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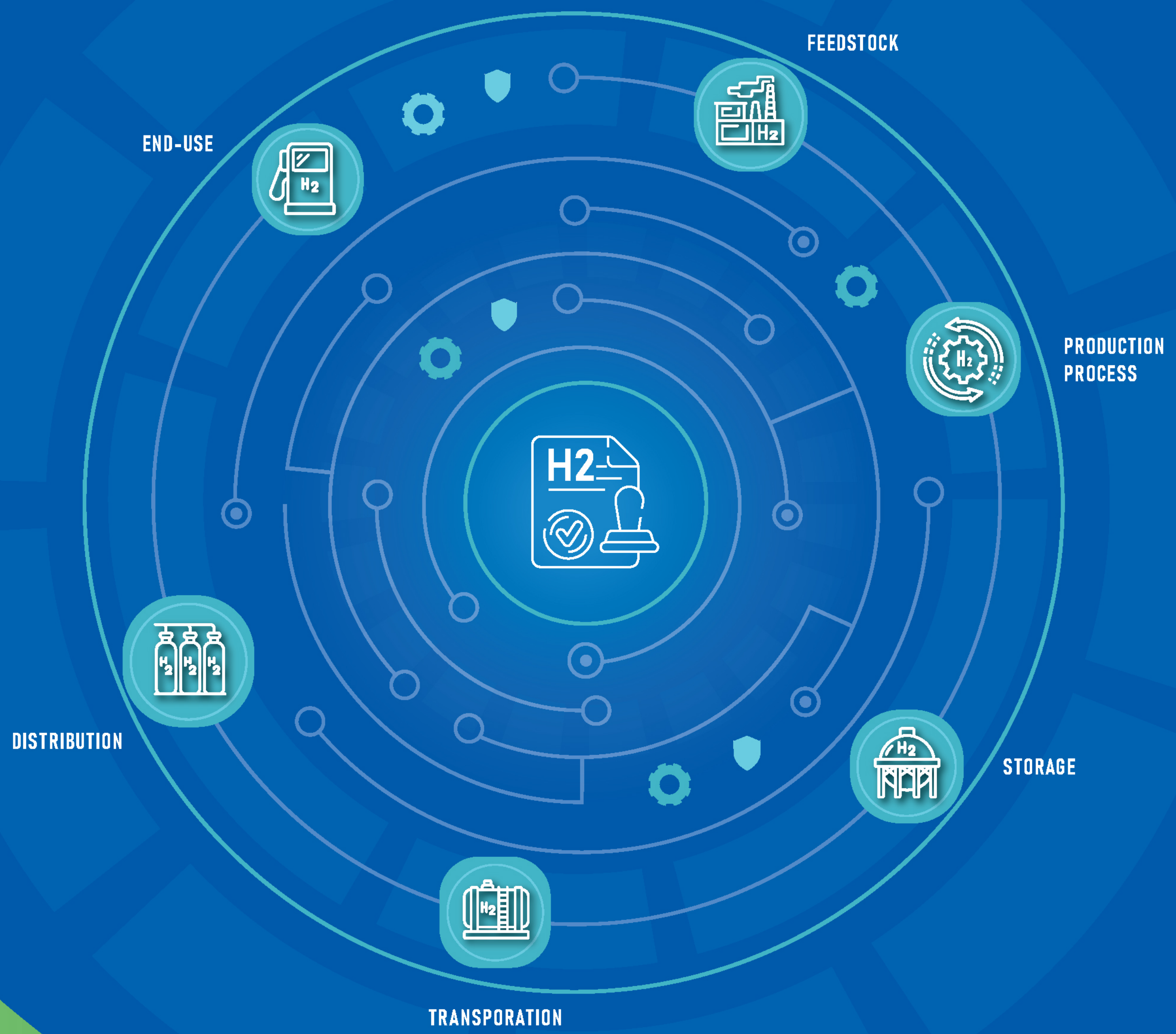
BUILDING A CASE FOR A HYDROGEN CERTIFICATION FRAMEWORK IN INDIA



Authors Jaideep Saraswat, Nikhil Mall, Varun B.R.

Reviewed By Sivaram Krishnamoorthy, Srinivas Krishnaswamy, Raman Mehta, Vrinda Gupta

Editing & Design By Aman Kumar, Swati Bansal, Priya Kalia and Santosh Kumar Singh

About Vasudha Foundation

Vasudha Foundation is a non-profit organisation set up in 2010. We believe in the conservation of 'Vasudha', which in Sanskrit means the Earth, the giver of wealth, with the objective of promoting sustainable consumption of its bounties. Our mission is to promote environment-friendly, socially just and sustainable models of energy by focusing on renewable energy and energy-efficient technologies as well as sustainable lifestyle solutions. Through an innovative approach and data- driven analysis, creation of data repositories with cross-sectoral analysis, along with outreach to ensure resource conservation, we aim to help create a sustainable and inclusive future for India and Mother Earth.

About SED Fund

Stichting SED Fund is a philanthropic initiative to support the Sustainable Development Goals (SDGs) of clean air, access to energy, clean water, climate action and equity, by backing efforts of governments and civil society on clean energy transition, according to principles of sustainability, diversity and equity. We amplify impact by consolidating philanthropic resources, strengthening country level institutions and civil society groups and supporting initiatives that will have the most impact in support of these goals.

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CISRS House, 14 Jangpura B,
Mathura Road, New Delhi - 110014
For more information, visit www.vasudha-foundation.org

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Preface

India's energy transition is viewed with keen interest globally. It has witnessed high economic growth over the past two decades, and the energy demand is further expected to soar to be the highest in the world in the coming decades. Thus, India's net zero pathway encompasses green hydrogen as a critical vector to sustainably support its low-carbon energy needs. Given, a huge potential to become a major hydrogen exporter, whilst securing energy independence, there is an urgent need to secure mechanisms to foster a strong hydrogen market in India.

India is one of the largest hydrogen consumers in the world with about 6-7 percent of total global consumption. The hydrogen demand is expected to reach 12 MMT by 2030. Cognisant of hydrogen's importance, India has introduced many initiatives to develop a green hydrogen economy over the last few years. As part of the recently launched National Green Hydrogen Mission, a target to produce at least 5 MMT of green hydrogen per annum by 2030 has been set. Hydrogen can be prepared from a variety of feedstocks and currently, the majority of this demand is met via Grey Hydrogen produced by Steam Methane Reforming of natural gas. There is a price differential between hydrogen produced from fossil fuels and the hydrogen produced via the electrolysis of water using electricity generated from renewable resources. Although there are buyers in the market willing to pay a higher price to procure low-carbon hydrogen, but normally this occurs as a result of compliance with laws (compliance/regulatory carbon market). Or it can also be a voluntary decision to tackle climate change. However, it is impossible to determine the embedded emissions by perusing the end product. Therefore, there is a need to bridge the information asymmetry between the buyer and the seller of hydrogen to create a transparent hydrogen market, necessitating a robust certification mechanism.

This report is a comprehensive take on the various modalities to develop a hydrogen certification framework for India. In addition, this report captures the outcomes of a survey encapsulating stakeholder views from across the hydrogen value chain. Finally, a set of recommendations is provided to assist policymakers in initiating the certification exercise.

1 Introduction

In recent years, India has positioned itself as the leader in addressing climate change at the global fora. As per the requirement of the Paris Accord, the Government of India (GOI) submitted the revised and updated Intended Nationally Determined Contributions (INDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) in August 2022[1] . In this, India aims to achieve net-zero emissions by 2070. And to further meet this long-term target, a conjunction of several short-to-medium-term targets has been put forth. First, India will reduce the emissions intensity of its GDP by 45 percent by 2030 in comparison to 2005 levels. Second, around 50 percent of cumulative power installed capacity will be derived from non-fossil fuel sources by 2030. Clearly, India's efforts are right on track to curb climate change.

However, achieving a net-zero emissions target requires much more concerted efforts as this strategy is a confluence of several attributes captured in Figure 1. This paper focuses on the importance of 'a comprehensive approach to emissions reductions' attribute. It was observed that with earlier carbon reduction strategies there was a possibility to subsume difficult carbon-emitting sources under the residual emissions bucket. With the net-zero strategy in place, there is the necessity to tackle all intractable sources. These sources are often termed as hard-to-abate sectors comprising heavy industries, long-haul transportation, and more. There is a need to follow technology solutions that can assist in decarbonising these sectors.

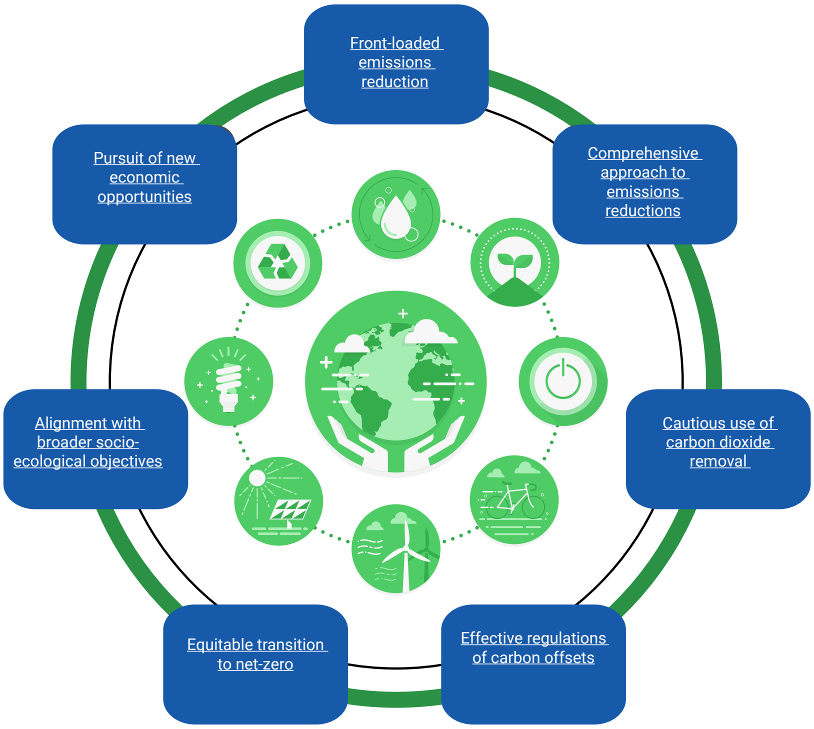


Figure 1: Attributes of Net-zero Strategy[2]

1 https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf
2 https://www.nature.com/articles/s41558-021-01245-w

1.1

Role of Hydrogen

Hydrogen is a secondary energy carrier akin to electricity. It is also a versatile fuel that has many applications. Hydrogen has the advantage of conversion into other derivatives like ammonia, Liquid Organic Hydrogen Carriers (LOHC) like Toluene, and more. Also, it can be used for electricity generation and storage, heating applications for residential and industrial processes, as a feedstock for various chemical industries, and as a fuel for the transportation sector as explained in Figure 2. It is a unique fuel where the emissions associated with the fuel are not at the point of consumption but at the point of production or during its movement across the value chain. At the same time, hydrogen can also be produced by a process that is free of emissions. Furthermore, in comparison to other fuels, hydrogen contains more energy on a mass basis. These facets make hydrogen an important carrier to be examined to achieve net-zero targets.

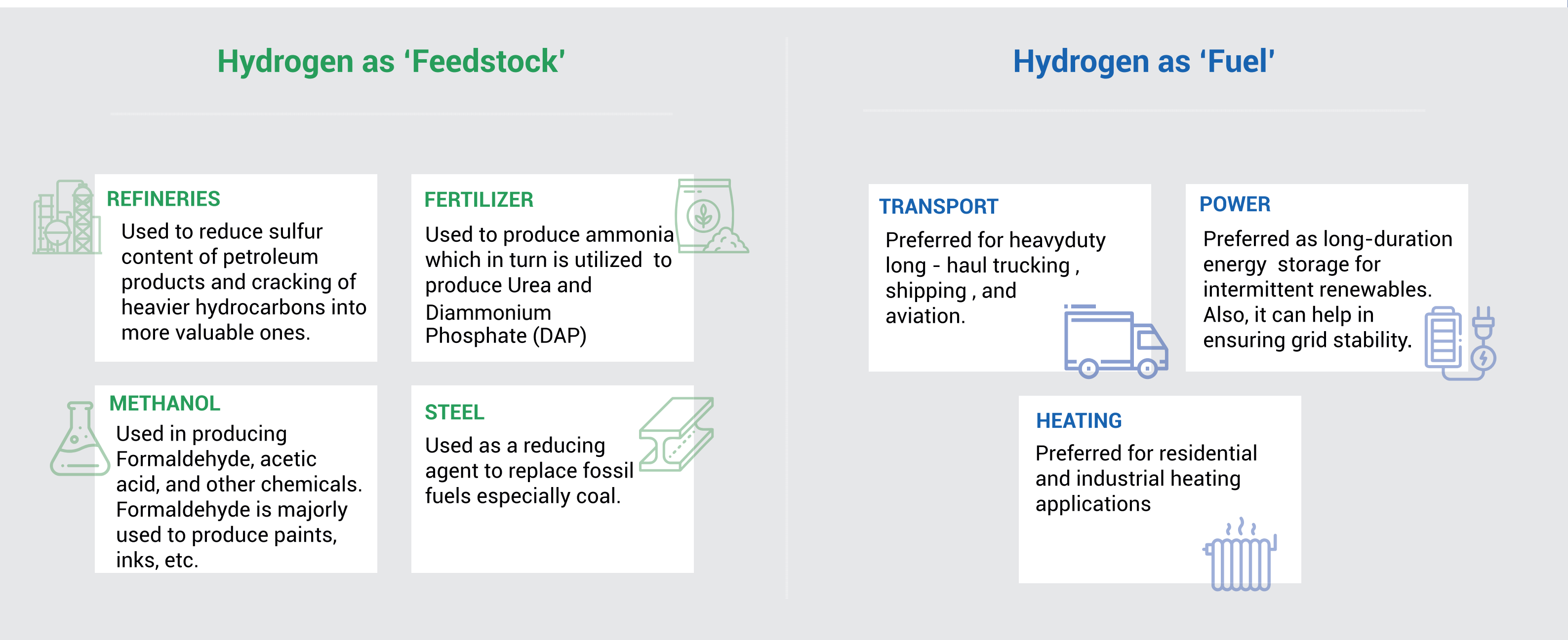


Figure 2: Key Hydrogen Applications [3,4,5,6,7]

[3] Matijasevic, Lj, and M Petric. 2016. "Integration of hydrogen systems in petroleum refineries." Chem. Biochem. Eng. Q. 291-304
[4] Rabiei, Zahra. 2012. "Hydrogen management in refineries." Petroleum and Coal 357-368.
[5] Ausfelder, F, and A Bazzanella. 2016. "Hydrogen in the chemical industry." In Hydrogen Science and Engineering: Materials, Processes, Systems and Technology, by D Stolten and B Emonts, 19-39. Wiley-VCH Verlag GmbH & Co.
[6] Saraswat, V K, and Ripunjaya Bansal. 2016. India's Leapfrog to Methanol Economy. New Delhi: NITI Aayog
[7] https://www.energyforum.in/fileadmin/user_upload/india/media_elements/publications/20210727_H2_Report/20210727_mn_H2_report.pdf

Globally, hydrogen is already consumed for many applications. In 2020, the net demand for hydrogen was around 90 MMT from which 70 MMT was directly utilised as pure hydrogen and the remaining 20 MMT was converted into other derivatives like methanol[8]. Close to 30 countries have fleshed out hydrogen strategies and roadmaps to become leaders in this sphere[9]. Therefore, there is an expected increase in hydrogen demand going forward. In 2050, green hydrogen and its derivatives will account for around **12 percent** of final energy consumption. This will require to achieve about 50 GW of hydrogen electrolyser capacity by 2050[10].

1.2

Colour and Carbon Emissions associated with Hydrogen

Since hydrogen can be produced from several different processes, it was realized that colour coding of hydrogen will provide brevity to the researchers and the readers. Obviously, there is no difference in the chemical properties or molecular structure of hydrogen produced from these sources, nevertheless, it is a theoretical representation that has garnered interest. Figure 3 represents various popular hydrogen production processes along with their assigned colours.

[8] https://www.iea.org/reports/hydrogen
[9] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://web-assets.bcg.com/48/33/6d7cc16f4144b88137935f807e83/building-on-belgium-federal-hydrogen-strategy.pdf
[10] World Energy Transition Outlook, IRENA, 2021

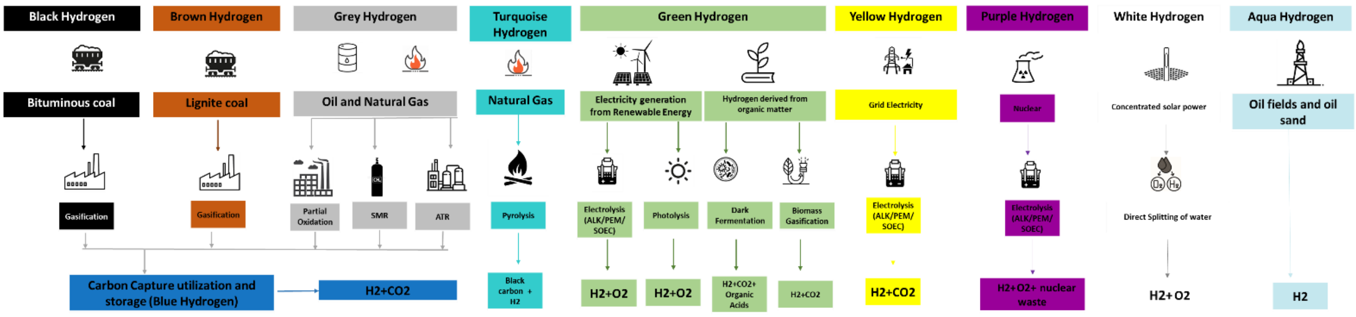


Figure 3: Various Hydrogen Production Processes and their Designated Colours[11,12,13,14,15]

Though the colouring scheme can provide a crude sense of the environmental impact, but it does not furnish exact emissions generated during the process. Also, with so many colours in place, it is taxing to remember each one of them and the associated process. This underscores the importance of exploring other ways to classify. Table 1 captures the emissions from various popular hydrogen production processes.

[11] The economics and the environmental benignity of different colors of hydrogen, International Journal of Hydrogen Energy, 2022
[12] Droege T. What are the colors of hydrogen? Williams Companies; 2021. 23 April 2021
[13] http://australiainstitute.org.au/wp-content/uploads/2020/12/P695-National-Hydrogen-Strategy-Input-WEB.pdf
[14] Yu M, Wang K, Vredenburg H. Insights into low-carbon hydrogen production methods: green, blue and aquahydrogen. Int J Hydrogen Energy 2021
[15] Boretti A. White is the color of hydrogen from concentrated solar energy and thermochemical water splitting cycles. Int J Hydrogen Energy 2021

Table 1: Emissions from various hydrogen production processes [16, 17]

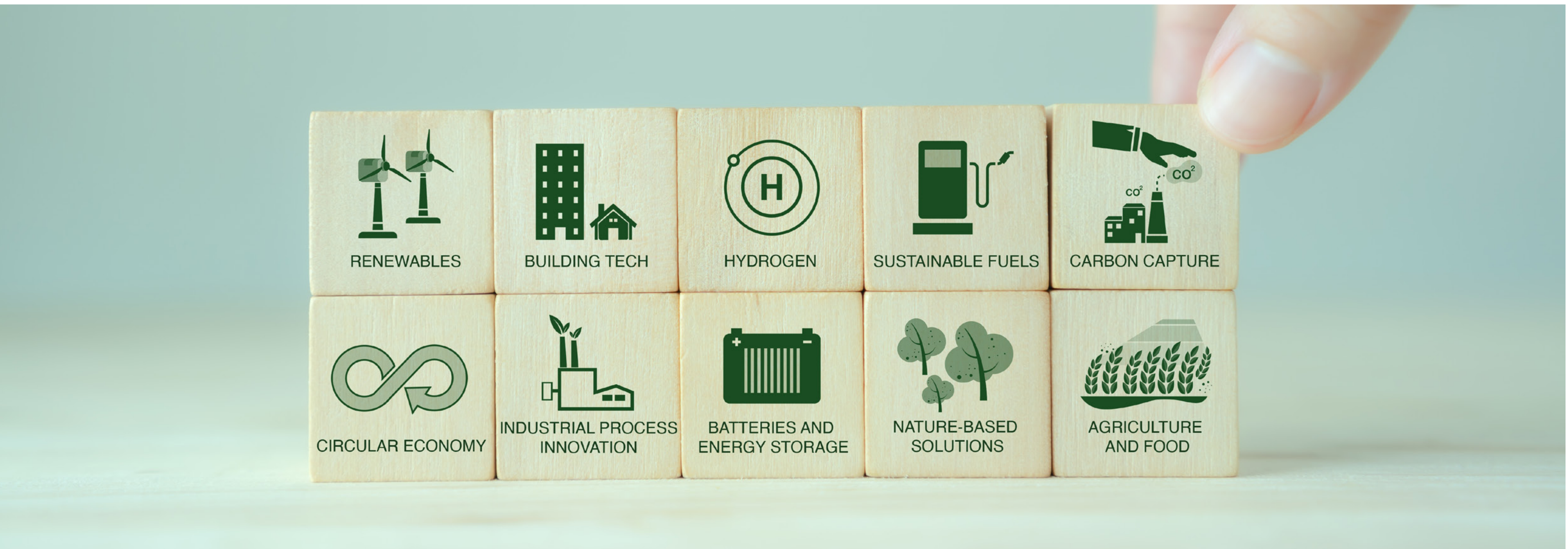
Sl. No.	Production Process	CO_2 Emissions (kg/kg H2)	Remarks
1	Electrolysis using Grid Electricity	39	Assuming 55kWh of electricity is needed to produce 1 kg of hydrogen via electrolysis. Also, for 2021-22, CEA's average CO_2 emission rate ($kgCO_2/kWh$) is used.
2	Steam Methane Reforming (SMR)	9	Of this 9 kg CO_2, around 5.4 kg is due to the process stream and the remaining is from methane combustion to heat the reformer.
3	Auto-thermal Reforming (ATR)	9	Entire CO_2 emission is from the process stream.
4	SMR + Carbon Capture and Storage (CCS)	1	Around **90 percent** of emissions are captured by the flue gas stack. However, natural gas input increases per kg of hydrogen produced to supply energy to the CCS equipment.
5	ATR + CCS	NA	Here, the CCS equipment will have lower energy input as there are no separate streams of emissions to cater to.
6	Electrolysis using RE electricity	None	Producing hydrogen from RE sources requires a continuous electricity supply
7	Direct splitting of water using concentrated solar power	None	Involves thermochemical water splitting cycles
8	Methane Pyrolysis using RE electricity	None	Requires less energy to produce 1 kg of hydrogen. Also, the final output is carbon black. Hence, there is no need for CCS equipment. Large-scale deployment of this process will mean continued dependence on fossil fuels.
9	Oil Field and Oil Sands beneath the earth strata	None	Involves injecting oxygen into oil reservoirs and oil sands (natural bitumen) beneath the earth's surface
10	Biomass Gasification/ Fast Pyrolysis + CCS	Net negative Emissions	Net negative emissions by capturing any process and fuel combustion emissions due to the biogenic nature of the feedstock

The vital conclusion here is that the environmental benefits of hydrogen use can only be accrued if cleaner production methods and primary sources are used. Only a few hydrogen production processes have truly low-to-zero emissions. All other sources have substantially higher emissions.

[16] https://sccs.stanford.edu/sites/g/files/sbiybj17761/files/media/file/hydrogen-brief.pdf
[17] https://cea.nic.in/wp-content/uploads/irp/2022/09/DRAFT_NATIONAL_ELECTRICITY_PLAN_9_SEP_2022_2-1.pdf

1.3

Mapping Hydrogen Value Chain



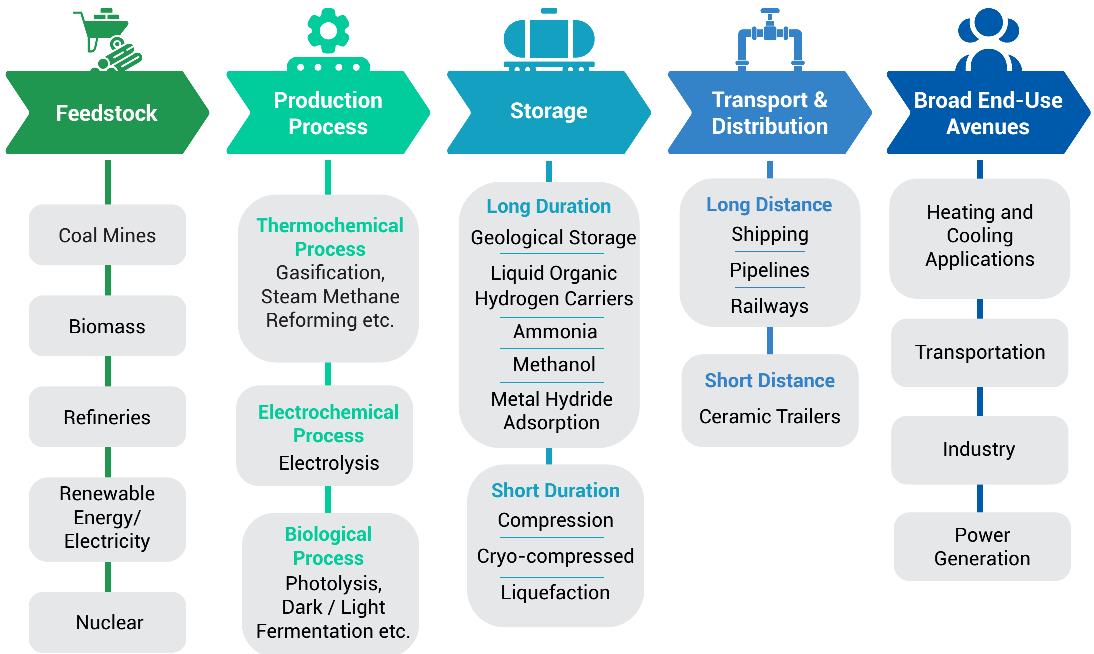


Figure 4: Schematic Mapping of Hydrogen Value Chain

Figure 4 illustrates a schematic mapping of a typical hydrogen value chain. As described in section 1.2, the type of fuel used leads to various colour-based classification for hydrogen. The feedstock of the type of fuels used constitute the preliminary link in the supply chain. From an emission accounting perspective, hydrogen production must include the emissions associated with acquisition and transport of the source fuel.

Production

Hydrogen production processes can broadly be classified into three categories – thermochemical, electrochemical, and biological processes. The production processes under each category are mentioned in Figure 4. The push for green hydrogen production has placed electrolysis as a key process. Concurrently, an industry push to scale electrolyser manufacturing capacity in the country is underway with around 16 GW capacity in the pipeline expected to be commissioned by 2025[18].

Storage

Hydrogen storage is approached in two tranches based on the duration of storage. Typically, economical solutions for long duration storage are geological storage such as salt caverns, or conversion to ammonia, methanol, and other liquid organic hydrogen carriers (LOHC) such as Toluene. For shorter durations, processes such as compression or liquefaction are employed to store hydrogen, where the costs of conversion to energy-dense liquids are not economical corresponding to the time frame of hydrogen use.

Transportation and Distribution

Pipelines, shipping, and railways are the typical modes of long-distance transport of hydrogen. The gaseous nature of hydrogen is volatile and hence over long distances, hydrogen is converted to energy-dense liquids to be stored and transported on the mentioned routes. Short-distance transport of hydrogen is typically done by compression and storage of hydrogen in ceramic trailers which are primarily transported by road.

Broad end-use avenues

Post distribution, the final link in the hydrogen value chain is the point of consumption. As described in Figure 4, hydrogen has significant applications in heating and cooling, transportation, and industry. With the prospects of hydrogen becoming integral to indirect electrification strategies, it has high potential in the power generation industry as well.

[18] Vasudha Foundation Analysis

1.4 Need for Hydrogen Certification

There is a price differential between hydrogen produced from fossil fuels and the hydrogen produced via the electrolysis of water using electricity generated from renewable resources[19]. There are buyers in the market who will pay a higher price to procure low-carbon hydrogen. This can happen out of compliance with laws (compliance/regulatory carbon market). Or it can also be a voluntary decision to tackle climate change[20]. However, it is impossible to determine the embedded emissions by perusing the end product. Therefore, there is a need to bridge the information asymmetry between the buyer and the seller of hydrogen to create a transparent hydrogen market.

Moreover, the certification will also allow governments to bar the import or export of emission-intensive hydrogen. At the same time, it will embolden the government to measure progress towards their climate targets. Finally, it will ratchet up investments in renewable energy (RE) to produce low-carbon hydrogen.

Therefore, certification of hydrogen will play a key role in boosting the demand for low-carbon hydrogen and ultimately leading to reduced global emissions[21,22]. For this, there is a need to provide policy support to bring forth harmonised certification for hydrogen.

[19] https://www.vasudha-foundation.org/reducing-the-cost-barrier-between-green-and-grey-hydrogen-in-india/
[20] Carbon Credit Lifecycle of Wind Energy Projects, Indian Wind Power, Volume 8, Issue 3
[21] https://ideas.repec.org/a/eee/energy/v128y2017icp447-462.html
[22] https://www.researchgate.net/publication/342949616_Comparative_economic_and_life_cycle_assessment_of_solar-based_hydrogen_production_for_oil_and_gas_industries

2 India’s Hydrogen Journey

India is one of the largest hydrogen consumers in the world with about **6-7 percent** of total global consumption. In 2018-19, India’s annual hydrogen consumption was around 6.6 MMT. Of this, the fertiliser and refinery sectors were the biggest consumers as seen in Table 2. Going forward, the hydrogen demand will touch the 12 MMT mark by 2030[23]. And the demand from the fertiliser and refinery industry will be around 7.7 MMT[24].

Industrial Sector	Hydrogen Consumption 2018-19 (in thousand metric tons)	Production Method
Crude oil refining	2600	Hydrocarbon Reforming
Ammonia	3602.36	
Methanol	412.67	
Chlor-Alkali Industry	34.37	Electrolysis
Chemical Industry	29.25	
Other Industries	9.51	
Total	**6688.16**	

Table 2: Sector-wise hydrogen consumption in India (2018-19)[25]

The majority of this demand is met via Steam Methane Reforming (SMR) using Natural Gas, also called Grey Hydrogen. However, shifting existing and future hydrogen demand to cleaner means will provide several benefits. First, it will aid in meeting India’s climate goals by decarbonising the hard-to-abate sectors. Second, it will enhance India’s energy security prospects by reducing dependency on foreign imports. India’s net energy import dependency was around **42 percent** in 2021[26]. Lastly, it will fuel India’s ambitions to be a net energy exporter. The GOI is well aware of these benefits and have taken several initiatives to develop a robust green hydrogen economy in India. Figure 5 captures the timeline of these initiatives.

[23] https://home.kpmg/in/en/home/insights/2022/04/kpmg-mantra-newsletter-april-2022.html
[24] https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/news/2022/06/ey-accelerating-green-hydrogen-economy.pdf?download
[26] India Energy Statistics, 2021

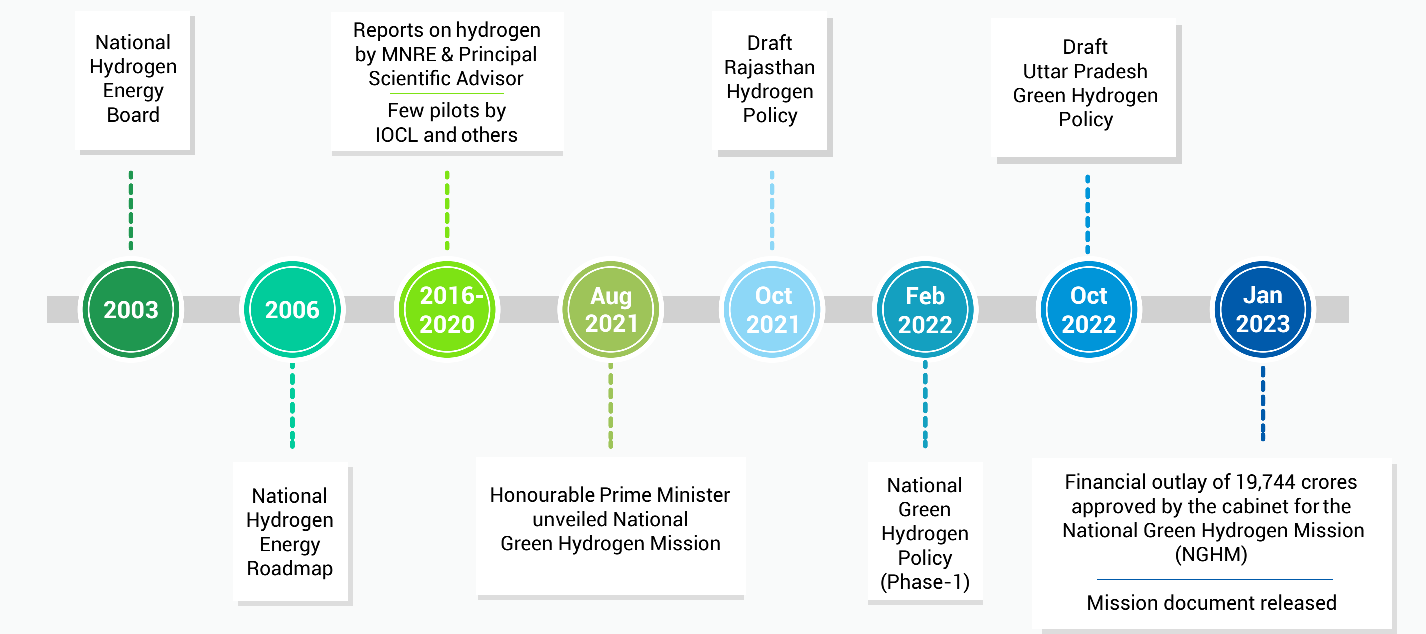


Figure 5: India's Hydrogen Timeline[27,28,29,30,31]

Beginning in 2003, the National Hydrogen Energy Board was instituted followed by the release of the National Hydrogen Energy Roadmap in 2006. Though the emphasis on hydrogen was put on the back burner after 2006, the interest was revived again in 2016 with a comprehensive plan to increase Research & Development (R&D) around the same. In Aug 2021, the efforts were bolstered when the Honourable Prime Minister of India announced the National Green Hydrogen Mission.

Furthermore, Rajasthan became the first state in India to release a draft hydrogen policy in October 2021. The policy aims to make the state an attractive investment destination for the stakeholders. The Rajasthan Micro, Small, and Medium Enterprises (Facilitation of Establishment and Operation) Act 2019 gives exemptions on several facets like NOC, clearance, consent, approvals, license, etc., for a period of 3 years. The state also offers a one-stop portal to provide all necessary support to the investors. In the R&D aspect, the state government will provide a one-time grant valuing **30 percent** of the cost incurred in the establishment of R&D centres. This will be subject to the maximum allocation of INR 5 crores. Apart from these benefits, several other direct benefits are provided to the industries like exemption of electricity duty, land conversion charges, and more, for a period of 7 years. Finally, this policy is forward-looking as it highlights the importance of a system that ensures a guarantee of the origin of green hydrogen.

Then, the Ministry of Power, Government of India released the first phase of the Green Hydrogen Policy in February 2022. The policy focuses on supply-side interventions. These include waiver of inter-state transmission charges for green hydrogen production plants commissioned before June 2025 for a period of 25 years. Banking of renewable electricity for 30 days is allowed with reasonable charges (as per the formula). Open access to green hydrogen production sites will be provided within 15 days as per the policy. The Ministry of New and Renewable Energy (MNRE) is designated to develop a single-window portal for all statutory clearances and approvals regarding the manufacture, transportation, storage, and approval of Green Hydrogen.

25 https://www.energyforum.in/fileadmin/user_upload/india/media_elements/publications/20210727_H2_Report/20210727_mn_H2_report.pdf
27 https://mnre.gov.in/img/documents/uploads/file_f-1673581748609.pdf
28 https://www.fticonsulting.com/insights/reports/india-energy-transition-green-hydrogen-economy
29 Vasudha Analysis
30 https://industries.rajasthan.gov.in/content/dam/industries/CI/pdf/Programmes%26Schemes/08_Rajasthan_Hydrogen_Policy_2021_V6.pdf
31 http://upneda.org.in/MediaGallery/UPGH2_policy_II.pdf

In October 2022, Uttar Pradesh became the second state next only to Rajasthan to release the draft Green Hydrogen Policy. The policy is prudently focusing on fertiliser industries and refineries as major demand centres in the short term. Concerning targets, the policy aims to achieve a **20 percent** blending of green hydrogen in the total hydrogen consumption of the state by 2028 for the aforementioned demand sectors. There are several provisions in place to enhance the ease of doing business for industries engaged in this domain. For instance, there is a provision of **100 percent** exemption from payment of land tax, land use conversion charges, stamp duty, and industrial water consumption charges. In addition, there is an upfront one-time support for technology acquisition of around **30 percent** subject to a maximum of INR 5 crores for industries or R&D centres. Furthermore, a 'Green Hydrogen Ecosystem Fund' will be put in place funded by levying green cess on emission-intensive activities. This fund will assist in strengthening the green hydrogen ecosystem in the state.

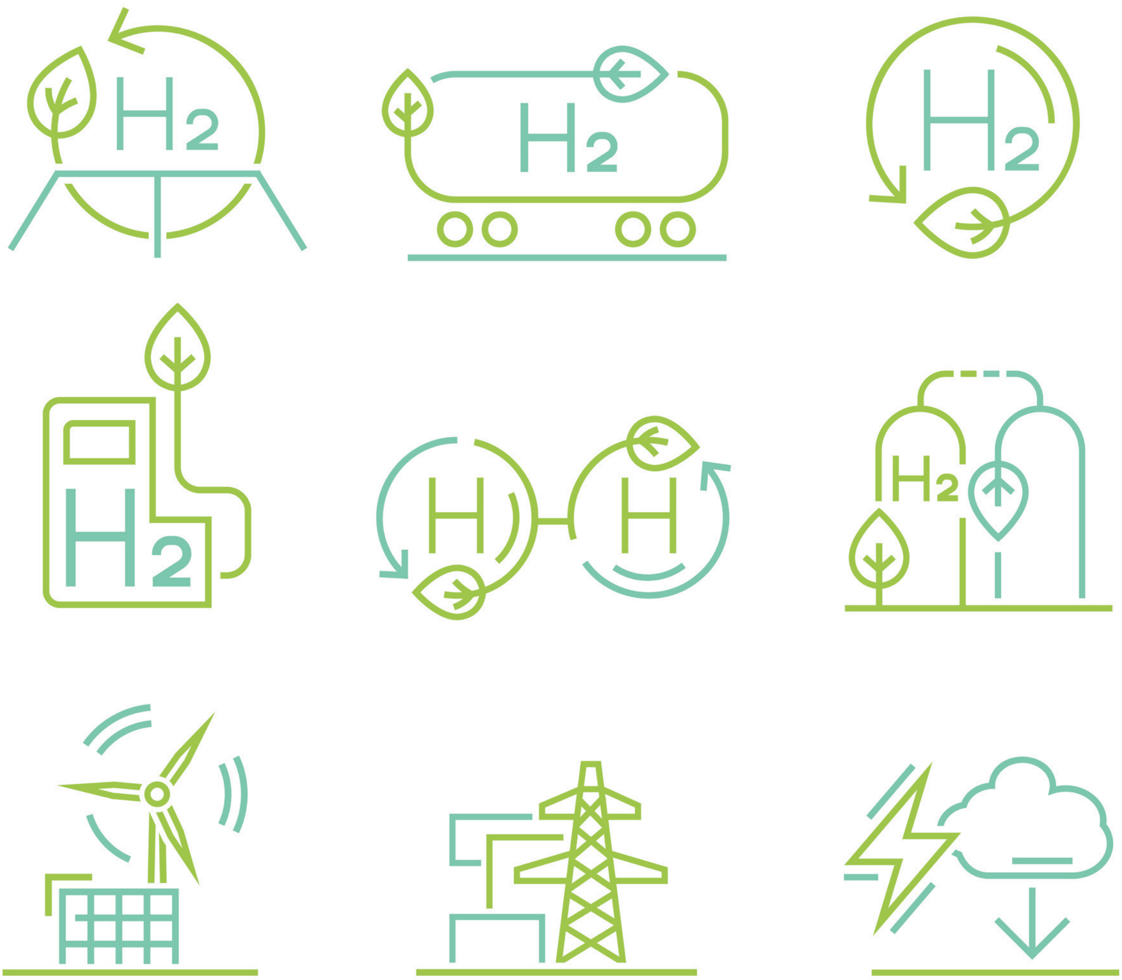
The latest development is the approval of the cabinet on the National Green Hydrogen Mission (NGHM) and the subsequent release of the mission document. It is a critical and timely initiative that has been envisaged to facilitate demand creation, production, utilisation, and export of Green Hydrogen. This mission aims to produce at least 5 MMT of green hydrogen per annum by 2030. Also, there is enough leeway provided to reach 10 MMT per annum owing to the growth of export markets. This is estimated to be about 10 percent of the global market. The initial outlay of this mission is pegged at around INR 19,744 crores. Of this, the Strategic Interventions for Green Hydrogen Transition (SIGHT) program will have an outlay of INR 17,490 crores, pilot projects will be implemented with around INR 1,466 crores, Research & Development will get INR 400 crores, and the remaining INR 388 crores will be for other mission components. To achieve this behemoth target, around 125 GW of renewable energy capacity addition will be required. This will require around INR 6-11 Lakh crores of investments by 2030[32]. Clearly, there is a conducive policy environment in India, both at the central and state level, that will assist in the transition from grey hydrogen to green hydrogen.

[32] https://www.oecd.org/environment/clean-energy-finance-and-investment-roadmap-of-india-21b6e411-en.htm

2.1

Status of Hydrogen Certification in India

A robust framework can facilitate the trading of hydrogen as a commodity on national and international markets. At the moment, India does not have such a framework in place and there are numerous issues and open questions to be addressed. First, the national certification processes must align with the international markets. Second, only a few voluntary certification schemes are functional and even these are not effectively monitored and evaluated. Third, a database on emissions from various hydrogen pathways is non-existent. Finally, the responsibility matrix of all the stakeholders is not clearly defined. There is an urgent need to develop certification standards and processes that infuse confidence among the stakeholders. If these are not managed properly, the green hydrogen revolution might stall.



3 Lessons Learned from Other Certification Processes

3.1 Lessons learned from RE electricity trading

One of the largest renewable energy expansion programs in the world is in India[33]. In terms of installed renewable energy capacity, it ranks fourth internationally[34]. A major factor in the sector's tremendous expansion has been policy and regulatory support for incentives to boost supply and demand. Renewable purchase obligations (RPOs), which require obligated entities like discoms to acquire a minimum proportion of power from renewable energy (RE) sources, is one such support mechanism.

The potential of RE resources is not distributed equally across the nation. Thus, the idea of renewable energy certificates (RECs) becomes important. The environmental characteristics of power produced by renewable energy sources are represented by RECs, which are 'green tradeable certificates', excluding power generated[35]. Without actually purchasing RE-generated power, RECs enable the obliged entities to fulfil their RPOs[36]. These certificates can be purchased on the national energy exchanges such as the Indian Energy Exchange (IEX) and Power Exchange of India Limited (PXIL).

At present, there are 2 types of RECs in place: solar and non-solar. The REC market segment is run in line with the Commission-approved thorough accreditation, registration, issuance, and redemption procedures as well as the Power Market Regulations and REC Regulations. A conceptual framework is detailed in Figure 6. As per the REC Regulations 2010, the REC mechanism envisages a compliance audit of the mechanism. To ensure that crucial elements of the REC Regulations are examined during the audit, the Central Agency provided a checklist to all auditors. Figure 7 illustrates the audit process.

33 https://mnre.gov.in/
34 https://www.investindia.gov.in/sector/renewable-energy#:~:text=Creating%20a%20sustainable%20world&text=India%20stands%204th%20globally%20in,Renewables%202022%20Global%20Status%20Report).
35 https://posoco.in/wp-content/uploads/2018/08/REC_REPORT_17082018_fPRINT.pdf
36 https://www.recregistryindia.nic.in/index.php/publics/AboutREC

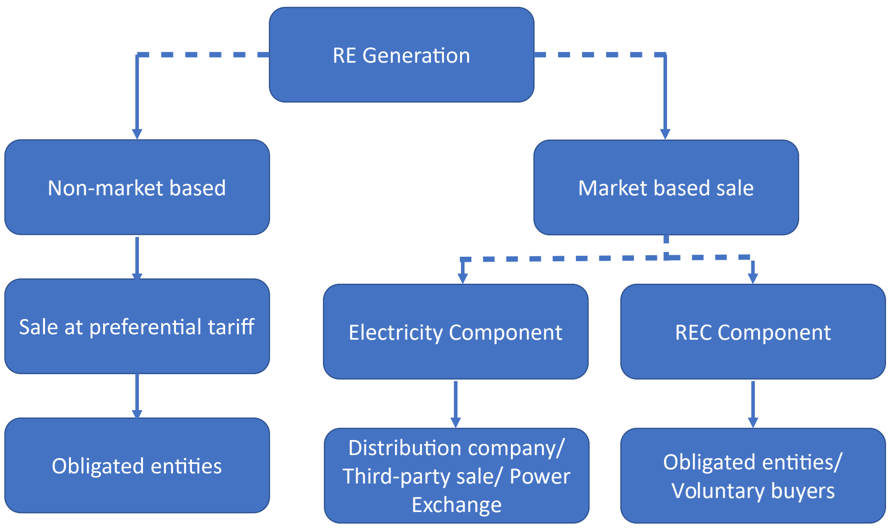


Figure 6: Conceptual Framework of REC Mechanism

Figure 7: Steps taken by Auditors for Compliance Audit of projects[4]

Some of the relevant observations provided by the Auditors during the process are:

- lack of documentation regarding usage of fossil fuel in co-gen/bagasse plants

- discrepancy between the accredited and registered plant capacity and the capacity stated in the application at the time of registration

- installation of generation meters but not auxiliary consumption meters; etc.

Other than the key observations of the auditors, some of the learnings from the REC mechanism that can benefit in the initial stage of the hydrogen certification mechanism are:

1. Avoid overreliance on regulation and observance at the state level

The current system depends on states to set RPO targets that are more credible and robust. However, long-term, stable markets are unlikely to emerge in the absence of stringent compliance legislation and enforcement actions against obligated entities. SERCs, who are tasked with enforcing RPO targets, are required to ensure that all distribution businesses and captive customers adhere to the RPO standards.

2. Importance of Voluntary Market

RECs had previously been bought by voluntary buyers, but their contribution is not significant. In order to have a better market structure, demand for RECs should grow at the same rate as the supply, which is not the case.

The International REC Standard (I-REC Standard)

An attribute-tracking system called the International REC (I-REC) enables consumers to follow and confirm their environmental goals' advancement as well as compliance with governmental renewable energy standards. This makes it possible to follow the characteristics of (renewable) power production from the point of production to the point of consumption. Factual qualities that can be tracked with the I-REC attribute tracking system include specifics like the location of the electricity generator, the type of primary energy input, the date of commissioning, the installed capacity, and the volume and time of electricity output. A digital statement, or I-REC standard certificate (abbreviated as I-REC Standard), is used to track this information. It is based on one MWh of power produced by a single-generation entity. The ability to claim the qualities of a specific generating facility belongs to the power users who own this digital assertion[37].

Steps involved in the I-REC process:

- Registering the generating facility with I-REC
- Producing renewable electricity
- Application for I-RECs
- Submitting meter readings
- Issuing I-RECs by the issuer
- Bookkeeping by Registry
- Trading of I-RECs
- Redemption of I-RECs
- Claiming the attributes of an I-REC

The I-REC tracking mechanism can help to resolve maximum issues faced by the auditors while auditing the project for REC in India and provide guidance to design a holistic hydrogen certification framework.

37 https://www.irecstandard.org/vision-for-standard-development/

3.2

Lessons learned from biofuels trading

Biofuels are typically liquid fuels obtained by direct conversion from biomass. It can be derived from a wide range of feedstock such as agricultural wastes, waste from the food, fibre, forestry, and wood industries. Although biofuels are typically employed as fuels for transportation, they can also be used for heating and energy production[38.]

International Certification Schemes

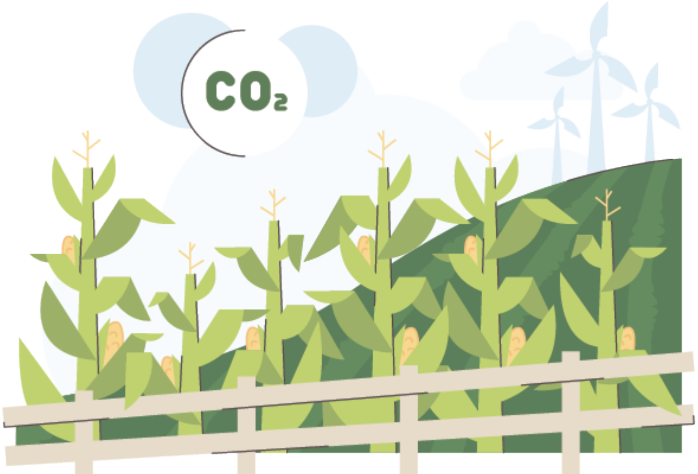
The EU's Renewable Energy Directive (RED) and Fuel Quality Directive (FQD): The directive not only provides targets to be fulfilled but also indicate criteria to be fulfilled by the biofuels to be used and this is necessary for compliance in the European Union (EU). Voluntary schemes certifying such biofuels, can be credited with increasing visibility and usage of certification schemes for biofuels originating from sustainably sourced biomass[39, 40]. Since then, the certification program for biomass and biofuels has expanded outside the EU. Certain certification programs, like International Sustainability and Carbon Certification (ISCC), Roundtable on Sustainable Palm Oil (RSPO), and others, also issue recognised credentials in India.

38 https://www.eia.gov/energyexplained/biofuels/

39 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF

40 https://eur lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0088:0113:EN:PDF#:~:text=Member%20States%20shall%20require%20suppliers,in%20paragraph%205(b).

• International Sustainability and Carbon Certification (ISCC)- This certification program applies globally and includes all forms of biomass. It supports the use of all forms of biomass in global supply chains in a way that is ecologically, socially, and economically sustainable. It is among the biggest certification programs for biomass and biofuels, with more than 25000 active certificates[41]. In India, there are a total of three certificates that are valid, including those for traders, collecting points, and biodiesel. For gathering-entities and/or producers, there is no legal certificate[42].



• *Bonsucro*- Developed by a multi-stakeholder roundtable, the Bonsucro standard is unique to the production of sugarcane. The first scheme was launched in 2005, and the certification process is applicable worldwide. It offers a thorough metric tool for sugarcane milling and growing that is sustainable. According to the ISEAL Code of Good Practice for Setting Social and Environmental Standards, the Production Standard and Chain of Custody Standard were created[43].For the Indian territory, there are a total of nine valid certificates under *Bonsucro.* Various stakeholders accredited with the *Bonsucro* Mass Balance Chain of Custody Standard include mills, farmers, smallholder farmers, and processors and traders[42].

• Roundtable on Responsible Soy Association (RTRS)- The Roundtable on Responsible Soy Association (RTRS) was founded in 2006 as a global multistakeholder project. The creation, adoption, and verification of a global standard are its key goals in order to encourage environmentally friendly soy production, processing, trading, and consumption[44]. In India, there are currently only two certified soy producers[42].

[41] https://www.iscc-system.org/process/overview/
[42] https://www.nccf.in/wp-content/uploads/2020/11/NCCF_BioFM_ConceptNote_Oct2020.pdf
[43] https://bonsucro.com/what-is-certification/
[44] https://responsiblesoy.org/sobre-la-rtrs

Lessons learned from certifying biofuels

Biofuel certification is not a recent process in the European Union. The certification of biofuels started way back in 2011. Since then, the certification process has been undergoing several critical assessments. Although not all aspects of biofuel certification are applicable to hydrogen, there are some possible synergies where hydrogen certification can benefit from what the EU has learned from the experience of certifying biofuels[45]. Some of the key challenges and lessons learned are elaborated below. Figure 8 illustrates the key factors to realise global market harmonisation learned from biofuels.

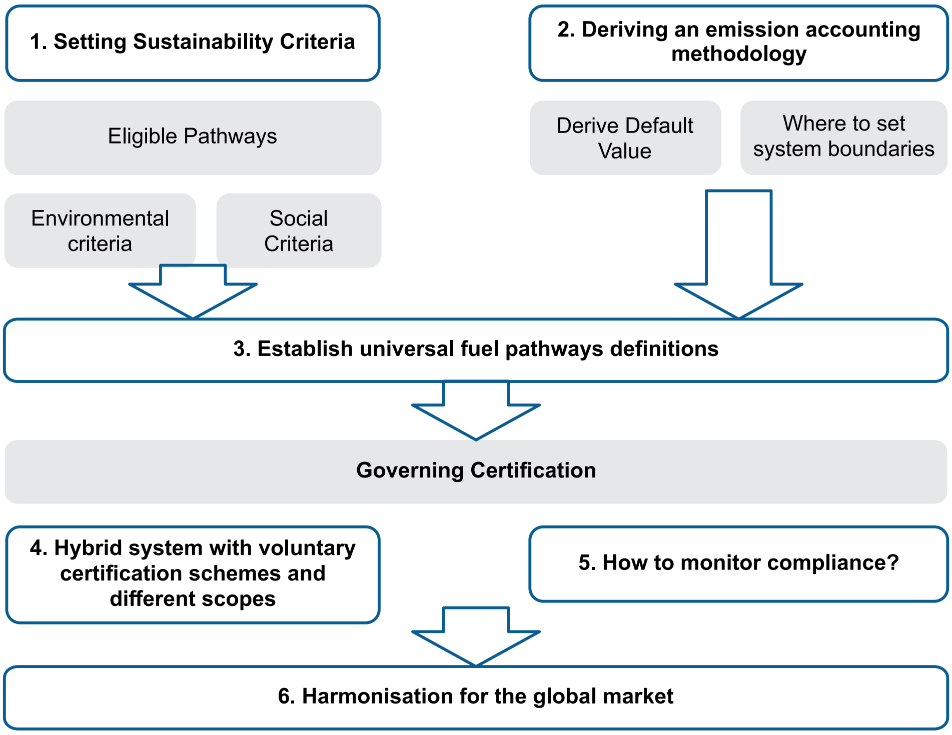


Figure 8 : Key factors to realize global hydrogen market harmonisation learned from biofuels

1. Setting sustainability criteria

Unsustainable production methods have been used as a result of the flexible certification of biofuels. It was discovered that many of the currently used biofuels from crops weren't sustainable. The regulatory specifications for the sustainability standards did not fully consider indirect effects, such as indirect changes in land use. As a result, the claimed emission reductions from biofuels were not realised[46].

In the case of hydrogen, a general agreement must be reached on which hydrogen pathways are regarded as acceptable in a climate-neutral energy system before formulating sustainability criteria.

45 https://www.sciencedirect.com/science/article/abs/pii/S0360544220322465
46 M. Riemer, "Lessons learnt from certifying biofuels for a future hydrogen certification scheme," 2022 18th International Conference on the European Energy Market (EEM), Ljubljana, Slovenia, 2022, pp. 1-7, doi: 10.1109/EEM54602.2022.9921171.

2. Deriving an emission accounting methodology

Keeping a check on the accounting for the entire value chain of biofuels is a tedious task. A standard set of values are used and always updated from time to time as it requires a robust database of life cycle emissions. 'Intersect points' in the supply chain, where responsibility is shifted to the following downstream component, are particularly significant for certification[47]. The information must be transferred in a transparent manner and the onus must be on the stakeholders of the entire value chain and not just the producers.

The repercussions of the energy carriers in the system may not always be fully captured by certification of the producer's operations, as environmental effects are not necessarily site-specific. For hydrogen, checks and balances of emissions must be initiated from the beginning.

3. Establish universal definitions

Definitions play a major role in setting the baseline for any process at the international level. If different countries use different terminologies and definitions for the same pathway, the complications increase at the time of trading. For instance, a certification system based on vague language may be deceptive. Also, the EU-level Guarantees of Origin (GO) program does not standardise the definitions of biogas and biomethane[48] which creates complications for international trading.

Studies and scenarios frequently employ the 'colour scheme' of hydrogen generation techniques. However, this does not clearly indicate the emissions that go along with them. Similarly, labels such as 'low-carbon hydrogen' that are omitted from products do not provide information on the production process or the precise emissions[49]. Different hydrogen value chains emerge depending on the location, the manner of production, the handling, and the application. For hydrogen certification, standard definitions should be set at the inception stage that is inclusive of all factors.

4. Hybrid certification

Hybrid certification refers to a public authority system that uses commercial certification programs. This regulatory framework is a part of a larger trend where states are giving market-based systems some of their authority. The World Trade Organization (WTO) laws have led to the emergence of private certification schemes in the EU to supplement governmental authority for biofuels. The sustainability requirements were less stringent in the private certification programs. The certification process was largely determined by the certification fees. The availability of many low-cost schemes hinders the quality of the audit. Although the criteria may be comparable, how they are operationalised determines the cost[46].

However, it is crucial to significantly strengthen the openness of the process, especially for the vast hydrogen market. This may be done by creating a complaint mechanism, implementing more dependable tracking systems, and choosing acceptable certification schemes.

47 https://link.springer.com/chapter/10.1007/978-3-030-02499-4_8

48 https://www.sciencedirect.com/science/article/abs/pii/S0301421520300586

49 https://www.sciencedirect.com/science/article/pii/S2214629620302425

5. Monitoring and transparency

Mass balance systems or book-and-claim systems can be used to track the chain of custody during the manufacturing of renewable fuels. Mass balancing maintains the tangible connection between the energy flow and the certificate and is more reliable. Tracking every responsible party in the supply chain, however, results in a significant administrative load. Although book-and-claim merely keeps track of the production and consumption locations, it may have cheaper administrative costs. If multiple tracking systems are used, the lack of a physical connection between the product and certification raises the possibility of double-reporting emission reductions[50].

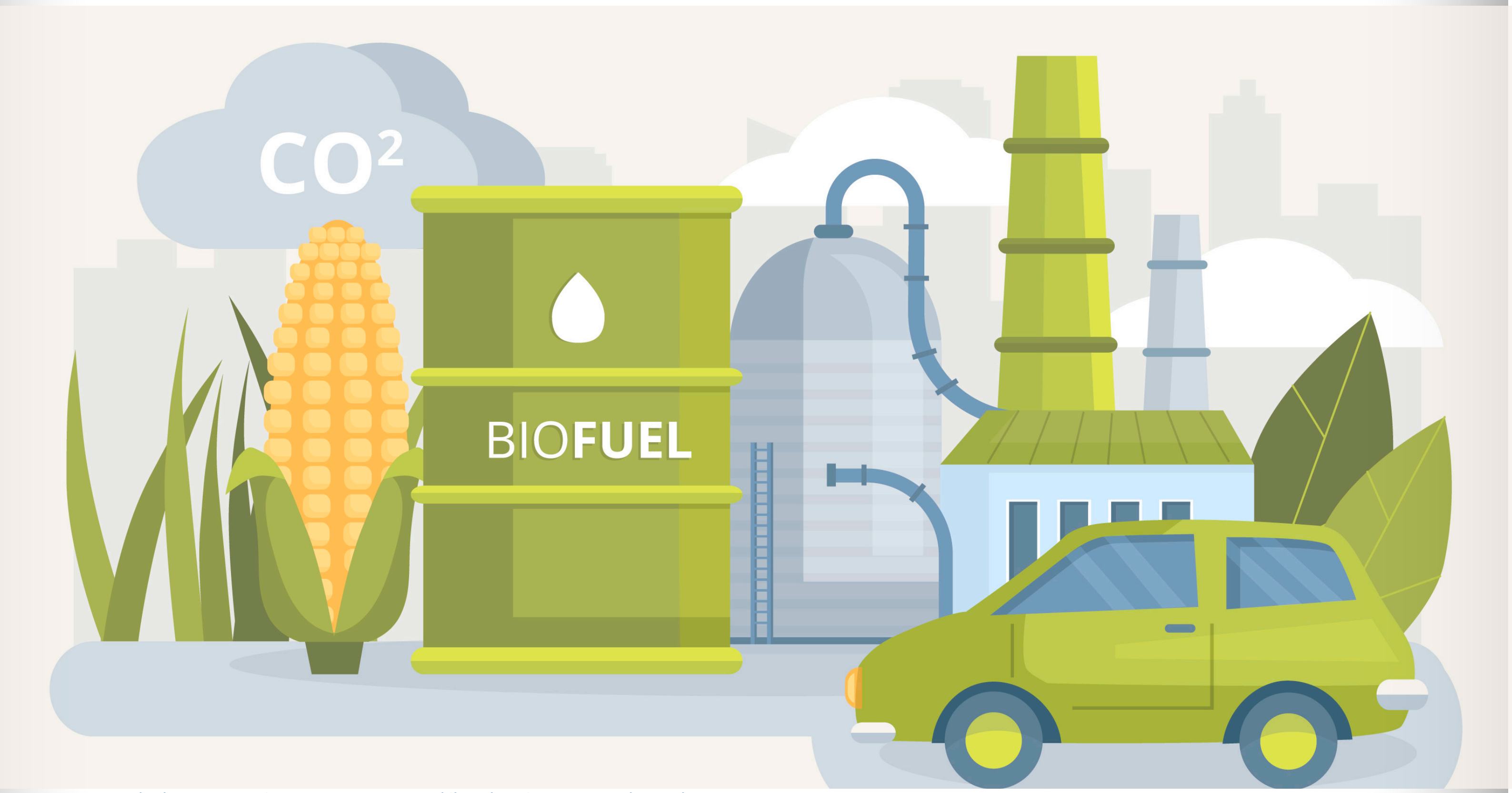
Blockchain could be used as a tool to enhance the procedure in a way that is both cost-effective and efficient.

6. Harmonisation for the global market

Regulations governing sustainability cannot be enforced with certainty since fuel producers are dispersed across a wide geographic area. With rare resources like biofuels, providers may choose to sell to clients that have less stringent requirements, and the sustainability standards won't have any guiding influence. Biofuels enabled international collaboration because feedstock was readily available, as some nations were reliant on imports owing to resource limitations.

Similarly, hydrogen will develop into a significant fuel in the future, but disparities in dominance concerning renewable energy is bound to be reflected in the market as well. Thus, a geopolitical coalition for the fuels requires global coordination for a harmonised international market.

50 https://www.irena.org/publications/2022/Mar/The-Green-Hydrogen-Certification-Brief



4 Understanding key elements of Hydrogen Certification

4.1

Importance of defining system boundary

Defining the boundaries of the value chain included in the emissions accounting for the certification process will have a major impact on market creation. Even the international traceability of the product can be facilitated by the interoperability of hydrogen certification schemes. The hydrogen value chain includes hydrogen production, transportation, storage, and end-use. Each of these broad categories has numerous processes that require energy usage thus leading to emissions as seen in Figure 9. These emissions can vary widely depending on the material and technology used during the process. Even green hydrogen after production can accrue a large number of emissions by the time it reaches the end-use facility in case the energy needed for all these processes is not supplied from renewable sources. Furthermore, on a similar line, it must be reinstated that the conversion of green hydrogen doesn't yield green ammonia, as it is based on the process and energy sources used for conversion.

Therefore, defining system boundaries is immensely important to develop an internationally acceptable hydrogen certification framework. Even existing certification schemes for hydrogen vary substantially in their system boundary considerations[51]. Moreover, leaving certain facets outside the boundary definition of the framework will not incentivise the stakeholder to bear the cost and will obstruct a reliable and transparent transfer of information across the value chain[52].

51 https://www.sciencedirect.com/science/article/abs/pii/S0301421520300586
52 https://jura.ku.dk/english/staff/research/?pure=en%2Fpublications%2Fcertification-of-the-sustainability-of-biofuels-in-global-supply-chains(615880fb-b0f8-4390-843b-62d0e6ed4bb0).html

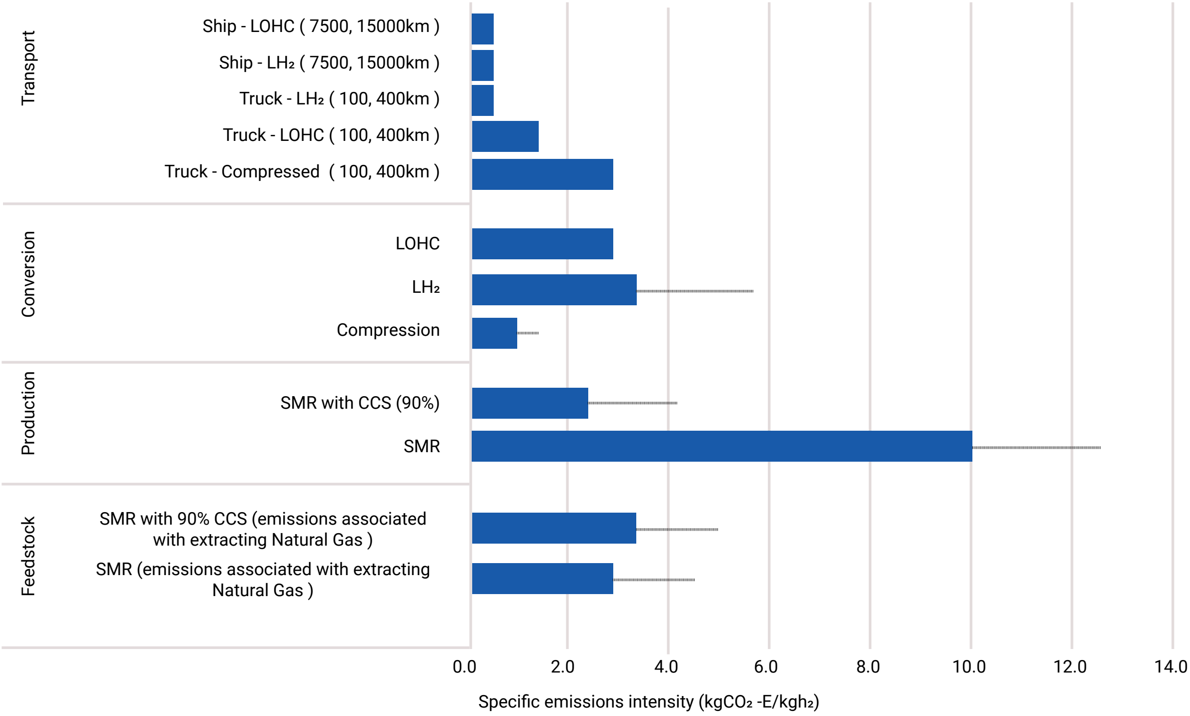


Figure 9: Emissions from Various Facets of the Hydrogen Value Chain [53]

A solution to this complex problem lies in a modular approach[54]. In this approach, each facet of the supply chain will be certified. But the onus of securing certification will be on the decision-making authority of that part of the value chain. For instance, the producer of hydrogen will be responsible to certify hydrogen for production and conversion modules. Once, the hydrogen is transferred/sold to the exporter, the onus of securing certification for the transportation attribute will be with the exporter and so on. This will reduce the administrative burden on a single stakeholder of the value chain. Also, it will allow ease of integration with international schemes.

[53] https://www.sciencedirect.com/science/article/abs/pii/S0360544220315905
[54] https://www.sciencedirect.com/science/article/abs/pii/S0360544220322465

4.2

Establish parameters to be considered in the certificates

For hydrogen certification to be accepted across jurisdictions, it will be important that enough information is provided along with the certificates and that the information provided is reliable[55]. The information on emissions is paramount as hydrogen has several routes for production, transportation & storage, and each route has a different emissions profile. Though the colour scheme is often used by scientists & researchers, it does not provide details on the emissions associated[56]. Similarly, details on electricity/fuel source, site and time of electricity production, mode of transportation of fuel, source of water, and electricity/fuel used to demineralise the water will allay concerns of the end-users and increase uptake. Transparency issues concerning production and distribution processes can be negated by ensuring clear traceability and documentation. A verifiable tracking system can support the development of green hydrogen trading and establish a mainstream marketplace.

The *decarbonising end-sectors* working group under the aegis of the International Renewable Energy Agency (IRENA) emphasised the need to verify all green hydrogen tracking systems data. Key recommendations for the creation of green hydrogen certificates and standards were developed in this regard. The working group outlined four main requirements concerning the certification of green hydrogen, as illustrated in Figure 10.

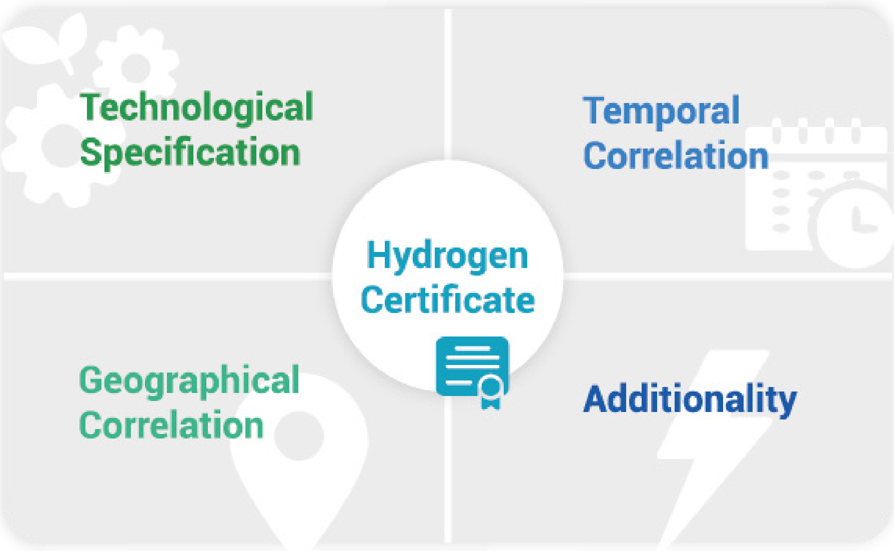


Figure 10: Key information to be included in hydrogen certificates [57]

55 https://www.researchgate.net/publication/331694633_Certification_of_the_Sustainability_of_Biofuels_in_Global_Supply_Chains_Analytical_Solutions
56 https://www.sciencedirect.com/science/article/pii/S2214629620302425
57 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://coalition.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_Green_Hydrogen_Certification_Brief_2022.pdf

Technological specifications

The certificate must convey sufficient information that provides complete transparency on the resource used to produce electricity and ensure its renewable nature.

Additionality

This feature is primarily to ensure that new additional electricity requirements do not lead to the establishment of new fossil-fuel-based capacities. It is recommended that the green hydrogen certificate should have an additionality requirement attached to them, to ensure that the development of green hydrogen capacities leads to the financing of corresponding renewable capacities to support the demand.

Temporal correlation

The certificate must provide a timestamp or specify a time interval to ensure that the hydrogen produced is from renewable sources and corresponds to the demand. This will further support the establishment of future power purchase agreements and enable robust production forecasts. A physical link is necessary to substantiate the type of electricity used in the electrolysis process.

Geographical correlation

Thus, information regarding the site of hydrogen production and the source of renewable electricity procured will help build the veracity of the green hydrogen produced.

Additionally, tracking certificates should inform on the GHG emissions produced for each kilogram of green hydrogen that can occur across its value chain, to provide credibility for classification as low-carbon or green hydrogen.

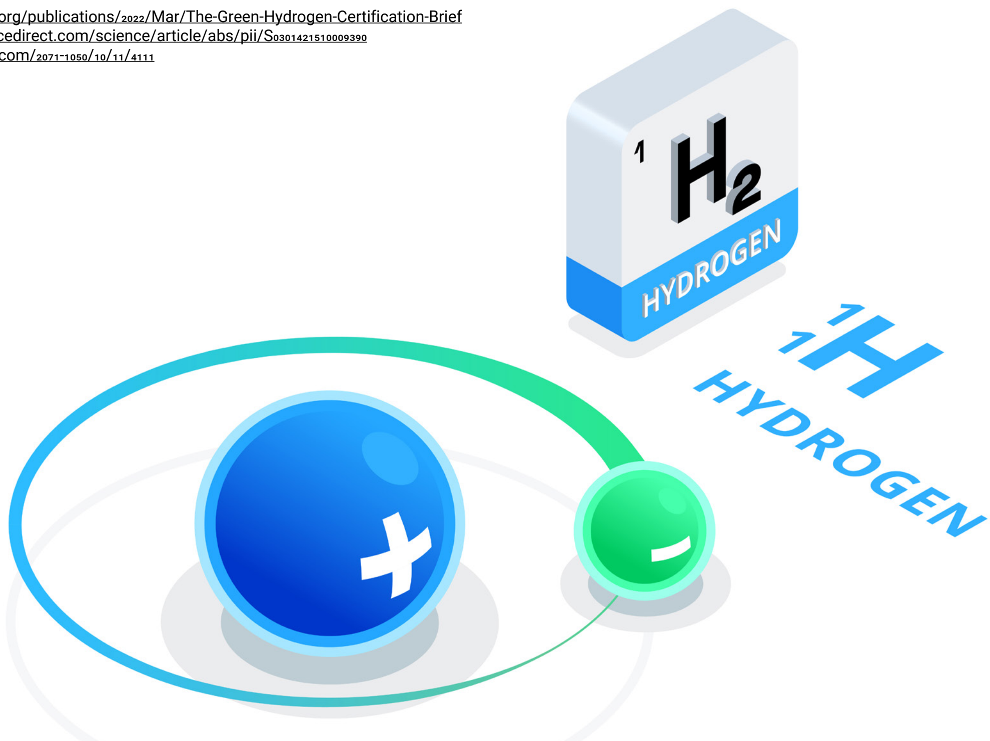
4.3

Need for tracking systems

There are two tracking systems in place for identifying the chain of custody in fuel production- Mass balance system; book and claim system. In the former, a physical link is established between the energy/fuel flow and the certificate. This system is more commonly used for biofuels like in European Renewable Gas Registry. Though, it leads to a higher administrative burden but is considered more trustworthy. However, in the latter, the tracking is carried out only at the production and consumption place leading to reduced administrative costs. This system is more commonly used to track green electricity like Guarantees of Origin in Europe and Renewable Energy Certificates in India. As per several studies, the absence of a physical link between the energy flow and certificate and integration of RE certificates can lead to double or triple counting[58]. There is a need to consider trade-offs between a robust hydrogen certification system and high administrative costs.

Moreover, continuous tracking and monitoring require rigorous effort and resources from the state actors. Thus, the usage of innovative technologies like blockchain must be explored to bring down costs. Also, the presence of voluntary certification schemes is paramount. However, these schemes must have backing from the state actors via regulatory provisions[59]. This is flowing from the fact that the presence of several voluntary schemes bears the risk of selection of only those that have less stringent processes in place[60]. In addition to state backing, there are other means to increase transparency in the process. These include releasing monitoring reports in the open domain and instituting a complaint system.

58 https://www.irena.org/publications/2022/Mar/The-Green-Hydrogen-Certification-Brief
59 https://www.sciencedirect.com/science/article/abs/pii/S0301421510009390
60 https://www.mdpi.com/2071-1050/10/11/4111



5 Hydrogen Certification Landscape Globally

5.1 Global Hydrogen Certification Projects

The hydrogen certification efforts are popping up sporadically. Although several technical standards exist for hydrogen such as 'ISO 14687' which specifies the minimum quality characteristics of hydrogen fuel that can be distributed for utilisation in vehicular and various stationary applications[61] , there is an absence of formal standards to certify the type of hydrogen produced.

It is highly unlikely that the international agreement on the scope of hydrogen certification schemes will emerge soon to forge a way for one 'harmonised' scheme[62]. These emerging schemes differ broadly in two categories- the way low carbon hydrogen is defined and the system boundary considered in the emissions accounting process. If these two parameters do not match for the two jurisdictions exploring the trade of low-carbon hydrogen, the aim of the certification process will get defeated.

The existing range of hydrogen characterisation initiatives can be categorised under hydrogen standards, Guarantee of Origin (GO) schemes, and country-led projects. These initiatives have largely been pioneered by standardisation agencies, certification bodies, and country-level initiatives developed under the scope of their respective energy and climate policies. This section captures a brief description of these major initiatives to summarise the parameters considered in global efforts so far. Key aspects such as the qualification level, list of qualifying processes, and system boundary for the respective initiatives have been studied, and a snapshot of the same is provided in Table 3. Additionally, there have also been private-sector initiatives to track green hydrogen such as the GreenH2chain platform, as described in Figure 11[63].

61 https://www.iso.org/standard/69539.html
62 https://www.sciencedirect.com/science/article/abs/pii/S0959378016302813
63 https://www.flexidao.com/case-studies/green-h2-chain-by-acciona

Character-isation Initiative	Category Type	Baseline GHG threshold	Qualification metric	Qualifying processes	System boundary defined
CERTIFHY	GO Scheme	Hydrogen via natural gas SMR	Carbon intensity ≤ 36.4 gCO_2 e/MJ of Hydrogen	All renewable processes meeting threshold with 99.5 percent purity	Point of Production
AFHYPAC	GO Scheme	None specified	Must be 100 percent renewable	Any renewable process including electrolysis powered by waste	Point of Production
CEN/CENELEC/ TC 6 standard	International Standard	Hydrogen via natural gas SMR	Carbon intensity ≤ 36.4 gCO_2 e/MJ of Hydrogen	All renewable processes meeting threshold with 99.5 percent purity	Point of Production
TUV SUD Standard	National Standard	Hydrogen via natural gas SMR	35 – 75percent emission reduction below baseline carbon intensity of 89.7 gCO2e/MJ of Hydrogen	Renewable electrolysis, biomethane SMR, and glycerine pyro-reforming	Point of Use
California LCFS	Regulation	WTW emissions from new fossil fuel vehicles	30percent lower GHG and 50percent lower NOX emissions (on WTW per mile basis)	Renewable electrolysis, biomethane SMR, thermochemical conversion of biomass including MSW biomass including MSW	Point of Use
HyXchange	GO Scheme	None specified	GHG footprint lower than 3kg of CO2/kg of H2	All processes meeting qualifying metric with 99.5 percentpurity	Point of Production

Table 3: Snapshot of Hydrogen Characterisation Initiatives[64,65]

[64] https://www.sciencedirect.com/science/article/abs/pii/S0301421520300586
[65] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://static1.squarespace.com/static/5f4522713948a17f632d7ba3/t/632f8bd596470d13401C450C/1664060375514/19_BoS3_221409_denOuden_HyXchange.pdf

CERTIFHY

The CertifHy initiative was undertaken by a consortium led by *HINICIO*[66], composed of the Association of Issuing Bodies (AIB), GREXEL[67], Ludwig Bölkow System Technik (LBST)[68], CEA (European Energy Forum), and TÜV SÜD and financed by the Clean Hydrogen Partnership. The primary objective of the initiative is to advance development in Europe concerning green and low-carbon hydrogen certification. The initiative began in 2014 and is now in its third phase of implementation. Across the first two phases, the CertifHy Scheme was conceptualised, and the Green and Low-Carbon Hydrogen labels were established. A pilot to test different procedures for GO issuing, transfer, and cancellation was conducted and this provided the basis for the first non-governmental GO scheme for Hydrogen in the world.

As described in Table 3 , the scope of the certification system covers the point of production. Hydrogen produced via Steam Methane Reformation (SMR) of natural gas forms the baseline threshold for this scheme and a carbon intensity that is less than 36.4 gCO_2e/MJ of hydrogen is considered the qualifying metric. All renewable processes which meet the threshold with 99.5 percent purity qualify for certification under this scheme.

AFHYPAC

The French Association for Hydrogen & Fuel Cells (AFHYPAC), is a consortium of various R&D institutes, regional associations, local government, regulators, and industry entities across the hydrogen value chain. A GO scheme for renewable hydrogen in France was developed under the aegis of this cohort. Each GO corresponds to 1 MWh of renewable hydrogen and would have a validity of two years from its date of origin. This scheme also featured interoperability with the country's existing electricity and biomethane scheme.

The scope of this GO scheme covers the point of production. While no baseline GHG threshold has been specified, the qualification metric requires a 100 percent renewable source of production. All renewable processes including electrolysis powered by waste have been deemed qualifying under this scheme.

CEN/CENELEC/TC 6 standard

The European Committee for Electrotechnical Standardisation (CENELEC) is a body responsible for European standardisation in the field of electrical engineering. The CEN-CENELEC Joint Technical Committee 6 overlooking the domain of hydrogen in energy systems deals with devices and processes concerned across the hydrogen value chain ranging from production, storage, transport, measurement, and end-use, from renewable energy and other sources. The scope of these standards includes terminology, Guarantee of Origin, and safety guidelines. The standard also possesses the potential to accommodate factors surrounding societal aspects and operational conditions.

The CEN/CENELEC/TC 6 standard adopts certification specifications similar to that of the CertifHy GO scheme focused at the point of production. The baseline threshold covers hydrogen produced via SMR of natural gas, and the qualifying metric is set at a carbon intensity that is less than 36.4 gCO_2e/MJ of hydrogen. All renewable processes which meet the threshold with 99.5 percent purity qualify for certification under this scheme.

[66] HINICIO is a Brussels-based strategy consultancy firm specialising in energy transition and sustainable mobility.

[67] Leading energy certificate registry provider in Europe.

[68] LBST is a German-based consulting company for energy, hydrogen, mobility, and sustainability.

TUV SUD Standard

TÜV SÜD Standard functions as the National standard in Germany for hydrogen certification. The scope of this standard is directed at the point of use and encompasses definitions and regulations for feedstocks, eligibility of production processes, GHG savings, and hydrogen delivery conditions. Under this standard, hydrogen produced from renewable energy sources including waste qualifies as green hydrogen.

The baseline against which emission intensities are compared is restricted to hydrogen produced via SMR. However, the percentage of GHG savings required for certifying green hydrogen, varies according to the method of production (process) and the intended end use. 35 – 75 percent emission reduction below the baseline carbon intensity of 89.7 gCO_2e/MJ of Hydrogen is set as the qualifying metric. Three types of green hydrogen production processes qualify under this standard - electrolysis of water using renewable electricity, steam reforming of biomethane, and pyro-reforming of glycerine (obtained as a by-product of biodiesel production). Under the first process, the renewable electricity of the electrolytic hydrogen has to be certified by one of four quality labels - TÜV-Nord/TÜV-South Green Electricity, OK Power, or Green Power Label.

California Low Carbon Fuel Standard (LCFS)[69]

Developed as a regulation by the California Air Resources Board, the LCFS aimed to reduce carbon intensity (CI) of the transportation fuel pool by at least 20 percent by 2030. The regulation sets annual CI benchmarks for gasoline, diesel, and the fuels that replace them. These benchmarks are made progressively stringent over time. The CI is expressed in grams of carbon dioxide equivalent per megajoule of energy provided by the respective fuel. CI takes into account the GHG emissions across the lifecycle of the fuel ranging from production, transport, and end consumption. The LCFS also determines the mix of fuels to be used to reach the program targets through the market.

Similar to the TUV SUD Standard, the system boundary has been defined at the point of use. Well-to-Wheel (WTW) emissions from new fossil fuel vehicles are considered the baseline GHG threshold under this regulation. A qualifying metric of 30% lower GHG and 50% lower NOX emissions (on WTW per mile basis) has been marked under this regulation. The qualifying processes recognised under this regulation are - renewable electrolysis, biomethane SMR, and thermochemical conversion of biomass including municipal solid waste (MSW).

HyXchange[70]

HyXchange is the hydrogen exchange initiative that supports the development of a hydrogen market hub around the planned Dutch hydrogen transmission pipeline infrastructure. This initiative holds significance to European hydrogen supply and imports from outside the EU. HyXchange further aims to accelerate hydrogen trading by enabling the exchange of certificates, more specifically GOs for low carbon and renewable hydrogen. A pilot version of a GO scheme for hydrogen supported by the Information and Communication Technology (ICT) platform developed and operated by Vertogas, which is the government-designated GO issuing body. The pilot saw active participation from 18 energy companies.

Similar to the CertifHy scheme, the system boundary was defined at the point of production. While no baseline threshold was defined under this scheme, a qualifying metric of GHG footprint lower than 3kg of CO_2/kg of H_2 was set. All processes meeting 99.5 percent purity is deemed qualifying under this scheme.

[69] https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard
[70] Tilburg. J. Hinicio. 2022

Figure 11: GreenH2chain Platform

The GreenH2chain platform is a blockchain-based solution that guarantees the renewable origin of hydrogen. It was developed by a Spanish energy company - ACCIONA Energía, in collaboration with a prominent Renewable Energy monitoring software company – FlexiDAO, to provide a credible hydrogen certification mechanism accessible to their consumers. This platform enables renewable hydrogen consumers to verify and visualize the entire green hydrogen value chain in real time and from anywhere in the world. Additionally, consumers can access all the necessary information on their hydrogen consumption as well as data for calculating the abatement of carbon dioxide (CO_2) emissions. As part of an ongoing pilot initiative, the platform has been implemented in Mallorca (Spain) in the Power to Green Hydrogen project, designed to create a green ecosystem on the island also known as *Green Hysland.*

5.2

Key Takeaways from leading countries on Hydrogen Certification

Australia

In Australia, a string of hydrogen projects is underway as a part of mobility solutions, gas blending projects, and other decentralised energy trials. There are several export projects being planned in the region to cater to international demand markets, with the 50 GW[71] western green energy hub being the largest among them. Most upcoming projects are dependent on hydrogen produced from electrolysis and over 40 projects in the country are scheduled to be paired with renewable energy projects to supply renewable hydrogen. Thus, there is a definite need for a hydrogen certification mechanism to transparently meet the demands of domestic and international markets.

The Australian Government is a key member of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) which has a mandate to promote the development of advanced industry standards to enable international trade. In 2020, a hydrogen production analysis taskforce (H2PA) was formed to develop a methodology for determining the emissions associated with the production of hydrogen under the aegis of IPHE. In light of achieving harmonised regulation and standards for international interoperability, the outcome of this task force is critical. However, the duration for the development, adoption, and assimilation of the developed standards among member countries remains unclear.

In accordance with the Australian national hydrogen strategy, an industry-led GO scheme *(Zero Carbon Certification Scheme)* was launched through the Smart Energy Council's Hydrogen Australia Division. The qualifying metric for the Scheme is that the energy sourced to produce hydrogen must be 100 percent renewable. The certification audit will provide an assessment of all direct and indirect greenhouse gas emissions associated with the production and storage of the renewable hydrogen produced at the project site. This will include an assessment and confirmation that 100 percent renewable electricity was used in the hydrogen production process. The scheme promotes the uptake and distribution of renewable hydrogen products and their derivatives in Australia and overseas by assessing the embedded carbon in hydrogen, ammonia, and metals produced within the participating facilities. The scheme is hailed as a necessary intervention to build trust among the stakeholders and establish a framework for furthering certification efforts of renewable hydrogen in the long term.

[71] https://storage.googleapis.com/converlens-au-industry/industry/p/prj1a3de348a6c0ad7d282f7/public_assets/Discussion%20paper%20-%20A%20Hydrogen%20Guarantee%20of%20Origin%20Scheme%20for%20Australia.pdf

The Federal Government Department of Industry, Science, Energy and Resources is in the process of developing a Guarantee of Origin (GO) Scheme for domestically produced hydrogen. The adopted approach looks into certification of hydrogen from gas-based steam methane reformation (SMR), coal gasification, and electrolysis, with a focus on production-side emissions. The GO scheme aims to operate on a 'cradle-to-gate' methodology where the system boundary extends from tracking the emissions produced from the point of production, to the point of first sale, before it is transported to the consumer.

Amidst the upcoming certification mechanisms in development, the Australian hydrogen strategy upholds its primary focus as verification of the production capability of those industries that claim renewable credentials. While the development of a certification scheme focussing on renewable hydrogen and its derivatives is expected to drive an uptake in renewable production methods, it also holds the potential to drive down its cost of production. Further, certification measures will enable consumers to recognise renewable products, thus promoting a demand-led shift to the use of renewable hydrogen.

Germany

Germany aims to achieve its net-zero emissions target by 2045. Various studies undertaken by governmental agencies with Germany's previous net-zero target to achieve 95 percent GHG reduction by 2050, estimate the mean hydrogen demand to be 7.2 MtH2 per year by 2050[72]. As of 2020, Germany produced 1.7 MtH2 from non-renewable fuel sources[52]. In light of net-zero targets, the hydrogen demand will inevitably shift to hydrogen produced from renewable sources.

With regard to infrastructure for hydrogen, Germany possesses 390 km of hydrogen pipelines, three methanol terminals and two ammonia terminals[52]. Germany also has an additional 1700 km of hydrogen pipelines under development and targeted to be commissioned by 2030[52]. Germany's push for low-carbon hydrogen is reflected in its electrolysis projects pipeline of 16.7 GW[52]. The largest project has a capacity of 10 GW and aims to produce 1 MtH2/year using offshore wind by 2035, and at least 5 GW of the project is expected to be deployed by 2030[52.]

As an indirect form of operating a hydrogen certification mechanism, Germany employs the Renewable Energy-Act Ordinance (EEG) which was introduced to regulate the renewable electricity market. Electricity consumers in Germany bear additional costs attached to electricity from renewable sources via an EEG levy. Based on criteria that is consistent with certification standards, the German government aims to exempt hydrogen produced under such conditions, from the EEG levy. The criteria for hydrogen production to be exempted from the EEG levy is described in Table 4.

72 https://www.irena.org/Publications/2022/Nov/Accelerating-hydrogen-deployment-in-the-G7#:~:text=Launched%20by%20the%20G7%20in,implementation%20of%20existing%20multilateral%20initiatives.

Table 4: Criteria for exemption of hydrogen from EEG Levy

Parameter	Criteria for Hydrogen Produced
Renewable Characteristic	The electricity consumed for hydrogen production must be 100 percent renewable. If the electricity derives grid-connected electricity, then additional proof in the form of a GO for renewable electricity must be provided.
Additionality	The electricity installation must not be a subsidised entity.
Geographical correlation	85 percent of the electricity used for hydrogen production must be sourced in Germany. A maximum of 15 percent can be sourced from neighbouring countries that are connected to the German power grid.
Temporal Correlation	The maximum time difference between the electricity sourced and the hydrogen production (for a direct connection) is set at 15 minutes.

The German Energy Agency is currently undertaking a study[73] to assess the feasibility of a globally compatible certification system for renewable hydrogen. Various hydrogen regulations and standards such as the CertifHy GO Scheme, dena Biogasregister, TÜV Süd CMS 70, China Hydrogen Alliance's Standard, the Certification Scheme of the Japanese Prefecture Aichi, the Californian Low Carbon Fuel Standard, and the EU Renewable Energy Directive II are under study to check for their harmonisation potential.

73 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.adelphi.de/de/system/files/mediathek/bilder/The%20role%20of%20clean%20hydrogen%20in%20the%20future%20energy%20systems%20of%20Japan%20and%20Germany%20-%20Study.pdf

Japan

In 2020, Japan's hydrogen production hovered around 2 million tonnes[70]. 50 percent of this hydrogen was derived from fossil gas reforming and 5 percent was attributed to coal[70]. The balance was obtained as a by-product of steel, steam cracking, and Chlor-alkali processes. Refineries generate 90 percent of the hydrogen demand and the balance demand is primarily attributed to ammonia production[70].

Japan's Ministry of Economic, Trade, and Industry (METI) has constituted a working group to decide on policies concerning hydrogen and ammonia. Certification of low-carbon hydrogen was prioritised an important facet for development which was also reflected in Japan's sixth strategic energy plan which placed emphasis on hydrogen. The country has set a target to achieve 1 percent of total electricity generated to be from ammonia and hydrogen.

The Council for a Strategy for Hydrogen and Fuel Cells (CSHFC), established by METI in 2013, had initiated discussions on the need for a low-carbon hydrogen certification system under a sub-Working Group. The members of CSHFC ranged from industry stakeholders from gas companies, automobile sector, chemical sector, manufacturing sector, media representatives, and local government authorities to discuss facets associated with hydrogen fuel cells. A categorisation based on carbon intensity was proposed as an outcome of the working group – 1 star rating if carbon intensity ranged from 1.0-3.5 kg-CO_2/kg of H2, 2 star rating if carbon intensity ranged from 0.7-1.0 kg-CO_2/kg of H2, 3 star rating if carbon intensity ranged from 0.4-0.7 kg-CO_2/kg of H2, and 4 star rating if carbon intensity ranged from 0.1-0.4 kg-CO_2/kg of H_2.

A regional initiative to certify low-carbon hydrogen production was developed in 2018 by the Aichi Prefecture[74]. The qualifying processes under this initiative were hydrogen produced from renewable electricity, biogas, or derived as a by-product of sodium hydroxide. Apart from certification, the scheme also measures the actual CO_2 emissions from the hydrogen production process. Currently, five projects[75] undertaken by the Toyota Motor Corporation, have been certified under this scheme and consume low-carbon hydrogen.

[74] Area of local government. Japan constitutes 47 prefectures.
[75] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://periscopekasaustralia.com.au/wp-content/uploads/2022/01/Periscope-Analysis-Paper-Volume-7-DD08.pdf

6 Stakeholder Consultations

6.1 Methodology

This report has been prepared as a voluntary initiative to bring forth key inputs from stakeholders across the value chain. It focuses on pertinent questions that will aid in developing the hydrogen certification framework for India. 34 respondents from around 27 organisations playing different parts in the hydrogen value chain were approached for a direct discussion. Stakeholders engaged in this discussion can be divided into three broad categories-

- Government- State Nodal Agencies, Public-Sector Undertakings, and Research and Development Centres.
- Hydrogen Industry- Hydrogen equipment manufacturers, hydrogen developers, hydrogen end-use industries, hydrogen storage players, and more.
- Hydrogen experts, think tanks, financial institutions, academicians, and more.

The questionnaire discussed with the stakeholders is attached in Annexure-I for reference.

6.2

Key Outcomes of the Survey

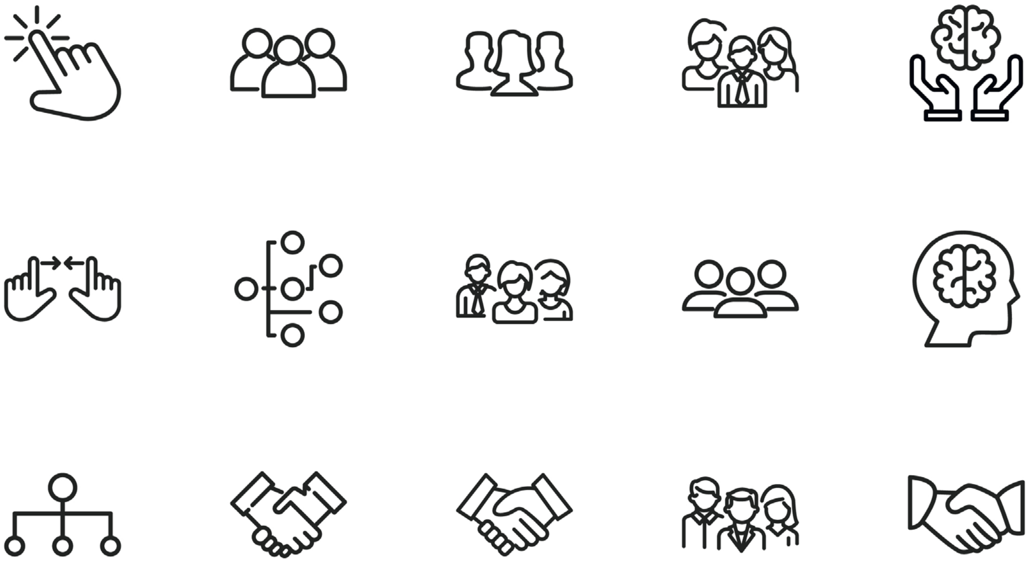
The survey resulted in unanimous agreement among all the survey respondents on the need for a robust hydrogen certification framework to support a green hydrogen ecosystem in India. It was observed that the hydrogen certification process must not include the environmental impacts of water use, or issues of social justice. This stems from the fact that hydrogen certification process must not be devised on biased footing as other competing biofuels like bio-methane are not required to incorporate these externalities[76] . This section captures the key inputs received from the hydrogen value chain stakeholders on various critical aspects of the certification framework.

Mapping Hydrogen Value Chain Stakeholders

We have used a multi-method approach (literature review and demonstration projects) to identify the key stakeholders in the hydrogen value chain. It is an important tool to systematically understand key stakeholders that have a significant impact on the decision-making process. Finally, we bucketed the stakeholders into six broad categories as seen in Figure 12. It was ensured that respondents are considered for the survey from all these broad heads.

Figure 12: Stakeholders in the hydrogen value chain

76 https://www.sciencedirect.com/science/article/abs/pii/S0301421520300586



Basis of hydrogen certification

Colour-based classification is restricting and furnishes little information on the associated emissions. Also, it does not account for future production processes and hence might require frequent updates. Carbon intensity-based classification also provides flexibility to accommodate multiple value chain pathways to be considered in the analysis. Even globally, various standards follow the similar classification approach. For instance, *Green Hydrogen Standard* (GH2) necessitates that green hydrogen projects must operate within a carbon emission intensity metric (<= 1 kg of CO_2/kg of H2) on average when considered over a 12-month period[77]. Concomitantly, as observed in Figure 13, a majority of respondents (70.59 percent), preferred a carbon-intensity based hydrogen certification framework.

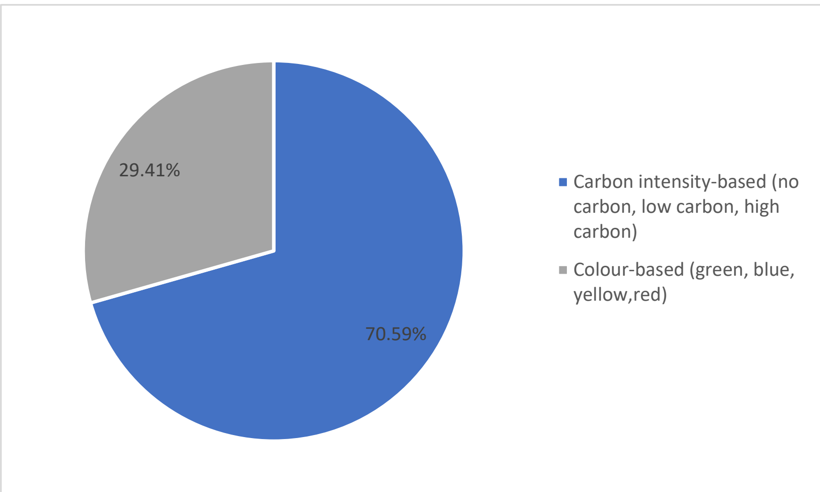


Figure 13: Basis of hydrogen certification

77 chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://gh2.org/sites/default/files/2022-05/GH2_Standard_2022_A5_11%20May%202022_FINAL_REF%20ONLY%20%281%29.pdf

Grouping of Hydrogen Production Methods based on carbon-intensity

It was proposed by the respondents that grouping of hydrogen production methods based on carbon intensity should be carried out once emissions profile for each facet is recognised in the Indian context. Still, some indications are available at the global level based on the International Partnership for Hydrogen and Fuel Cells (IPHE) working paper. As observed in Figure 14, a majority of the respondents attested to hydrogen produced via electrolysis using renewable electricity, and electricity produced from nuclear power plants to be classified as a no-carbon category of hydrogen production. Similarly, for low-carbon classification, hydrogen produced from coal gasification or steam methane reforming integrated with carbon capture systems (CCS), and biological processes were the preferences for consideration. Low carbon hydrogen pathways can provide transition to no carbon pathways in the long-term to achieve net zero target.

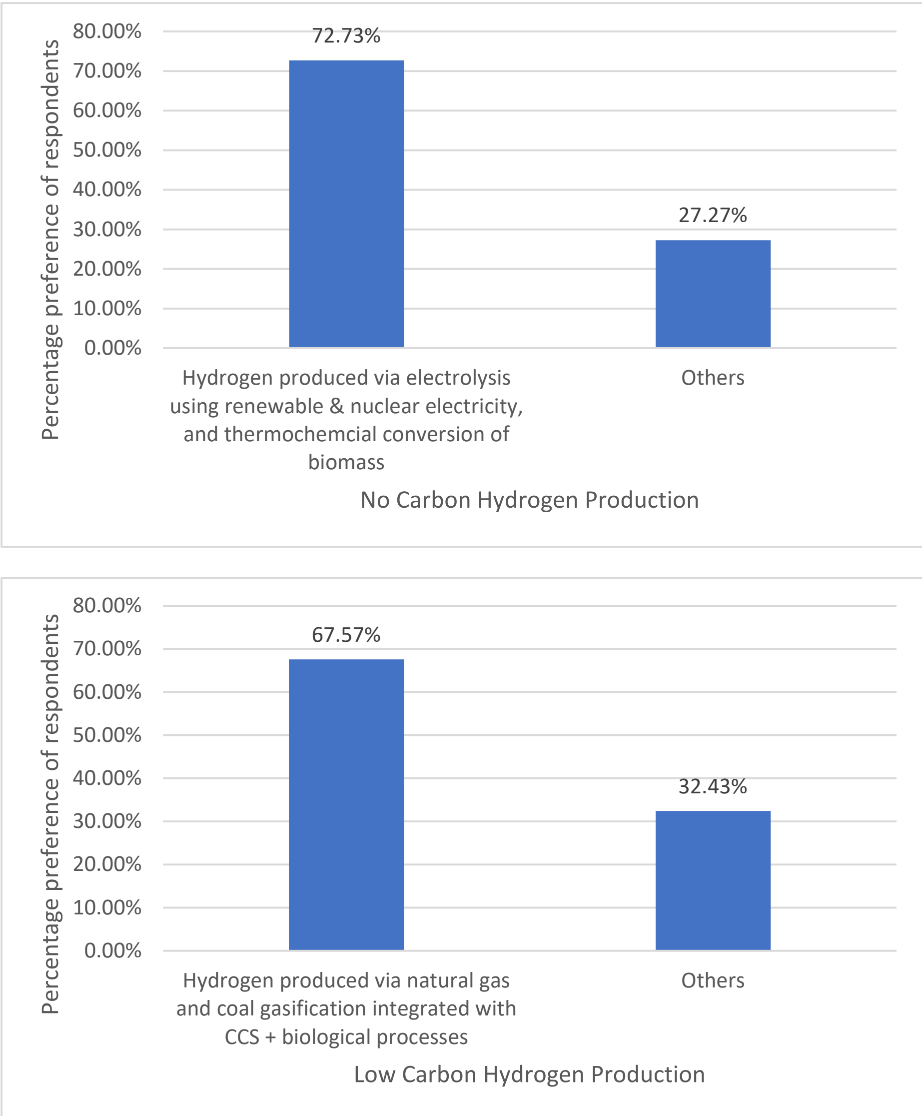


Figure 14: Grouping of hydrogen production methods based on carbon intensity

Additional Certification for Long-Distance Transport Medium

Owing to hydrogen's low energy density by volume, long-distance transportation of the fuel is economical when converted into a more energy-dense liquid. In light of India's bid to transform into a green hydrogen export hub as declared in the National Green Hydrogen Mission, this section aimed to determine the need for additional certification of the transport mediums for long-distance supply of hydrogen. As illustrated in Figure 15, most of the respondents (67.65 percent) notified their preference for an additional certification of hydrogen transport medium such as ammonia and liquid organic hydrogen carriers (LOHC) such as Toluene. However, the certification process can get exponentially more complex for these derivatives. Thus, it can be taken as a next step to the hydrogen certification scheme.

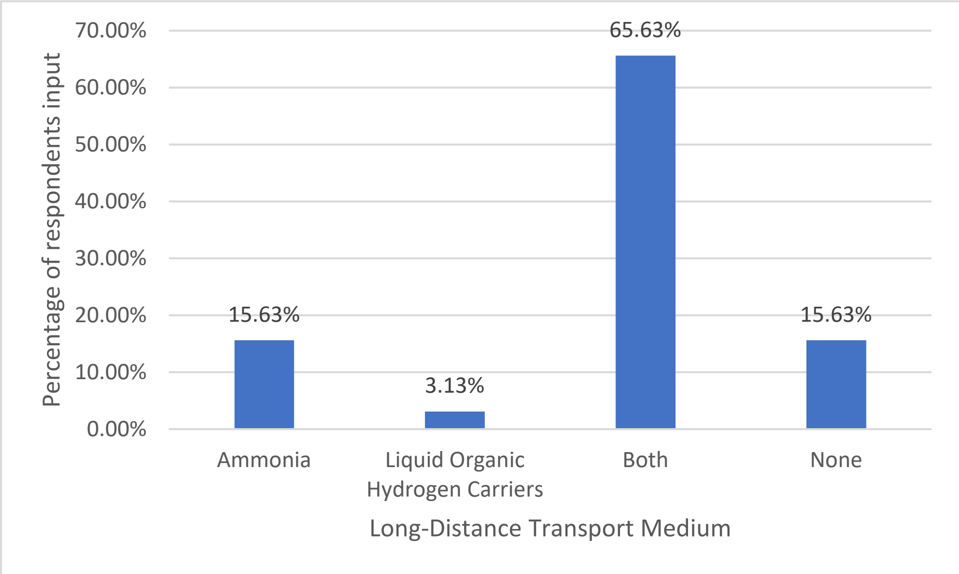


Figure 15: Requirement of additional certification for long-distance transport medium

System boundary for emissions accounting

As observed in Figure 16, most of the respondents preferred the system boundary to expand beyond the hydrogen production stage to include storage, transportation, and distribution stages. 44.12 percent of the respondents preferred the system boundary to extend across the value chain until point of use, which also included the process conversions to hydrogen carriers. 26.47 percent of the respondents preferred a modular approach to certifying hydrogen at various stages of the supply chain. This modular approach will also assist in prompt issuance of certificates at each stage. However, the downstream stakeholders of hydrogen value chain preferred keeping system boundary to hydrogen production since it is remote from their operations. This is similar to the widely used system boundary by the CertifHy GO scheme which defines the point of hydrogen production.

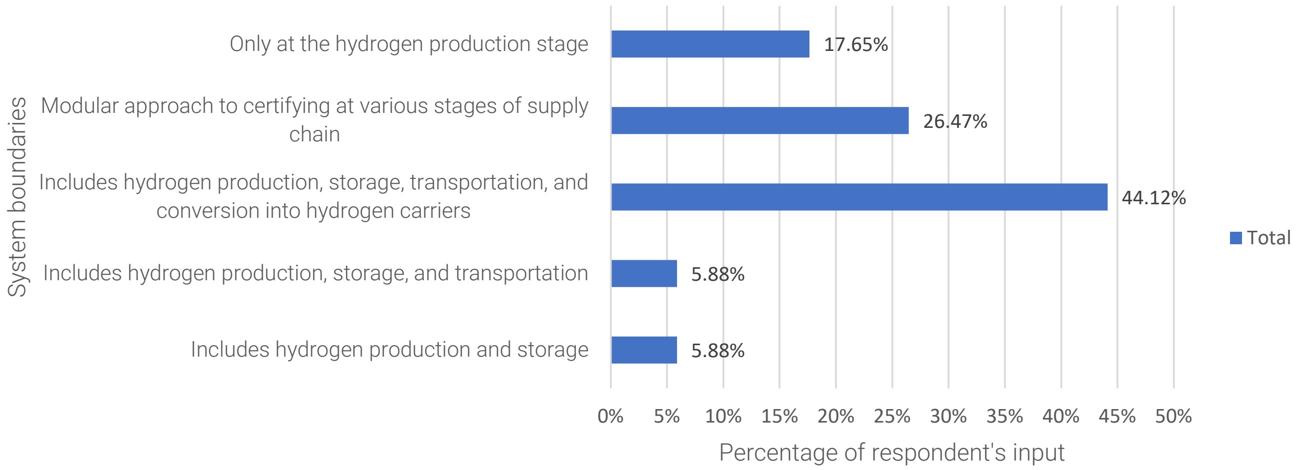


Figure 16: System boundary for emission accounting

Emissions accounting at hydrogen production: Elements to be considered

A holistic view of the supply chain warrants a detailed account of the emissions at the point of hydrogen production. Apart from the process of hydrogen production, emissions occur during the transport and procurement of the raw material. As observed in Figure 17, 73.53 percent of respondents conveyed the need to include emissions during raw material acquisition and transport along with that of hydrogen production.

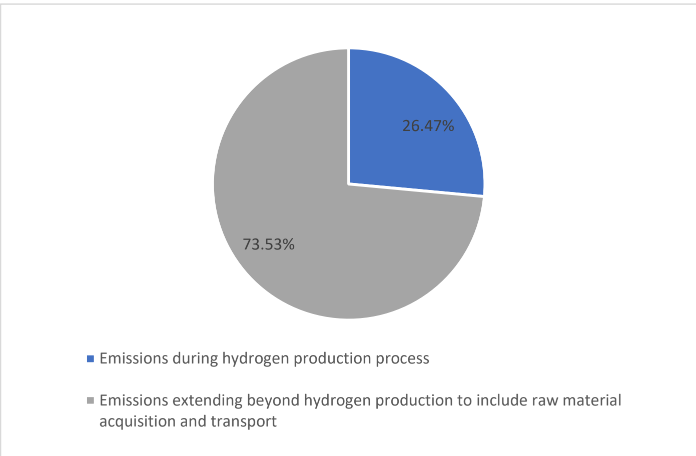


Figure 17: Emission elements to be accounted at hydrogen production stage

Information on hydrogen certificate

As previously discussed, the type of information furnished in the hydrogen certificate determines its credibility across jurisdictions among the concerned stakeholders. The key information points considered essential for inclusion in the hydrogen certificate are mentioned in Figure 18. The respondents were allowed to select more than one parameters. As per their responses the source of electricity/fuel used, mode of transportation of the fuel used, and the source of water, are deemed most important. Further, granular information such as details on the consumption and discharge of water, is also favoured in various international certification schemes. Finally, the data on fugitive hydrogen emissions must find a place in the entire GHG emissions accounting exercise as hydrogen is considered to have 100-year Global Warming Potential (GWP) of 5.8. As per estimates, hydrogen leakage rate of 1 percent would be similar to 0.6 percent leakage rate from the global fossil fuel industry in the scenario where a total replacement with hydrogen industry is considered[78] .

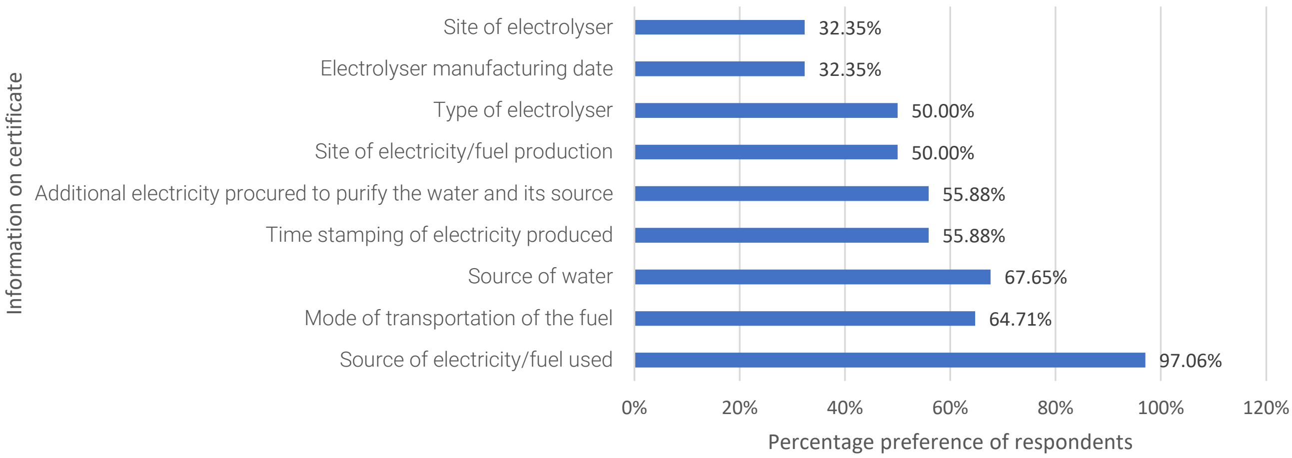


Figure 18: Information to be included in the hydrogen certificate

Verification of data furnished in the certificate

As observed in Figure 19, 82.35 percent of the respondents preferred an independent third-party agency functioning under a government approved framework to ensure credibility of the data furnished in the hydrogen certificate. This arrangement falls under the hybrid certification framework which emboldens market-based mechanisms similar to biofuels. This will reduce burden on the government to independently verify all projects. The independent agency must look into measurement and verification of hydrogen production data in a timely manner whilst also verifying the plant setup.

78 https://www.researchgate.net/publication/228402009_Global_environmental_impacts_of_the_hydrogen_economy

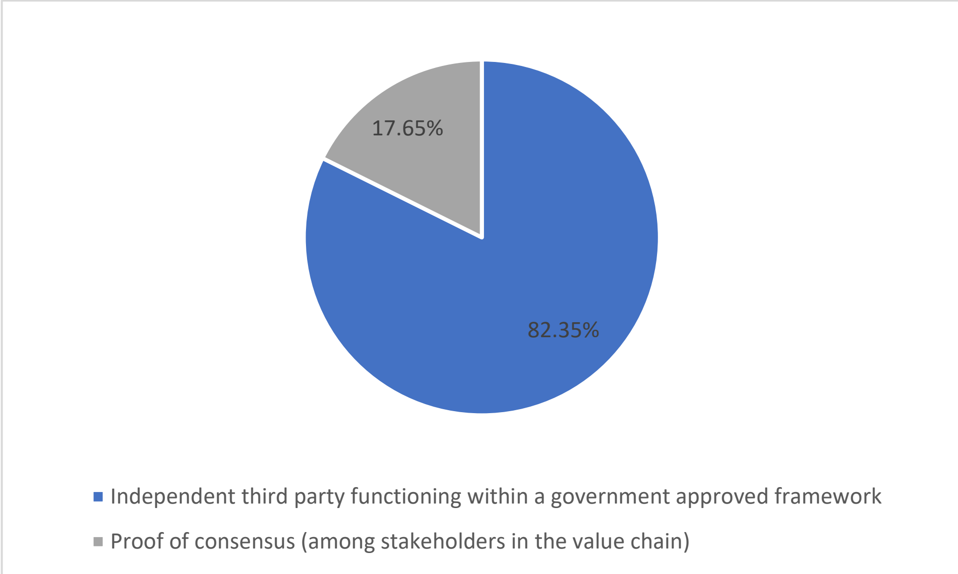


Figure 19: Preferred approach for certificate data verification

Approach for hydrogen tracking framework

For efficient tracking of hydrogen along the value chain, a majority of the respondents (70.59 percent) preferred technological innovations like blockchain-based decentralised portal as the way forward as illustrated in Figure 20. A minor 8.82 percent of the respondents indicated a preference to carry forward a centralised authority-based portal similar to that of Renewable Energy Certificates (RECs).

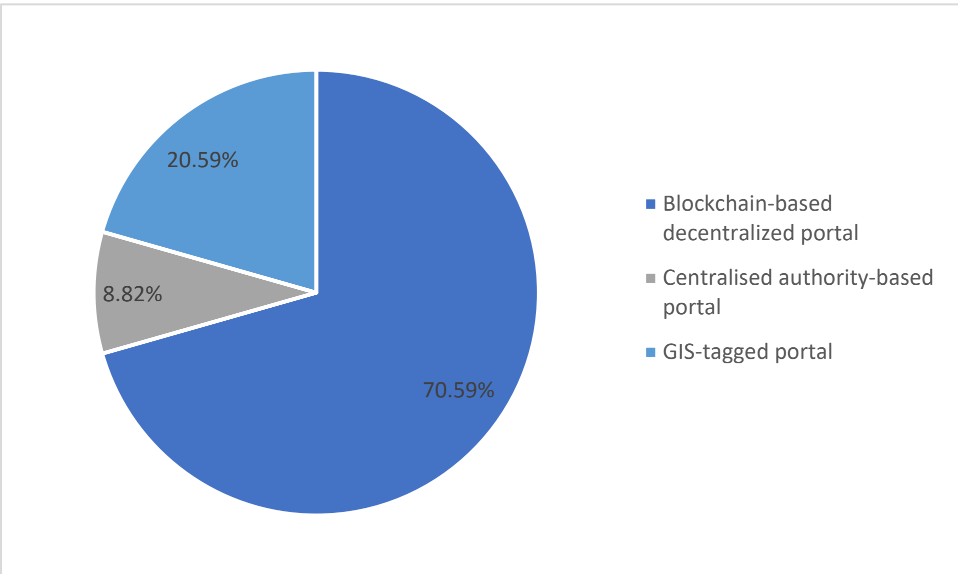


Figure 20: Preferred approach for hydrogen tracking framework

Interlinkage with Renewable Energy Certificates (RECs)

As the hydrogen market is still nascent and the cost of Round-the-Clock (RTC) supply from RE is on the higher end, inclusion of RECs along with grid electricity can be looked at for catalysing hydrogen uptake. As illustrated in Figure 21, 64.71 percent of the respondents indicated a preference for interlinkage of the hydrogen certificate with RECs.

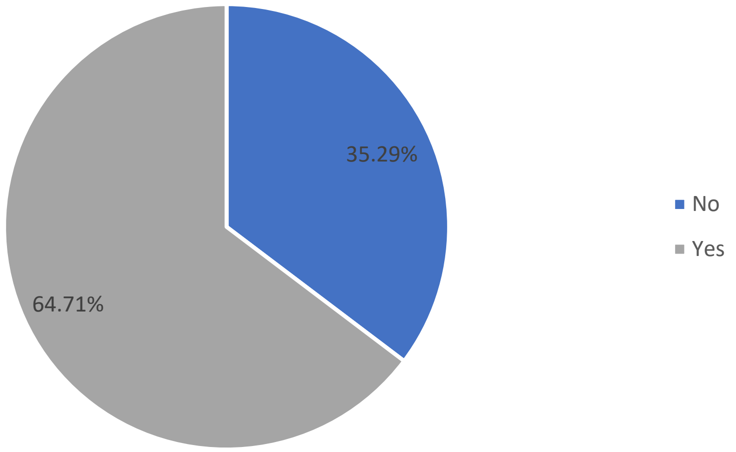


Figure 21: Preference for REC Interlinkage

Preferred Tracking System

Majority of the respondents (53.1 percent) are inclined towards a tracking system where fuel and certificate are traded in tandem as illustrated in Figure 22. This kind of system is indicative of a preference to *mass balancing* system instead of *book and claim* method of tracking.

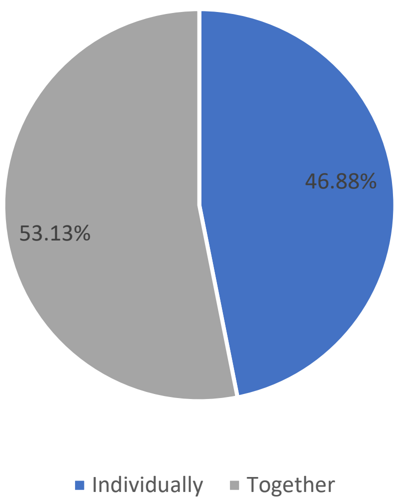


Figure 22: Preference for tracking hydrogen certificates

Floor and Ceiling Price for Hydrogen Certificates

Floor and ceiling prices are extensively used in RECs. However, majority of the respondents (64.71 percent) are wary of carrying forward this feature for hydrogen certificates as illustrated in Figure 23. This is driven from the idea that these prices will deter efficient functioning of hydrogen market.

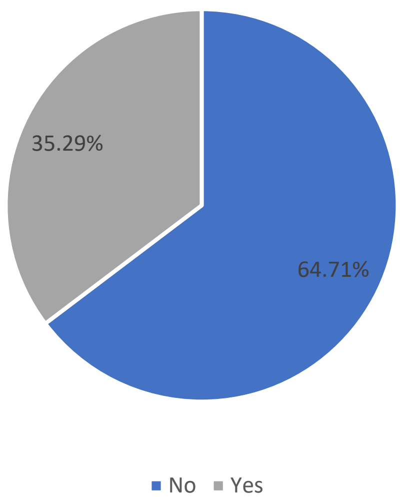


Figure 23: Preference for inclusion of Floor and Ceiling Price

7 Key Recommendations

Global experiences showcase that two different hydrogen certification schemes can lead to a significant difference in GHG emission balances. These differences can severely hamper hydrogen market creation which is a prerequisite to making this vector attractive. Thus, a decision must be made to develop a hydrogen certification framework at the earliest to allow an increase in investments in the hydrogen ecosystem and ultimately realise net-zero targets. Also, there are several countries leading in hydrogen production and end-use applications that are focusing to improve the regulatory environment to foster hydrogen up-scaling and gaining global dominance. As India shares the same ambition, it is an opportune time for India to iron out issues in the hydrogen ecosystem to facilitate trade at the national and international levels. This section highlights a few key recommendations bucketed in three broad themes that can be a guiding light to developing a hydrogen certification framework for India-

1
Creation of a hydrogen board

A board to be instituted under the aegis of the Ministry of New and Renewable Energy (MNRE) that will review hydrogen certification system on an annual basis. Key functions of the board are:

o Institute a project to carry out emission estimates for India based on the various pathways of the hydrogen value chain at the earliest. Even the geographical context will play a key role in grouping various hydrogen production processes. There is some work done in this sphere by International Partnership for Hydrogen and Fuel Cell (IPHE) at the global level[79].

o Examine the scope to widen the boundaries of emission assessment in accordance with emerging best practices.

o Create a pilot project in a hydrogen hub for understanding the intricacies of hydrogen certification. The pilot could also demonstrate areas to streamline administrative costs.

o Clarify whether certificates are based on lower or higher heating temperatures of hydrogen.

o Specify the time duration to carry out accreditation of the certificates.

o Ensure release of certificates in a timely manner to accelerate hydrogen deployment.

o Create a robust user manual to ensure transparency across the ecosystem.

o Create a hydrogen registry that issues, tracks, and redeems certificates.

o Establish a complaint monitoring system, to further infuse trust and transparency in the system.

o Explore possibility of integrating RECs with the hydrogen certificates in the initial phase to boost hydrogen uptake.

o Explore possibility of providing leeway to consume certain percentage of grid electricity until costs of Round-the-Clock supply of RE reaches grid parity.

o Publish and monitor reports.

[79] https://www.iphe.net/iphe-working-paper-methodology-doc-oct-2021

2
Modalities of Hydrogen Certification Framework

o Focus on the carbon-intensity-based classification of hydrogen (No Carbon/ Low Carbon/ High Carbon)

o For now, the no-carbon hydrogen processes must include hydrogen produced via electrolysis using renewable and nuclear electricity. And for low-carbon hydrogen, processes like coal gasification or steam methane reforming integrated with carbon capture systems (CCS), and biological processes can be considered. All other processes fall under the bucket of high-carbon hydrogen.

o Focus on creating a separate certification process for hydrogen derivatives. However, it can be considered in the medium-to-long term.

o Extend system boundary for emissions accounting across the value chain until the point of use.

o Incorporate at least the source of electricity/fuel used, the mode of transportation of the fuel, and the source of water in the certificates.

o Follow a hybrid certification process where the voluntary certificate schemes are drawn on the guidance provided by the hydrogen board.

o Employ technological innovations like blockchain to create a decentralised tracking portal.

o Use the mass balancing system for hydrogen similar to biofuels.

o Avoid having a floor and ceiling price in place to ensure the smooth functioning of the hydrogen market.

3
Explore International Collaboration

India is already a part of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). It must use advocacy to nudge global community to arrive at an internationally acceptable certification scheme.

Annexure – Survey Questionnaire

1. Select the benefits of a robust hydrogen certification framework (Please select * options as deemed appropriate) Check all that apply.

- Incentivise end-users to commit to using clean hydrogen
- Create social interest and promote consumer information
- Allow and support clean hydrogen trading and accelerate the emergence of markets
- All of the above

2. To what elements must the hydrogen certificate extend: *

- Hydrogen
- End-products (Green steel, green fertilizer, green cement, etc.)
- Both

3. What should be the basis of hydrogen certificates?

- Colour-based (green, blue, yellow,red) (Skip to question 6)
- Carbon intensity-based (no carbon, low carbon, high carbon)

4. Considering the various hydrogen production methods provided in the options - Which of the following can be classified as no-carbon hydrogen? (Please tick the options deemed appropriate; There will be a follow-up question on low-carbon hydrogen)
Check all that apply.

- Hydrogen produced via electrolysis using grid electricity
- Hydrogen produced via electrolysis using renewable electricity
- Hydrogen produced via electrolysis using electricity produced by nuclear power plants
- Hydrogen produced via natural gas
- Hydrogen produced via natural gas and CCS
- Hydrogen produced via coal gasification
- Hydrogen produced via coal gasification and CCS
- Hydrogen produced via biomethane
- Hydrogen produced via thermochemical conversion of biomass, including MSW
- Hydrogen produced via biological processes like Dark Fermentation

5. Considering the various hydrogen production methods provided in the options - Which of the following can be classified as low-carbon hydrogen? (Please tick the options deemed appropriate)
Check all that apply.

- Hydrogen produced via electrolysis using grid electricity
- Hydrogen produced via electrolysis using renewable electricity
- Hydrogen produced via electrolysis using electricity produced by nuclear power plants
- Hydrogen produced via natural gas
- Hydrogen produced via natural gas and CCS
- Hydrogen produced via coal gasification
- Hydrogen produced via coal gasification and CCS
- Hydrogen produced via biomethane
- Hydrogen produced via thermochemical conversion of biomass, including MSW
- Hydrogen produced via biological processes like Dark Fermentation

6. Transportation of hydrogen over long distances via compression or liquefaction is * not financially feasible. For which of the following should there be a separate certification scheme:

- Ammonia
- Liquid Organic Hydrogen Carriers
- Both
- None

7. What should be the System boundary within the supply chain for emissions * accounting for hydrogen?

- Only at the hydrogen production stage Includes hydrogen production and storage
- Includes hydrogen production, storage, and transportation
- Includes hydrogen production, storage, transportation, and conversion into hydrogen carriers
- Modular approach to certifying at various stages of supply chain

8. What elements constitute emissions from the hydrogen production stage? (Please tick the options deemed appropriate)
Check all that apply.

- Emissions from raw material acquisition (coal, natural gas, water)
- Emissions during raw material transportation stage
- Emissions during hydrogen production process

9. To ensure certificates contain sufficient information for consumers and policymakers, what information should hydrogen certificates incorporate? (Please tick the options deemed appropriate)

- Check all that apply.
- Source of electricity/fuel used
- Site of electricity/fuel production
- Mode of transportation of the fuel
- Time stamping of electricity produced
- Electrolyser manufacturing date
- Type of electrolyser
- Site of electrolyser
- Source of water
- Additional electricity procured to purify the water and its source

10. Should verification of all data be performed by:
Mark only one option

- Central authority/nodal agency
- Independent third party
- Proof of consensus (among stakeholders in the value chain)

11. Should green hydrogen certificates be interlinked with Renewable Energy Certificates?
Mark only one option.

- Yes
- No

12. Should there be a feature of floor and ceiling price for hydrogen certificates? *
Mark only one option.

- Yes
- No

13. A credible hydrogen tracking framework will have financial implications. Therefore, it is necessary to implement a cost-effective tracking system that avoids administrative burdens. Which of these approaches will fall in this bucket:
Mark only one option.

- GIS-tagged portal
- Blockchain-based decentralized portal
- Centralised authority-based portal

14. There is a need for a robust tracking system. In this regard, how should the hydrogen certificate be traded?
Mark only one option.

- Together
- Individually

15. Should there be a presence of penalties/fines and more for flouting the certification parameters?
Mark only one option.

- Yes
- No

VASUDHA FOUNDATION
Green ways for a good earth!

CISRS House, 14, Jangpura B, Mathura Road, New Delhi – 110 014, India

vasudha-foundation.org
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