importance of securing a reliable supply of hydrogen from overseas. This necessitates the development of robust international supply chains and the implementation of effective monitoring and verification mechanisms.

Sustainability Standard and Certification: While Japan lacks a formal certification scheme, the government has defined carbon intensity thresholds for low-carbon hydrogen and various derivatives - e.g., at 3.4 kg CO2eq/kg H2 for hydrogen and for at 0.87 kg CO2eq/kg NH2 for ammonia (well-to-gate, pathway-neutral).

Sustainability in Public Funding Schemes: The government provides significant support for low-carbon hydrogen through a Contract-for-Difference program (covering domestic and overseas projects) and hydrogen hub development schemes. Funding is conditional on an emissions intensity below 3.4 kg CO2eq/kg H2. Apart from domestic environmental legislation, the scheme also cites a number of additional, mostly voluntary, criteria, such as the encouragement of local economic benefits. The criteria are applicable to domestic and overseas projects. Additionally, Japanese development finance institutions, such as the Japan Bank for International Cooperation (JBIC), apply internationally aligned environmental and social policies when providing financial support for hydrogen projects. While these policies address broader sustainability considerations, specific guidelines for hydrogen are not in place.

Sustainability in Commercial Finance: There are no hydrogen-specific approaches to incorporate sustainability considerations in commercial financing so far. Nonetheless, commercial banks in Japan are increasingly adopting ESG frameworks in their due diligence, though many details of these approaches are not publicly available.

Domestic Environmental Regulation: The Japanese Environmental Impact Assessment (EIA) Act governs the management and mitigation of environmental impacts. While it does not include hydrogen-specific guidance, it remains relevant for domestic hydrogen projects.

Synthesis: The central eligibility for receiving public funding is a greenhouse gas (GHG) emission threshold of 3.4 kgCO2eq/kg H2. The scheme applies a well-to-gate boundary and is technology-neutral, meaning it does not prescribe specific production pathways. Consequently, certain emissions - such as emissions from transport, storage, and conversion or reconversion processes, as well as hydrogen and energy losses along these stages - are not considered. The exclusion of these factors may lead to an underestimation of the actual carbon intensity. This means that the climate benefits of hydrogen use are subject to an important degree of uncertainty For instance, Japan plans to use ammonia for co-firing in fossil fuel power plants to generate electricity. When using imported ammonia, the net climate impact of such applications requires careful assessment. Broader sustainability considerations are indirectly addressed through national environmental legislation. For imported hydrogen, the government does not impose additional environmental or social criteria.

South Korea

South Korea's approach to hydrogen sustainability is characterized by a strong emphasis on technological innovation and quantifiable metrics. The country's hydrogen strategy is driven by the goal to become a global leader in hydrogen technology and to reduce its reliance on fossil fuels.

Policy Drivers: Industrial competitiveness, energy security, and decarbonization are the primary drivers of South Korea's hydrogen strategy.

Specific Hydrogen Targets and Focus: South Korea's First Basic Plan for the Hydrogen Economy (2021) sets clean hydrogen consumption targets of 3.9 Mt by 2030 and 27.9 Mt by 2050. In 2050, the government expects that ~80% of hydrogen will be imported. It places a strong focus on usage in industries and for fuel cell electric vehicles.

Sustainability Standard and Certification: South Korea implements carbon-intensity thresholds across four grades, with a maximum emission limit of 4kg CO2 per kg of hydrogen, based on a well-to-gate assessment. The scheme focuses on GHG emissions, without prescribing production technologies or addressing wider environmental and social criteria.

Sustainability in Public Funding Schemes: Substantial government support has been planned to be disbursed through contracts-for-difference style auctions under the Clean Hydrogen Portfolio Standard (CHPS). Under the scheme, funding has been allocated for electricity co-generated from hydrogen or ammonia certified under the Clean Hydrogen Certification System. Project evaluation includes price- (60%) and non-price criteria (40%), including the emission intensity of the hydrogen supplied (graded from levels 1 to 4 under the certification system). The non-price criteria also include resident acceptance and project progress as indicators of social sustainability. The total supported capacity of the program was capped at 3,000 GWh. It should be noted, however, that the second round of tenders was cancelled in October 2025 without specifics on how the program will proceed going forward. Additional public funding instruments - offered by the Export-Import Bank of Korea, Korea Development Bank, Industrial Bank of Korea, and the Korea Credit Guarantee Fund - are linked to internationally recognized sustainability frameworks, such as the Equator Principles. However, dedicated financing for hydrogen projects remains limited.

Sustainability in Commercial Finance: South Korea has developed a national sustainable finance taxonomy (K-Taxonomy), partly modelled on the EU framework, with dedicated provisions for hydrogen. Eligible hydrogen must meet certification criteria, follow the "Do No Significant Harm" principle across environmental objectives, and comply with human rights, labor, and safety standards. While comprehensive, the K-Taxonomy remains largely voluntary.

Domestic Environmental Regulation: Like many other countries, South Korea has environmental impact assessment (EIA) legislation in place. While the legislation does not provide hydrogen-specific guidance, it remains relevant for domestic hydrogen projects, particularly for large-scale projects supported under the Clean Hydrogen Portfolio Standard (CHPS), which are required to conduct an EIA.

Synthesis: South Korea's strategy relies heavily on imported hydrogen, and the government provides financial support for its use in electricity generation. This support requires certification under the Clean Hydrogen Certification System. However, the certification excludes certain emissions, such as those from transport, storage, and conversion or reconversion processes, as well as hydrogen and energy losses along the supply chain. As a result, the actual climate benefits of these imports are subject to a degree of uncertainty. Additionally, it should be noted that the broader objectives of the government under this scheme, such as accelerating the development of the hydrogen economy in Korea, particularly on the demand side, and promoting industry and fuel cell adoption toward a partial transition to a hydrogen-based economy, are also important. Apart from the resident acceptance criterium applied to power generation projects in Korea's public funding scheme (CHPS) - which applies only to electricity production using hydrogen or ammonia and is not specific to the hydrogen value chain - broader sustainability considerations currently do not play a role. For domestic projects, environmental impacts are addressed through national environmental regulation.

India

India's approach to hydrogen sustainability combines existing national environmental regulations with newly developed, hydrogen-specific governance measures. The government builds on established laws governing air and water quality while introducing targeted regulations to address the unique challenges and opportunities of hydrogen. This flexible framework aims to support rapid implementation while reducing bureaucratic hurdles.

Policy Drivers: National climate targets (Net Zero by 2070), the need for energy security, and the desire to foster economic growth are the primary drivers of India's hydrogen strategy.

Specific Hydrogen Targets and Focus: The National Green Hydrogen Mission, launched in 2021, sets a target of producing 5 million tonnes of green hydrogen (based on electrolysis with renewable energy or biomass) annually by 2030, supported by an electrolysis capacity of 15 GW. The strategy emphasizes domestic production with the ambition to also develop export capabilities.

Sustainability Standard and Certification: India's Green Hydrogen Certification Scheme (GHCS) forms a core element of the national hydrogen policy. It defines green hydrogen as electrolytic hydrogen produced from renewable or biomass-based sources (12-month average) with a well-to-gate emission intensity 2 kg CO_2 eq/kg H_2. Certification is mandatory for hydrogen labelled as green, including when only part of a facility's output is intended for export. A certificate is not required only if all production is exported as green hydrogen. While the scheme establishes clear metrics for greenhouse gas emissions and an ambitious benchmark, it does not address broader environmental or social sustainability criteria.

Sustainability in Public Funding Schemes: The government has launched substantial funding programs linked to GHCI compliance. These incentives target both green hydrogen production (based on electrolysis and biomass) and electrolyser manufacturing. The integration of wider sustainability considerations into funding schemes remains limited.

Sustainability in Commercial Finance: The State Bank of India (SBI), one of India's largest commercial banks (publicly owned by the Government of India), adopts an Environmental, Social, and Governance (ESG) framework for its financial activities. Although the bank does not have a hydrogen-specific loan scheme, it contributes to the Sustainable Development Goals by financing initiatives under its broader ESG framework. The role of ESG frameworks in Indian commercial banks more broadly are not discussed in the report.

Domestic Environmental Regulation: Like other infrastructure development projects, hydrogen projects require environmental clearances in accordance with national legislation, which may include the conduct of an Environmental Impact Assessment (EIA).

Synthesis: India places an explicit emphasis on green hydrogen from electrolysis and biomass, which is supposed to replace fossil fuels in petroleum refining, fertilizer and steel production. Its GHCI has been developed to ensure compliance with a stringent GHG emission threshold, while guaranteeing the origin of the hydrogen. Despite challenges related to land availability and water scarcity, these are not explicitly addressed in the government's hydrogen policy. Given its focus on domestic hydrogen production rather than imports, all government-supported hydrogen projects are subject to domestic environmental legislation, which addresses, among other matters, water-related issues. Overall, the country's renewable energy potential and its commitment to developing a green hydrogen sector provide important opportunities for decarbonization and local value creation.

5.2 Comparative Analysis and Conclusions

Table 8 below provides a comparative overview of the study's results for the three countries. They have all developed hydrogen strategies reflecting national priorities, demonstrating progress in governance, target-setting, and market development. Across all three countries, energy security and decarbonization are central drivers of hydrogen development, with India emphasizing economic growth, South Korea industrial competitiveness, and Japan international leadership. Ambitious hydrogen targets are in place in each country:

- India aims to produce 5million tons of green hydrogen annually by 2030, primarily from renewable-based electrolysis;
- South Korea targets annual clean hydrogen consumption of 3.9 million tons by 2030 and 27.9 million tons by 2050;
- Japan plans to develop a total low-carbon hydrogen supply from 3 million tons in 2030 to 20 million tons by 2050.

All three nations prioritize carbon intensity as the primary metric for assessing hydrogen sustainability. Their approaches, however, differ significantly. India emphasizes green hydrogen, from renewable electricity and biomass, and has established an ambitious, internationally benchmarked GHG emissions threshold, surpassing that of the European Union in stringency. In Japan and South Korea, where imports are supposed to play a major role, the climate benefits of hydrogen are subject to a degree of uncertainty. Emissions from transport, storage, and (re-) conversion, as well as the impact of hydrogen or energy losses throughout the value chain, are not accounted for. Furthermore, unlike the EU's regulatory framework, end-users are not required to demonstrate the GHG savings compared to the existing fossil fuel alternative.

Certification and standards frameworks differ across countries. South Korea employs a technology-neutral system based on multiple carbon intensity thresholds, while Japan designates a single threshold. India, by contrast, restricts eligibility to electrolytic (using renewable energy) and biomass-based hydrogen and applies a stringent GHG limit of 2 kg CO2 eq/kg H2 under the Green Hydrogen Certification Scheme of India (GHCI) - representing an internationally ambitious benchmark. Public funding is tied to compliance with these thresholds in all countries.

South Korea's funding scheme stands out due to the inclusion of resident acceptance as a criterion to determine eligibility. Notably, the programme is intended to support electricity generation using hydrogen or ammonia, rather than hydrogen production directly. Hence, the resident acceptance requirement applies to power generation in Korea and does not extend to hydrogen production. Note that in mid-October 2025, the government suspended the second tender, leaving the program's future and any new tender's details uncertain. Japan's hydrogen government funding does not impose any additional sustainability requirements beyond those already applicable in the jurisdictions where the projects are implemented.

In the realm of financing, South Korea leads with its comprehensive K-Taxonomy, which provides guidance for private sector investment, albeit on a largely voluntary basis. In comparison, India and Japan currently maintain more nascent frameworks. Development banks also support hydrogen projects in the Asia-Pacific, notably those in South Korea and Japan. The Korea Development Bank (KDB) applies the Equator Principles, categorizing projects by environmental and social risk, prohibits financing new coal power plants, and provides transition finance for clean energy. Similarly, the Export-Import Bank of Korea (KEXIM) follows a sustainable finance framework aligned with global ESG standards. Similarly, Japan's international development bank, the Japan Bank for International Cooperation (JBIC), employs a comprehensive, internationally aligned due diligence framework before, during, and after financing the projects it supports.

Overall, broader sustainability considerations - including biodiversity, water resource management, land use, social impacts, and local value creation - are not embedded in hydrogen-specific guidelines or requirements. Economic and technological objectives are actively pursued, yet the integration of comprehensive sustainability criteria continues to present a significant challenge. Domestically, these dimensions may be addressed by existing environmental legislation as well as policies aimed at promoting socio-economic development and economic growth. Given their strong focus on imports, hydrogen governance in

Japan and South Korea exhibits an important gap when it comes to the consideration of sustainability in projects promoted overseas, where such environmental and social safeguards may not be in place.

TABLE 8: COMPARATIVE ANALYSIS OF SUSTAINABILITY GOVERNANCE APPROACHES IN JAPAN, SOUTH KOREA, AND INDIA

Aspect	Japan	South Korea	India
Policy Drivers	Energy security, industrial competitiveness, decarbonization, and international leadership	Energy security, industrial competitiveness, and decarbonization	National climate targets, energy security, and economic growth
Specific Hydrogen Targets and Focus	3 Mt/year by 2030; 12 Mt/year by 2040; 20 Mt/year by 2050. Low-carbon hydrogen domestically produced and imported.	3.9 Mt/year by 2030; 27.9 Mt/year by 2050 (clean hydrogen) with ~80 % imports	5 Mt green hydrogen/year by 2030; 15 GW electrolysis; domestic use and export
Sustainability Standard and Certification	No formal certification scheme in place; low-carbon hydrogen defined by thresholds (3.4 kg CO_2eq/kg H_2, 0.87 kg CO_2eq/kg NH_3), well-to-gate, pathway-neutral, compliance with thresholds required to access government funding.	Clean Hydrogen Certification System – 4 grades (Grade 1: 0–0.10, Grade 2: 0.11–1.00, Grade 3: 1.01–2.00, Grade 4: 2.01–4.00 kg CO_2e/kg-H_2); well-to-gate, pathway neutral; certificate required to access government funding.	Green Hydrogen Certification Scheme of India (GHCI): 2 kg CO_2eq/kg, well-to-gate; requires renewables-based electrolysis or biomass-based pathway; certificate required to access government funding.
Sustainability in Public Funding Schemes	Contracts-for-difference and H2 hub programs for H2 production; mandatory intensity cap (≤3.4 kg CO_2eq/kg H_2), some voluntary local benefits. No additional sustainability requirements, beyond those of the host country, are imposed when public funding supports overseas projects.	Contracts-for-difference for electricity co-generated through clean hydrogen/ammonia (CHPS)*; funding conditional on hydrogen certification compliance. Resident Acceptance is a criterion assessed for the power generation projects during the evaluation procedure.	National funding schemes (SIGHT-Programme) linked to India's definition of 'green hydrogen' and to the national certification scheme (GHCI).
Sustainability in Commercial Finance	Japanese development banks adopt rigorous due diligence procedures aligned with international standards.	K-Taxonomy with hydrogen provisions; comprehensive but largely voluntary; Equator Principles adopted by the Korea Development Bank	Limited information available regarding commercial hydrogen finance and sustainability provisions.
Domestic Environmental Regulation	National environmental regulation relevant for domestic hydrogen projects, without providing hydrogen-specific provisions.	National environmental regulation relevant for domestic hydrogen projects, without providing hydrogen-specific provisions. Large-scale projects are required to conduct an EIA.	National environmental regulation relevant for domestic hydrogen projects, without providing hydrogen-specific provisions.

*In mid-October 2025, the government announced the suspension of the second tender. It remains uncertain whether the program will continue and which characteristics a potential new tender may have.

Literature

Agency of Natural Resources and Energy. (2025, February). The 7th Strategic Energy Plan—Outline. https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/7th_outline.pdf

Barman, P., Kalita, A., Sarmah, P., Bhattarai, S., Bordoloi, S., & Khalid, F. (2025). Governance strategies, policy measures, and regulatory framework for hydrogen energy in India: A comprehensive review. International Journal of Hydrogen Energy, 140, 505–518. https://doi.org/10.1016/j.ijhydene.2025.05.373

Byrtus, S. (2025). Bridging India's Green Hydrogen Certification to EU RFNBO. GHCI & RFNBO – Synergies & Differences and Why they matter. GIZ GmbH. https://energyforum.in/fileadmin/india/media_elements/publications/GH2/GH2_Certification_to_EU_RFNBO.pdf

Cabinet Secretariat. (2023). The Basic Policy for the Realization of GX - A roadmap for the next 10 years -. https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/pdf/kihon_en.pdf

Cho, A., Kim, H., & Park, S. (2024). Resurgence of the hydrogen energy in South Korea's government strategies from 2005 to 2019. International Journal of Hydrogen Energy, 65, 844–854. https://doi.org/10.1016/j.ijhydene.2024.04.049

Choi, D. (2024, February 26). Will a Korean-style carbon-trade system be introduced? The Ministry of Environment begins developing the system. ETNews. https://www.etnews.com/20240225000067

Collins, L. (2025, October 17). South Korea abruptly cancels controversial clean hydrogen power generation tender announced five months ago. Hydrogeninsight.Com. https://www.hydrogeninsight.com/power/south-korea-abruptly-cancels-controversial-clean-hydrogen-power-generation-tender-announced-five-months-ago/2-1-1887750

DD News. (2024, September 23). For India, One Earth, One Family and One Future is a commitment: PM Modi at UN's Summit of The Future. https://ddnews.gov.in/en/for-india-one-earth-one-family-and-one-future-is-a-commitment-pm-modi-at-uns-summit-of-the-future/

Equator Principles Association, E. P. (2017, January 2). Korea Development Bank: The First Korean Bank to Adopt the Equator Principles. Equator Principles. https://equator-principles.com/kdb-adopts-the-equator-principles/

Gogger, L. (2025, May 22). South Korea enhances Safety Standards for Hydrogen Refueling Facilities. MPR Korea Certification. https://www.korea-certification.com/?p=24559

Government of Japan. (n.d.-a). Act on Rationalizing Energy Use. Japanese Law Translation. Retrieved 21 October 2025, from https://www.japaneselawtranslation.go.jp/en/laws/view/3959

Government of Japan. (n.d.-b). Environmental Impact Assessment Act—Act No. 81 of June 13, 1997. Japanese Law Translation. Retrieved 21 October 2025, from https://www.japaneselawtranslation.go.jp/en/laws/view/3375

Government of Korea. (2021, November 26). Prime Minister Kim Boo-kyum presents blueprint for major shift to clean hydrogen economy, including “First Basic Plan for Hydrogen Economy Implementation”. https://www.korea.kr/briefing/pressReleaseView.do?newsId=156482955

HECS. (2025, June 6). Environmental Impact Assessment (EIA) in India. Complete Step-by-Step Guide for Project Developers 2025. HECS – Hubert Enviro Care Systems. https://hecs.in/environmental-impact-assessment-eia-india-guide-2025

IEA. (2024). Global Hydrogen Review 2024. International Energy Agency.

IRENA. (2022). Geopolitics of the Energy Transformation. The Hydrogen Factor. International Renewable Energy Agency.

Jang, C. (2022). Trends and Implications of the EU’s Sustainable Finance Policy. KDB Future Strategy Research Institute. https://eiec.kdi.re.kr/policy/domesticView.do?ac=0000166923

JBIC. (n.d.). JBIC Guidelines for Confirmation of Environmental and Social Considerations. Retrieved 16 October 2025, from https://www.jbic.go.jp/en/business-areas/environment/confirm.html

JBIC. (2022, May). JAPAN BANK FOR INTERNATIONAL COOPERATION GUIDELINES FOR CONFIRMATION OF ENVIRONMENTAL AND SOCIAL CONSIDERATIONS. https://www.jbic.go.jp/en/business-areas/environment/image/Environemtal_Guidelines_2022.pdf

JBIC. (2025, July 1). Loan for Low-Carbon Ammonia Production and Sales Business in United States. https://www.jbic.go.jp/en/information/press/press-2025/press_00043.html?utm_source=chatgpt.com

KangaNews. (2024, July 15). The Export-Import Bank of Korea. https://www.kanganews.com/news/19445-export-import-bank-of-korea-2024

KDB. (n.d.). Sustainability | Investor Relations. Retrieved 21 October 2025, from https://www.kdb.co.kr/CHGLIR05N00.act?_mnuId=IHIHEN0028&JEX_LANG=EN

KDB. (2025). KDB Sustainable Finance Framework. Korea Development Bank. https://www.kdb.co.kr/wcmscontents/pdf/KDB_Sustainable_Financing_Framework_2025.pdf

KEEI. (2023a, December 19). Current Status and Outlook of the Domestic and International Clean Hydrogen Market. Energy Comprehensive: Korea Energy Statistics Information System - Korea Energy Economics Institute (KEEI). https://kesis.keei.re.kr/board.es?mid=a10306000000&bid=0060&act=view&list_no=1988&tag=&nPage=1

KEEI. (2023b, December 28). The Ministry of Trade, Industry and Energy has designated the Korea Energy Economics Institute as the clean hydrogen certification operator. Contributions and References. https://www.keei.re.kr/board.es?mid=a10202030000&bid=0009&list_no=60346&act=view

KEEI. (2025, April). Operational Rules for the Clean Hydrogen Certification Operating Agency. Korea Energy Economics Institute. https://www.keei.re.kr/boardDownload.es?bid=0024&list_no=124736&seq=1

Korean Ministry of Environment. (2022). Korean Green Taxonomy Guidelines. Government of the Republic of Korea. https://gmi.go.kr/js/pdfjs/web/viewer.html?file=/upload/format/K-Taxonomy%20Guidelines.pdf

KPX. (2024, May 24). Korea Power Exchange Announcement No. 2024-02: Clean Hydrogen Power Generation Market Competitive Bidding. https://www.kpx.or.kr/board.es?mid=a11201000000&bid=0042&act=view&list_no=72611&tag=&nPage=1

Lee, Y., Cho, M. H., Lee, M. C., & Kim, Y. J. (2024). Policy agenda toward a hydrogen economy: Institutional and technological perspectives. International Journal of Hydrogen Energy, 54, 1521–1531. https://doi.org/10.1016/j.ijhydene.2023.12.129

Lee, Y., Kim, M. J., & Pak, S. B. (2024). Technical and Institutional Policy Goals of the FCEV Industry: Comparing Perceptions of Policy Experts in South Korea and Japan. Journal of Japanese Criticism, 30, 298–327. https://doi.org/10.29154/ILBI.2024.30.298

Lee, Y., Kim, Y. J., & Lee, M. C. (2025). Navigating stakeholder perspectives on hydrogen generation technologies: A Q-methodology study of current hydrogen production policy in South Korea. International Journal of Hydrogen Energy, 113, 777–786. https://doi.org/10.1016/j.ijhydene.2025.02.431

Lee, Y., & Pak, S. B. (2025). Advancing Global Cooperation toward the Hydrogen Economy: A Case Study of Japan–Korea Cooperation. Pacific Focus, 40(1), 100–124. https://doi.org/10.1111/pafo.12270

Majumder-Russell, D., & Lee, S. (2024, November 21). Hydrogen law, regulations & strategy in South Korea. CMS. Tax - Law - Future. https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/south-korea

METI. (2021, October). Strategic Energy Plan. Ministry of Economy, Trade and Industry. Government of Japan. https://www.enecho.meti.go.jp/category/others/basic_plan/pdf/strategic_energy_plan.pdf

METI. (2023). Sixth Hydrogen Energy Ministerial Meeting Held [Press Relsease]. Ministry of Economy, Trade and Industry. https://www.meti.go.jp/english/press/2023/0925_002.html

METI. (2024a). Basic Policy on the Promotion of Supply and Utilization of Low-Carbon Hydrogen, etc. https://www.enecho.meti.go.jp/category/saving_and_new/advanced_systems/hydrogen_society/carbon_neutral/06_kihonhoushin.pdf

METI. (2024b). Enforcement Regulations of the Act on Promoting the Supply and Use of Low-Carbon Hydrogen and Other Resources for a Smooth Transition to a Decarbonized Growth Economic Structure. Ministry of Economy, Trade and Industry. e-Gov Law Search. https://laws.e-gov.go.jp/law/506M60000400069

METI. (2024c, June 4). Attending the Japan-EU Hydrogen Business Forum and the Discussion Meeting on Hydrogen Cooperation between Japan and the EU. Ministry of Economy, Trade and Industry. https://www.meti.go.jp/press/2024/06/20240604004/20240604004.html

METI. (2024d, September 10). Hydrogen Society Promotion Act Enacted. Toward a Forthcoming Hydrogen-based Society. Part 2: Utilization of Clean Hydrogen. Agency for Natural Resources and Energy, METI. https://www.enecho.meti.go.jp/en/category/special/article/detail_204.html

METI. (2025, March 27). The Second Japan-Korea Hydrogen, Ammonia and Other Cooperation Dialogue Held. https://www.meti.go.jp/press/2024/03/20250327003/20250327003.html

Ministry of External Affairs. (n.d.). National Statement by Prime Minister Shri Narendra Modi at COP26 Summit in Glasgow. Speeches and Statements. Government of India. Retrieved 21 October 2025, from https://mea.gov.in/Speeches-

Statements.htm?dtl/34466/National+Statement+by+Prime+Minister+Shri+Narendra+Modi+at+COP26+Summit+in+Glasgow

MNRE. (n.d.). Project Database. Government of India - MInistry of New and Renewable Energy. Retrieved 21 October 2025, from https://nghm.mnre.gov.in/project

MNRE. (2023a). National Green Hydrogen Mission. Government of India. Ministry of New and Renewable Energy. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/01/2023012338.pdf

MNRE. (2023b, June 28). Office Memorandum 353/40/2023-NT: Scheme Guidelines for implementation of 'Strategic Interventions for Green Hydrogen Transitions (SIGHT) Programme—Component II: Incentive Scheme for Green Hydrogen Production (under Mode 1)' of the National Green Hydrogen Mission. MInistry of New and Renewable Energy (Hydrogen Division) - Government of India. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/07/2023072641.pdf

MNRE. (2023c, August 18). Office Memorandum. Subject: Green Hydrogen Standard for India. No. 353/35/2022-NT. MInistry of New and Renewable Energy (Hydrogen Division) - Government of India. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/aug/doc2023819241201.pdf

MNRE. (2024). International Conference on Green Hydrogen (ICGH-2024). Government of India - Ministry of New and Renewable Energy. https://nghm.mnre.gov.in/admin/uploads/172213866170084icgh_2024.pdf

MNRE. (2025, April 29). Office Memorandum 353/69/2024-NT: Issuance of Green Hydrogen Certification Scheme of India—Reg. Ministry of New and Renewable Energy (Hydrogen Division) - Government of India. https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/05/202505052107647402.pdf

MNRE, & The Federal Government of Germany. (2024). Indo-German Green Hydrogen Roadmap. https://nghm.mnre.gov.in/admin/uploads/17299552361242Indo-German_Green_Hydrogen_Roadmap.pdf

MOFA. (2021). 2050 Hydrogen Supply Scenario. Ministry of Foreign Affairs Korea. https://www.mofa.go.kr/www/brd/m_4080/down.do?brd_id=235&seq=371662&data_tp=A&file_seq=4

MOTIE. (2019, June). Third Basic Energy Plan. https://www.khfcia.com/21/?bmode=view&idx=15194700

MOTIE. (2021). 1st Hydrogen Economy Implementation Master Plan. Ministry of Trade, Industry and Energy (MOTIE) of the Republic of Korea. https://h2hub.or.kr/main/info/policy-industry-techinfo.do?mode=view&articleNo=673&article.offset=0&articleLimit=10

MOTIE. (2024, March 4). Notice on the Operation of the Clean Hydrogen Certification System (Notice No. 2024-39). National Law Information Center. Ministry of Trade, Industry and Energy. https://www.law.go.kr/LSW/admRulInfoP.do?admRulSeq=2100000237332

MPR Korea Certification. (n.d.). KGS Factory Registration for Korea. Retrieved 24 October 2025, from https://www.korea-certification.com/en/kgs-factory-registration/

Oh, D., Lee, D., & Yoon, S. Y. (2024). A Comparative Legal Study of the EU Taxonomy and the Korean Green Taxonomy. Business Law Review, 38(3), 373–421. https://doi.org/10.24886/BLR.2024.09.38.3.373

Pal, R., Tripathi, V., Kothadiya, K., Aggarwal, P., & Yadav, D. (2025). Augmenting the National Green Hydrogen Mission. Council on Energy, Environment and Water (CEEW).

PIB Delhi. (2022, February 17). Ministry of Power notifies Green Hydrogen/ Green Ammonia Policy. Ministry of Power. Press Information Bureau Delhi. https://www.pib.gov.in/www.pib.gov.in/Pressreleaseshare.aspx?PRID=1799067

PIB Delhi. (2024, October 25). Joint Statement: 7th India-Germany Intergovernmental Consultations (IGC). Prime Minister's Office India. Press Information Bureau Delhi. https://nghm.mnre.gov.in/admin/uploads/172995434562252Press%20Release_%20Press%20Information%20Bureau.pdf

Poten & Partners. (2025, June). Update on Korean Clean Ammonia Market. Ammonia Energy Association 2025 APAC Conference, Perth. https://ammoniaenergy.org/wp-content/uploads/2025/06/Chris-Rumley-APAC-2025.pdf

Sang-won, H. (2025, May 9). Hydrogen power generation bidding market opens this year... Clean hydrogen supply cut in half. Gasnews.com. Hydrogen and Fuel Cells. https://www.gasnews.com/news/articleView.html?idxno=120125

SBI. (2023, January). Environmental, Social, and Governance (ESG) Financing Framework. https://sbi.bank.in/documents/17836/3726866/ESG+Financing+Framework+2023.pdf

SECI. (2023, October 7). Request for Selection (RfS) for Selection of Green Hydrogen Producers for Setting up Production Facilities for Green Hydrogen in India under the Strategic Interventions for Green Hydrogen Transition (SIGHT) Scheme (Mode-1-Tranche-I). https://www.seci.co.in/Upload/Tender/SECI000111-2344468-RfSforHydrogenProductionunderSIGHTprogram(Mode-1Tranche-I).pdf

Shibata, Y. (2022). Cautions on the use of hydrogen and ammonia for power generation. https://eneken.ieej.or.jp/data/10650.pdf

SHIN & KIM LLC. (2025, September 30). The new Ministry of Climate, Energy and Environment of Korea. Energy and Resources. https://www.shinkim.com/eng/media/newsletter/2980

Song, H. S. (2023). Challenges for Climate Finance towards Carbon Neutrality [Issue Paper]. Korea Capital Market Institute. https://www.kcmi.re.kr/en/report/report_view?report_no=1526

Staffell, I., Scamman, D., Velazquez Abad, A., Balcombe, P., Dodds, P. E., Ekins, P., Shah, N., & Ward, K. R. (2019). The role of hydrogen and fuel cells in the global energy system. Energy & Environmental Science, 12(2), 463–491. https://doi.org/10.1039/C8EE01157E

Tae-kyung, K. (2025, October 20). The Key to Carbon Neutrality: The Diverse Colors and Prospects of Hydrogen. Today Energy: Contribution. https://www.todayenergy.kr/news/articleView.html?idxno=289950

Tam, S. (2023, June 9). South Korea opens hydrogen power bidding market. Argus Media. https://www.argusmedia.com/en/news-and-insights/latest-market-news/2457898-south-korea-opens-hydrogen-power-bidding-market

The Japanese-German Energy Partnership. (2025, May 20). The Japanese-German Energy Partnership. https://energypartnership-japan.org/

The Ministerial Council on Renewable Energy, Hydrogen and Related Issues. (2017, December 26). Ministerial Council on Renewable Energy, Hydrogen and Related Issues. https://japan.kantei.go.jp/98_abe/actions/201712/26article5.html

The Ministerial Council on Renewable Energy, Hydrogen and Related Issues. (2023, June 6). Basic Hydrogen Strategy. https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_5.pdf

Tokyo Metropolitan Center for Climate Change Actions. (2025). Project to promote the introduction of equipment, etc. With a view to the full-scale utilization of renewable energy-derived hydrogen. https://www.tokyo-co2down.jp/subsidy/3_7hydrogen_recycle;

Yoo, J. (2024). Evaluation of existing hydrogen policies and policy challenges (2206; Issues and Perspectives). National Assembly Research Service. https://www.nars.go.kr/report/view.do?cmsCode=CM0043&brdSeq=44246

Yoo, S. (2024, February 29). The Ministry of Trade, Industry and Energy held a briefing session on the clean hydrogen certification system, with approximately 350 hydrogen companies and organizations participating. e4ds news. https://www.e4ds.com/sub_view.asp?ch=16&t=0&idx=18545

Authors

WAKAKO ITO

Wakako Ito is Director of Research and Executive Director at JFIR. She is also the Senior Program Coordinator at the Research Center for Advanced Science and Technology, the University of Tokyo, and Specially appointed Research Fellow at Institute for Future Engineering (IFENG). She served as a Research Fellow at Shinjuku Institute for Policy Studies and an Adjunct Lecturer at Hosei University, Kanagawa University and Keiai University. She holds an M.A. and a PhD in Political Science from Hosei University. Her research focuses on China's space, science and technology, and dual-use technology policies. Her English-language publication includes "The State-oriented Model of Internet Regulation: The Case of China," Tomoko Ishikawa and Yarik Kryvoi eds., Public and Private Governance of Cybersecurity: Challenges and Potential (Cambridge University Press, 2023).

TOMOHIKO ADACHI

Mr. Adachi is an experienced international business lawyer advising on a wide range of matters in the energy and infrastructure sectors, including project development, financing, and related offtake arrangements. From 2022 to 2024, he served as Director of the Hydrogen & Fuel Cells Office at the Ministry of Economy, Trade and Industry, where he played a leading role in developing and enacting the groundbreaking Hydrogen Society Promotion Act. This legislation enables the Japanese government to implement large-scale support schemes for the introduction of clean hydrogen and its derivatives. He was also deeply engaged in international collaborations to advance clean hydrogen initiatives. Notably, he served as Co-Vice Chair of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) and Co-Chair of the Japan–Germany Energy Partnership, Hydrogen Working Group. In addition to his legal practice, Mr. Adachi is also a project researcher at the Research Center for Advanced Science and Technology, the University of Tokyo, where his work focuses on the intersection of energy policy and technology relating to the energy transition.

FANG-TING CHENG

After completing her doctoral studies at the Graduate Schools for Law and Politics, the University of Tokyo, Dr. Cheng joined the JETRO Institute of Developing Economies in April 2014. Her areas of expertise are international relations, global governance, and global environmental politics. Her research has focused on issues related to climate change, and her contributions include participating in United Nations Climate Change Conferences, authoring and publishing papers in Japanese and English. From 2019 to 2021, she was a visiting researcher at the National Taiwan University in Taipei, Taiwan, where she conducted research in the fields of international relations and environmental and energy policy. Notable academic books that she has authored include Japanese Environmental Diplomacy since the Kyoto Protocol (Mie University Press, 2013) and The Formation of Complementary Relationships among Overlapping Regimes: Negotiations on Climate Change, U.S.–China Relations, and the Paris Agreement (Gendaitosho, 2017).

TOMOKO ISHIKAWA

Tomoko Ishikawa is Professor at Nagoya University in Japan. She has served as an ICSID Conciliator, appointed by the Chairman of the Administrative Council (2017-2023), a member of the Legal Advisory Committee of the Energy Charter Treaty, an arbitrator at Shenzhen Court of International Arbitration and a mediator at the Kyoto International Mediation Centre. Her professional experiences include serving as a Judge at Tokyo District Court and holding the position of Deputy Director at the International Legal Affairs Bureau of the Ministry of Foreign Affairs of Japan, where she worked on bilateral/trilateral investment treaties, Free Trade Agreements and WTO dispute settlement. Currently, she is leading a multidisciplinary research programme on climate change governance and low-carbon hydrogen (07/2023-3/2029, https://h2governance.gsid.nagoya-u.ac.jp/en/). Her recent publication includes T. Ishikawa, Corporate Environmental Responsibility in Investor-State Dispute Settlement: The Unexhausted Potential of Current Mechanisms (Cambridge University Press, 2022) and Tomoko Ishikawa and Yarik Kryvoi (eds.), Public and Private Governance of Cybersecurity: Challenges and Potential (Cambridge University Press, 2023).

YOUHYUN LEE

Dr. Lee is an Associate Professor in the Department of Public Administration at the College of Social Sciences, Ajou University (Suwon, Republic of Korea), where she currently serves as Head of Department. She holds an M.A. in Public Administration from the Graduate School of Governance, Sungkyunkwan University (Seoul, ROK), and a Ph.D. in Legal Science from the École Doctorale de Droit de la Sorbonne, Université Paris 1 Panthéon-Sorbonne (Paris, France). In addition, she serves as a member of the Central Environmental Policy Committee of the Ministry of Environment, ROK (Environmental Economics Division). Her research interests include energy policy, environmental policy, and local governance. Her recent work has been published in the Pacific Focus, Energy Research & Social Science and International Journal of Hydrogen Energy.

SEONG BIN PAK

Seong Bin Pak is a professor at the College of Social Sciences and Director of the Center for Japanese Policies at Ajou University. He concurrently serves as Vice President of The Korean Journal of Japanese Studies and a member of the Board Committee and Editorial Director of Korea-Japan Next Generation Academic Forum. He served as Chairman of Editorial Board of The Korea Journal Japanese Studies, member of the Central Government Policy Evaluation Committee, etc. He received PhD in International Political Economy from the University of Tsukuba, Japan. While contributing to improving Japan-Korea relations, he has presented on topics including "Japan-Korea Hydrogen Economy Industry Strategy and Cooperation Measures" at the 2024 Japan-Korea Business Conference, as well as Japan-Korea economic cooperation regarding hydrogen and economic security at seminars hosted by the Korean government and other institutions.

RAJESH SHARMA

Rajesh Sharma has given training and taught courses across Asia and Africa. He has researched extensively on the arbitration laws of China and India and other Asian countries, Investment Arbitration, Dispute Settlement in FTAs, WTO related issues, investment law and mediation. He has served as the Legal Advisor to the Macau University of Science and Technology. He has advised transnational companies on trade and investment policy in China and has done training courses with and for the WTO and UNITAR. He was awarded with the Best Paper award for the research paper titled “Hydrogen Trade and Lessons for India” by the National Institute of Disaster Management of the Government of India. He has been engaged in developing hydrogen related law, policy, community response, in avoiding, managing and dealing with potential disputes and delivered concept notes in Australia, India, Japan, China, Hong Kong, Papua New Guinea, Nepal and elsewhere.

KENTARO TAMURA

Kentaro Tamura obtained a PhD in International Relations from the London School of Economics and Political Science (LSE). After working for the Ecotechnology System Laboratory at Yokohama National University, he joined IGES in 2003. He has cantered his research on international cooperation on climate change, in particular the development and design of international climate regime, political economy and comparative studies of domestic climate and energy policy making processes in major economies, and international transfer and diffusion of low-carbon technologies.

MAXIMILIAN RISCHER

Maximilian Rischer has been a Research Associate at the Research Institute for Sustainability (RIFS) at GFZ Helmholtz Centre for Geosciences since September 2024, contributing to the project “Geopolitics of the Energy Transformation: Sustainability Governance in the Hydrogen Sector.” His current research at RIFS focuses on governance frameworks that advance hydrogen as a sustainable energy carrier beyond CO2 reduction, examining institutional and national approaches to sustainability standards, certification schemes, public and private finance, and policy design. Before joining RIFS, he conducted research on the hydrogen economy in Namibia, through desktop studies and ethnographic fieldwork, and also gained project management experience with an international engineering firm specializing in energy infrastructure.

RAINER QUITZOW

Rainer Quitzow leads a research group on the Geopolitics of Energy and Industrial Transformation at the Research Institute for Sustainability (RIFS) at GFZ Helmholtz Centre for Geosciences. His research focuses on sustainable innovation and industrial policy and geopolitics of transitions in energy and industry. In particular, he analyses geoeconomic competition in emerging climate-friendly industries and the role of foreign and industrial policy strategies in this context. Rainer Quitzow is also Professor of Sustainability and Innovation (Honorarprofessor) at the Technische Universität Berlin. Before his career as a researcher, Rainer Quitzow worked in the field of international development with a focus on governance and environmental and trade policy. At the World Bank in Washington, D.C., he conducted governance and policy impact analyses for development programmes in Latin America and Africa.

The Research Institute for Sustainability (RIFS) conducts research with the goal of understanding, advancing, and guiding processes of societal change towards sustainable development in Germany and abroad. The Institute is embedded within the GFZ Helmholtz Centre for Geosciences and is thus part of the Helmholtz Association. Its research approach is transdisciplinary, transformative, and co-creative: RIFS cooperates with partners in science, political and administrative institutions, the business community, and civil society to understand the problems of sustainable development, identify appropriate solutions, and support their implementation in cooperation with relevant actors and affected communities. Its central research topics include the energy transition, climate change and socio-technical transformations, as well as sustainable governance and participation. A strong network of national and international partners and a Fellow Programme support the work of the Institute.

RIFS Study
November 2025

Contact:
Maximilian Rischer: Maximilian.rischer@rifs-potsdam.de
Rainer Quitzow: rainer.quitzow@rifs-potsdam.de
Address:
Berliner Straße 130
14467 Potsdam
T: +49 (0) 331–28822–340
F: +49 (0) 331–28822–310
media@rifs-potsdam.de
www.rifs-potsdam.de

ViSdP:
Prof. Dr. Doris Fuchs,
Scientific Director, Speaker

Editor:
Damian Harrison

DOI: 10.48481/rifs.2025.036

GFZ Helmholtz Centre for Geosciences

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES