
Growing Green Hydrogen Ecosystem

# Best Practices in Green Hydrogen Standards & Regulations Development:

## EU Case Study and Mapping to India

Prepared by

PMANIFOLD in consortium with Indian Institute of Technology Madras, Royal HaskoningDHV Enhancing Society Together

Supported by

International PtX Hub, giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, igef Indo-German Energy Forum

COVERAGE

## Introduction

- Global Hydrogen Landscape
- India Green Hydrogen Value Chain
- Areas for Green Hydrogen Standards (across value chain)

## EU Case study

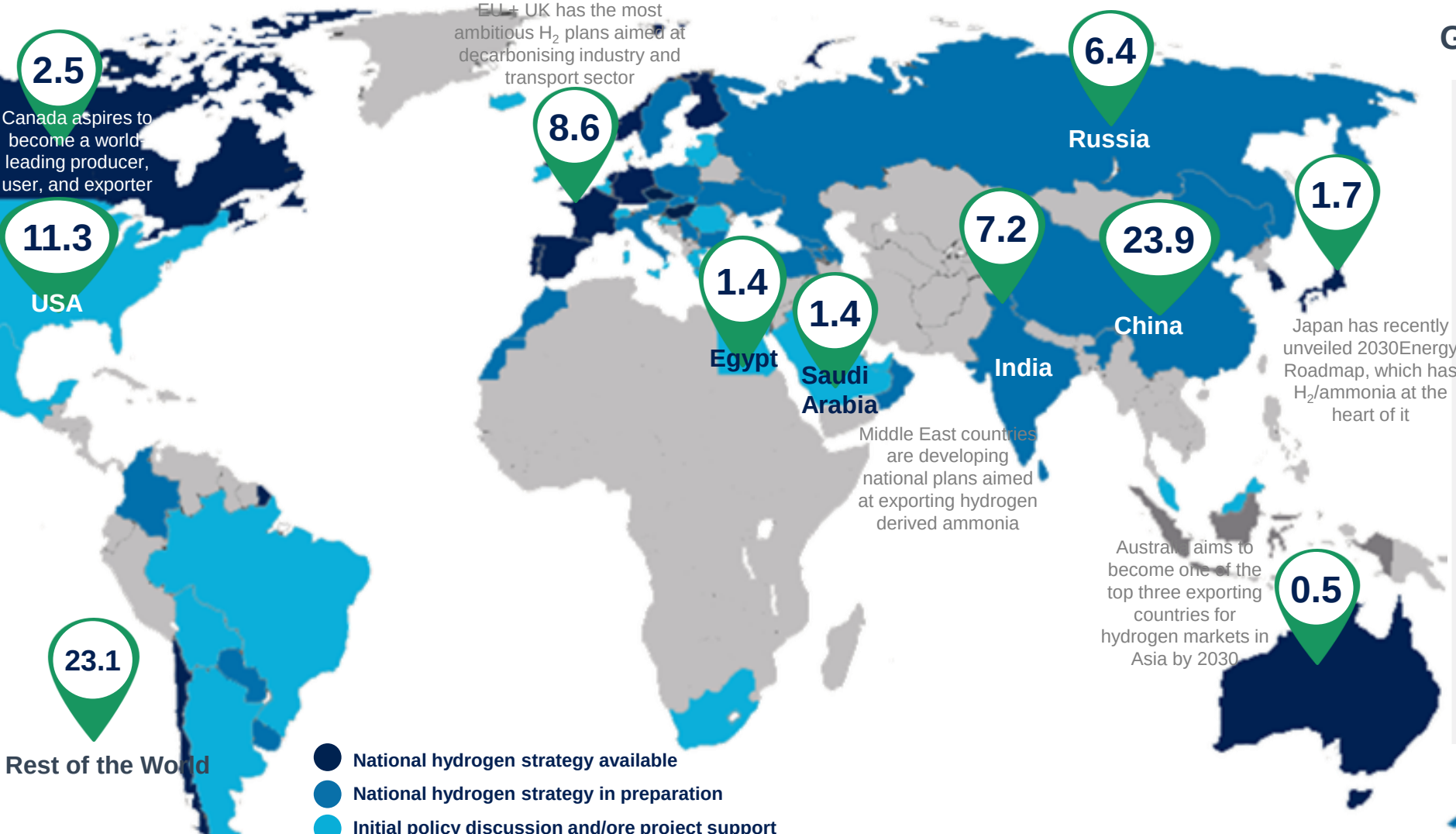
- EU evolving Strategy on Green Hydrogen
- $H_2$ Regulations: RED II to RED III
- Evolving (Green) H2 Standards
- $H_2$ Certifications
- Key Take aways for India

## India Mapping

- Mapping Existing International and Indian Standards
- Green Hydrogen standards importance for India

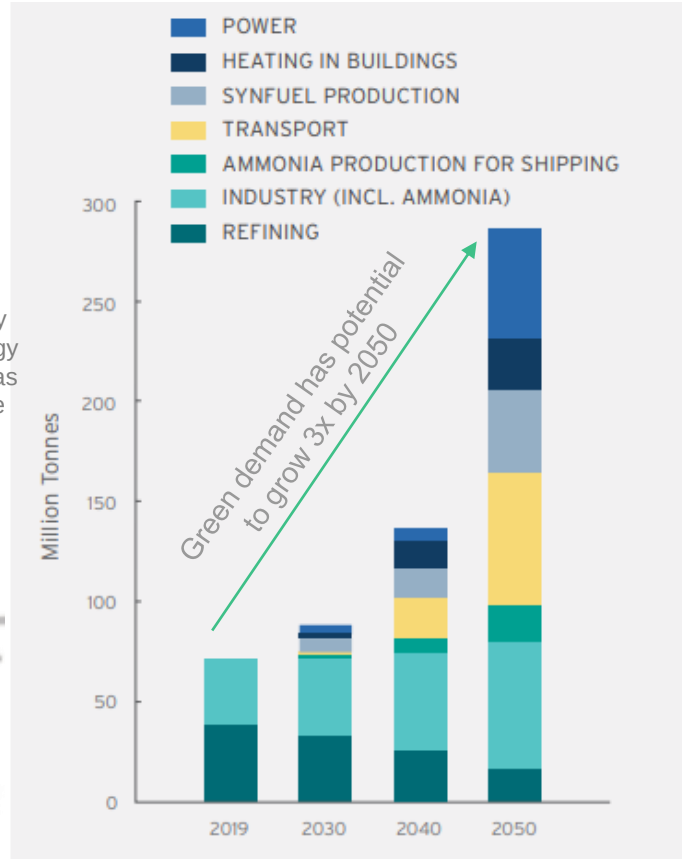
# Global Hydrogen Landscape

**Hydrogen**
Potential game changer for global emission reductions



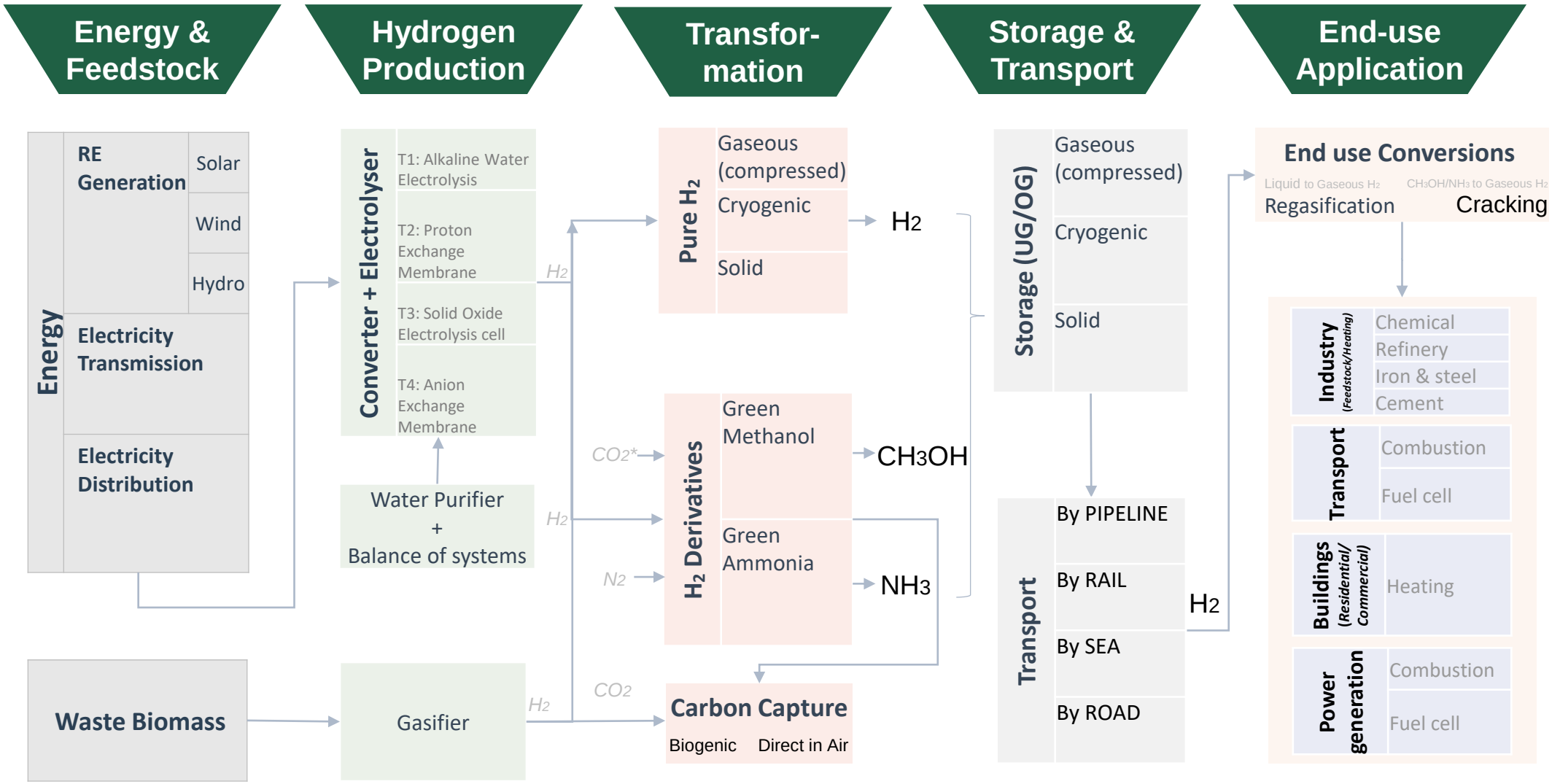

*Source: IEA Statista, 2021*
*Consumption unit: Million Tonnes/Year*

## Global Hydrogen Demand Outlook




*Source: World Energy Council, 2021*

# India Green Hydrogen Value Chain




*Source: Prepared by pManifold, IITM, & RHDHV*

** Either directly captured or through sustainable biomass route*

# Areas for Green Hydrogen Standards (across value chain)

## Energy & Feedstock

**Electricity Generation**

- Safety of electrical installations
- Electricity quality aspects
- Performance including efficiency, durability, and safety

**Electricity Transmission & Distribution**

- Communication protocols
- Interoperability and reliability
- Physical asset management
- Design, installation, & operation of electrical distribution systems

## Hydrogen Production

**Electrolyser**

- Connection devices
- Assemblies
- Materials & test protocols
- Stack design, construction, O&M
- Electricity grid connection

**Water Purification**

**Air Separator Unit**

**Balance of system**

- Temperature sensor
- Ventilation system
- Hydrogen gas detection system
- Pressure sensor
- Fire detection system
- Heat detection
- Water leak detection system

## Transfor-mation

**$H_2$ Compressors**

**$H_2$ Embrittlement**

- Metallic materials compatibility
- Susceptibility
- Measurement

**Carbon capture & Utilization**

**Receptacles**

**Piping and Pipelines**

## Storage & Transport

**Geological/Underground Industrial Tank**

**Above ground Industrial Tank**

- Corrosion Protection
- Fire alarm and detection system
- Hazard communication
- Portable fire extinguisher
- Emergency shut-off valves/controls
- Venting of hydrogen system
- Weather protection
- Gauges & Fittings

## End-use Application

**Transport/Stationary Power**

**Fuel-cell based Application**

- Fuel cell stack modules
- Air delivery & Cooling Systems
- Battery Module
- Gauges & Fittings
- Auxiliary power systems
- Remote diagnostic system
- Heat exchanger/radiator

**Pure $H_2$/$H_2$-blended Application**

**Refueling/Dispensing System**

- Pressure Relief Device/Regulator
- Fuel Lines and Piping Systems
- Gauges & Fittings
- Heat exchanger/radiator

**Industry**

- Turbine
- Product Handling

## Safety & Reliability

- Safety
- Material compatibility
- Leakage
- Odorisation

## Sustainability

- Emission

## Performance

- Measurement
- Efficiency
- Certification
- Durability
- Cost

## Gas Quality

- Blend
- Purity
- Variations

## Design

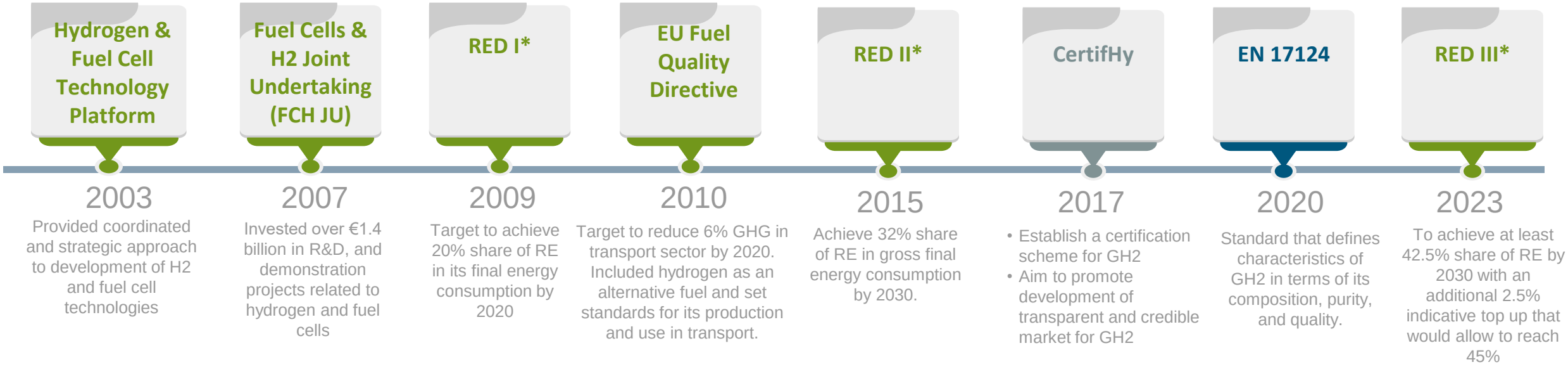
- Equipment/Component
- Connection devices
- Metal

# European Union Case study

Green Hydrogen Regulations, Standards and Certifications

# EU evolving Strategy on Green Hydrogen

## Right Mix of Directives/ Regulations, Tech. Standards, and Certifications




### Directives & Regulations

- Legal and regulatory procedures
- Essentials to enable project realization which meets the required quality and emission criteria
- **E.g., RED II**

Mandatory

### Technical Standards

- Includes several regional; and international standardisation Committees
- Responsible for hydrogen standardisation topics along the entire hydrogen value chain
- **E.g., CEN, ISO, IEC**

### Certifications

- **Guarantee of origins (GOs)** and additional environmental attributes
- Reliable tool for consumers to track
- **E.g., CertifyHY**

Voluntary

** Guarantee of Origin (GO) is closely related to RED and is a mechanism to track and verify the origin and quantity of renewable energy produced in EU. It.is used by energy suppliers and consumers throughout the EU to track and verify the origin of renewable energy.*

# H2 Regulations: *RED II to RED III*

**RED II Delegated Acts on H2 (2015)**

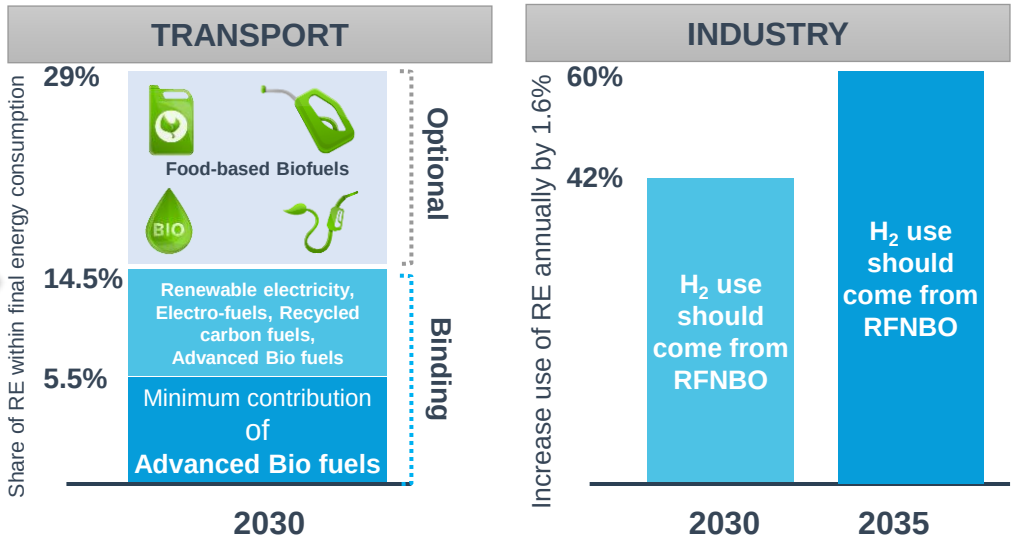
By 2021, Achieve **70%** reduction in GHG emissions compared to applicable benchmark for fossil equivalents

**DA Article 27** sets out detailed requirements for sourcing renewable electricity (EU-internal and outside) to be used in the production of Renewable Fuels of Non-Biologic Origin (RFNBO), including renewable $H_2$ :

- ✓ **Renewability**: Are produced using fully renewable energy (no biomass or nuclear energy)
- ✓ **Additionality**
- ✓ **Temporal correlation**
- ✓ **Geographical correlation**

2021/0218(COD) - 14/09/2022 - Renewable Energy Directive (europa.eu)

**RED III 2030 targets considering $H_2$ (2021)**




***RFNBO**: Renewable Fuel of Non-biological Origin*
***RED**: Renewable Energy Directive*

**Source**: https://www.consilium.europa.eu/en/press/press-releases/2023/03/30/council-and-parliament-reach-provisional-deal-on-renewable-energy-directive/

# Evolving (Green) H2 Standards

## Energy & Feedstock

**CEN-CLC/JTC 6 - "Hydrogen in Energy systems"**

Research ongoing

## Hydrogen Production

**Balance of system**
- ISO/TC 118/SC 6
- ISO/TS 19883:2017

**Electrolyser**
- ISO 22734:2019

**Safety**
- ISO/TC 193 – in preparation
- ISO/AWI 22734-1
- ISO/TR 16922 Natural gas - Guidelines for odorizing gases

- Stack design
- Clarifying emissions threshold associated by different hydrogen production technologies

## Transfor-mation

**$H_2$ absorbed in reversible metal hydride**
- ISO 16111:2018

**Cryogenic vessels and specific hydrogen technologies applications**
- CEN/TC 268

- Conversion services (liquefaction, (de)hydrogenation, purification, etc.).

## Storage & Transport

**Gas cylinders**
- EN 17533:2020

**Gas infrastructure**
- 17649:2022

**Safety aspects**
- ISO 26142 :2010

**Gas cylinders for stationary storage**
- ISO/CD 19884-1:3 general requirements, materials and pressure estimation methods

- Performance requirements and tests for valves for hydrogen/gas transportation in pipelines

**Road vehicles**
ISO 19881:2018
ISO 13985:2006
EN ISO 17268

ISO/CD 19887
ISO/AWI 19885-1:3
ISO/AWI 17268-1

- Methanol and ammonia norms for utilization as transport fuel.

- Safety/pressure limits in H2 transportation.

## End-use Application

**Industry (heating)**
- CEN/TC 234- WG11
- Max. hydrogen content allowed /guaranteed for end-use

- Feedstock labelling of renewable / low carbon ammonia

**In place** — Standard published

**In preparation** — Standardisation topic is addressed

**To be identified** — No standardisation topic nor Technical Committee identified

# Existing Green Hydrogen Certification in Europe

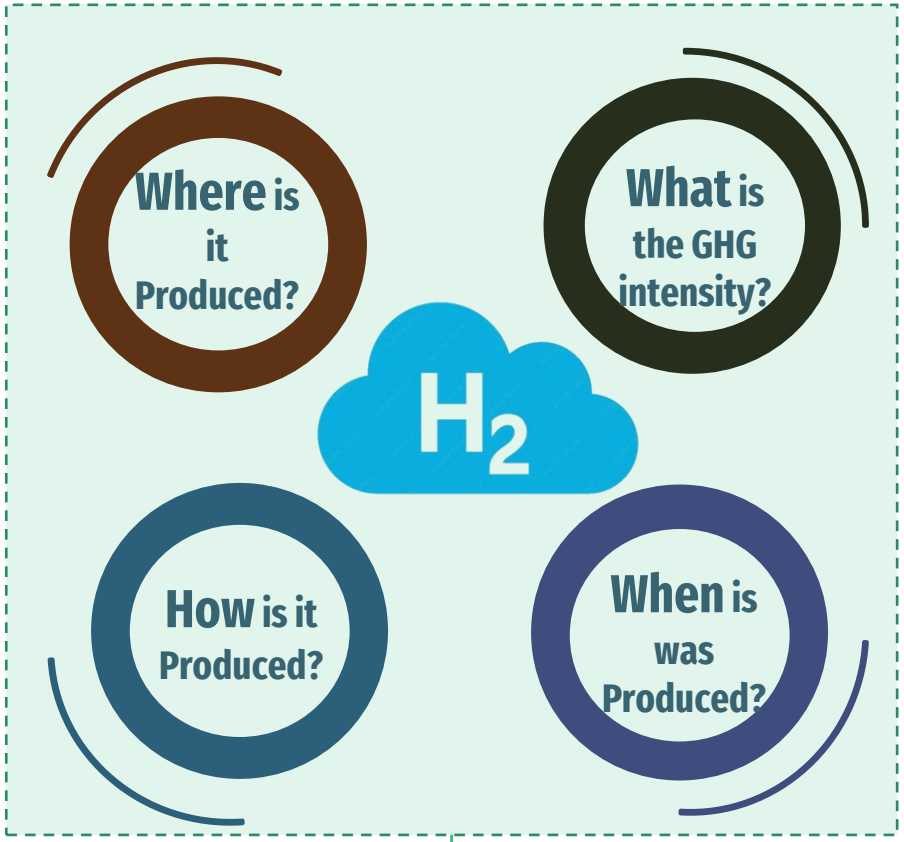
CertifHy™ is currently developing an EU Voluntary Scheme for the certification of hydrogen as RFNBO according to the European Renewable Energy Directive.*

**OBJECTIVE**

to provide a standardized certification system for green hydrogen, verifying its renewable origin and providing a guarantee of sustainability

**ESTABLISHMENT**

helped to increase the credibility of the green hydrogen market and provide assurance to customers that the hydrogen they are purchasing is produced from renewable sources.



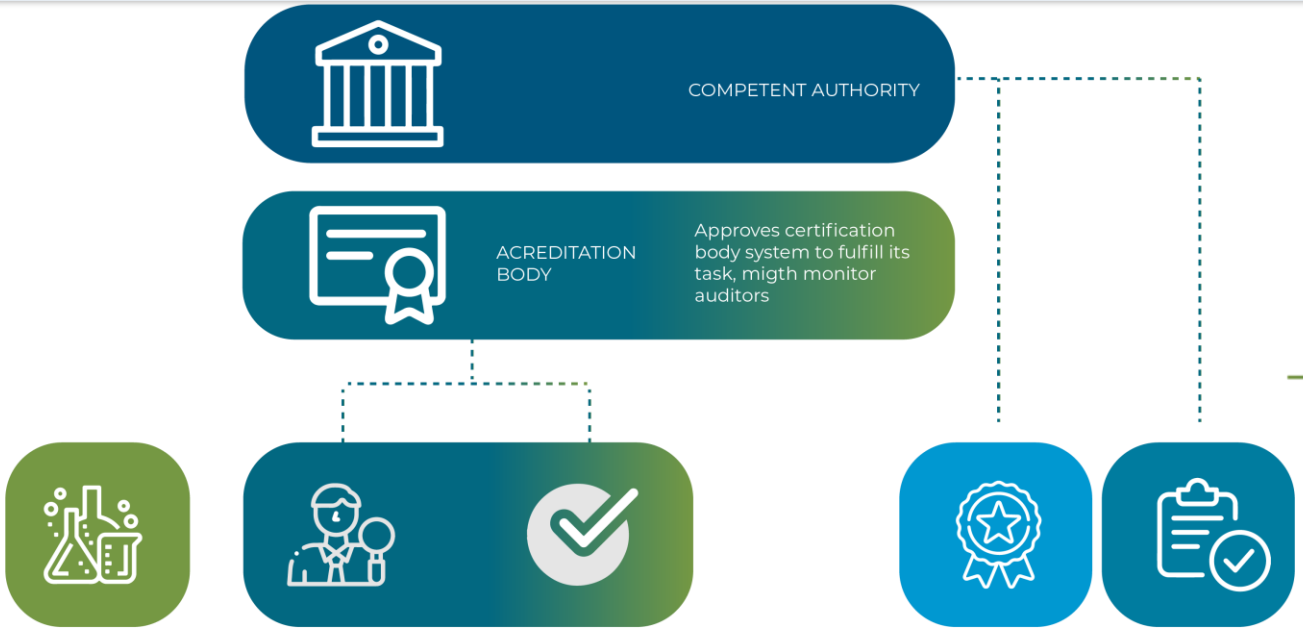

CertifHy™ **Green Label**

CertifHy™ **Low Carbon**

**CertifHy™ Voluntary Scheme **is pending** recognition by the European Commission as EU Voluntary Scheme for RFNBO*

*Source: HOME - CERTIFHY*

# Implementation Mechanism for CertifHy




| Stakeholder | Tasks & Roles |
|---|---|
| Competent Authority | Managing entity, Governance |
| Accreditation Body | Accreditation |
| Auditor | Assessment of GO Compliance |
| Certification Body | Certification of GO Compliance |
| Issuing Body | GO Issuance |
| Registry Administrator | Registration Transactions |

COVERED BY

CertifHy & Stakeholder platform

(+800) Organisations represented by individual members

CERTIFICATION BODIES

TÜV SÜD

Today and more soon

CertifHy

OVERALL CONTROL SYSTEM | PHISICAL HYDROGEN FLOW | REGISTRY SISTEM

ISSUING BODY AND CONTROL OF CERTIFICATION | CERTIFICATION PROCEDURE

*Source: HOME - CERTIFHY*

# Key Takeaways for India

## REGULATIONS

- India’s GH2 export potential (equipments, services, GH2) to the EU will depend on **complying with the EU's rules on renewable hydrogen production**
- Transport and industry targets of the RED II-revision in the EU will drive the demand for GH2 in the region, and India could benefit from this if it can **produce and export renewable hydrogen that meets EU's standards**
- Clear and consistent **regulatory framework** is necessary to drive growth of GH2 market, including incentives and support schemes for GH2 production, research and development, and infrastructure deployment

## STANDARDS

- Standardization of **electricity grid connections, Power to X technologies, and gas quality aspects** is crucial for GH2 production. Existing standards for the design and use of H2 blends also need to be updated
- Standards for vehicle **on-board H2 storage** and safe integration, as well as H2 **propulsion systems and refueling infrastructure/processes**, are necessary for the transport sector
- **Safety** is a top priority, and sensing technologies need to provide reliable and comparable results when measuring and metering hydrogen's chemical and physical properties

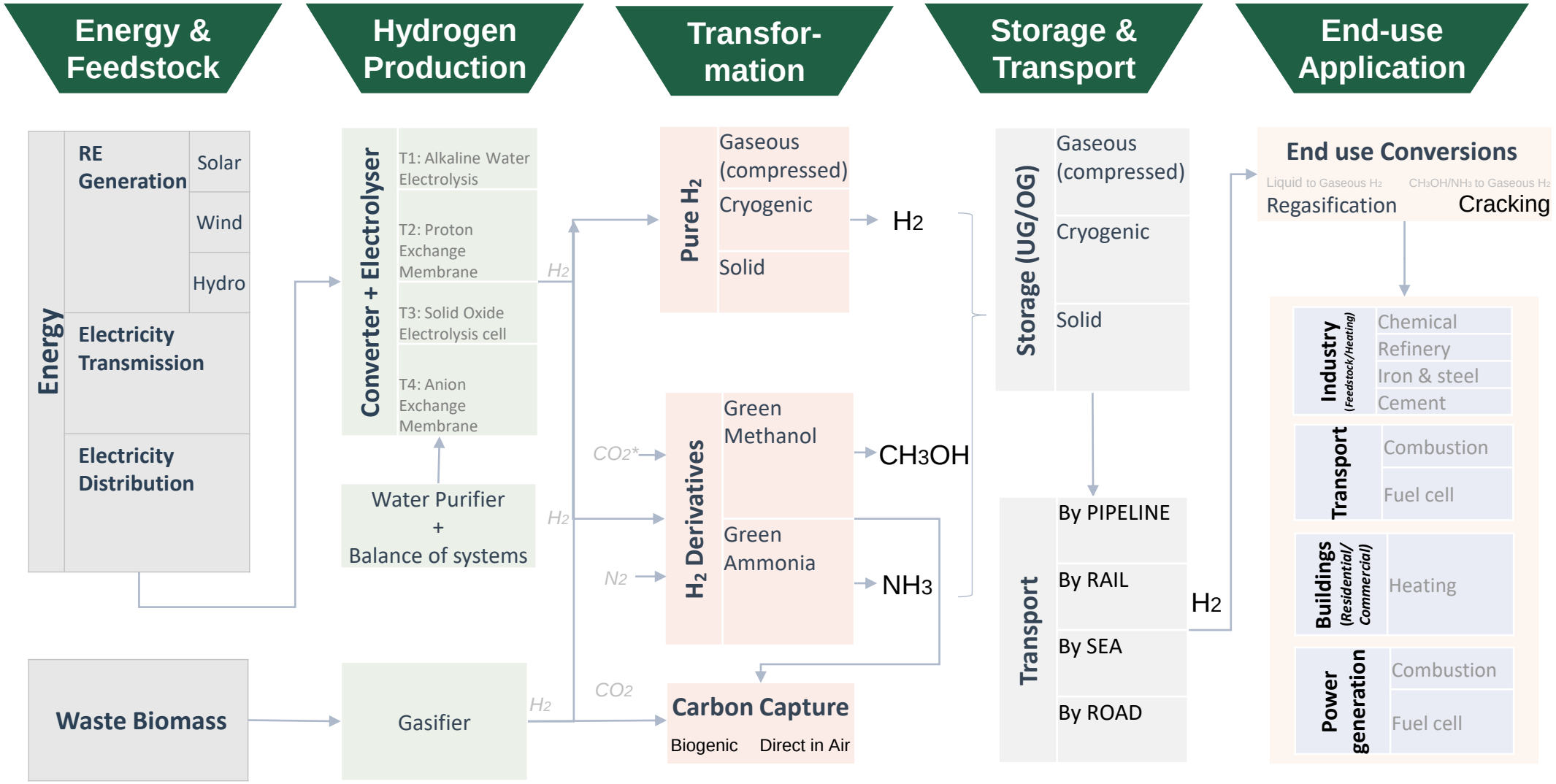
## CERTIFICATIONS

- Reliable and efficient **Guarantees of Origin** (GOs) system is essential for the development of renewable and low carbon H2 market
- **CertifHy** GH2 is H2 originating from renewable sources and having GHG balance below a defined threshold. It is pending EU Voluntary Scheme for the certification of hydrogen as RFNBO compliant with REDII and REDIII Delegated Acts requirements

# India Mapping

Progress on Green Hydrogen Standards Development

# Mapping Existing International and Indian Standards

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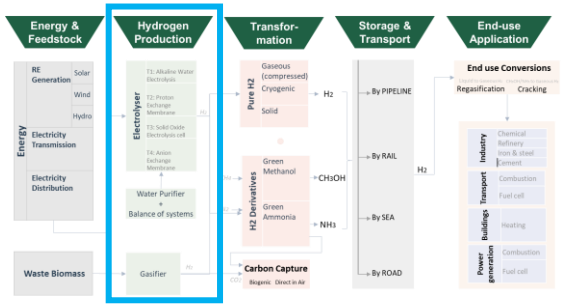
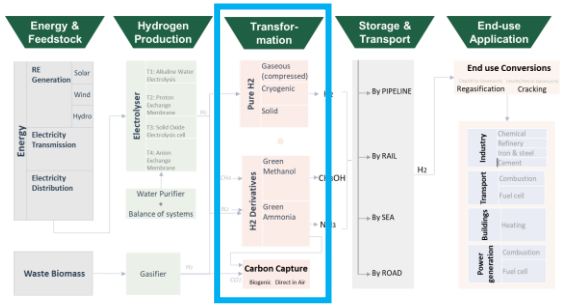
# Hydrogen Production




| Sub Elements L1 | Sub Elements L2 | International Standards/ Guidelines | Country | Indian standards | Description |
|---|---|---|---|---|---|
| **Electrolysers** | $H_2$ Generator | ISO 22734:2019 | International | - | $H_2$ generators that use a variety of feedstocks, including natural gas, biogas, and methanol. |
| | $H_2$ Generators: Design, Manufacturing, Testing, and Commissioning | ISO 22734: 2019 | International | **IS 16509: 2020** | $H_2$ generators using water electrolysis – industrial, commercial, and residential applications |
| | $H_2$ fuel cell generators: System Efficiency, Durability, Safety | ISO 16110-1:2007 | International | **IS 16512-1:2007** | $H_2$ generators using fuel processing technologies |
| | Metrology: Efficiency | JRC 2021 | EU | | Harmonized protocols for testing of low temperature water electrolysers |
| **$H_2$ Production Plants** | Steam Reformer | CGA H-10 | US | - | Combustion safety for steam reformer operation |
| | Piping | ASME B 31.12 | US | - | $H_2$ Industrial piping |
| | Plant Operations | EIGA Doc 122/04 | EU | - | Environmental impact of $H_2$ plant |
| | Small: Gaseous (<1,000 $Nm^3/h$) | EIGA Doc 155/09/E | EU | - | Best available techniques for $H_2$ production by SMR |
| | Large: Gaseous (>10,000 $Nm^3/h$) | EIGA Doc 220 | EU | - | Best available techniques for $H_2$ production by SMR |
| **Balance of Plants** | Component/ Equipment | ISO/TC 118/SC 6 | International | - | Systems for hydrogen drying, separation, compression and purification; product and functional standards for the components and operation of these systems |

** International standards list are not exhaustive and study is in progress*

# Hydrogen Transformation




| Sub Elements L1 | Sub Elements L2 | International Standards/ Guidelines | Country | Indian standards | Description |
|---|---|---|---|---|---|
| **$H_2$ Production Plants** | Compressed and Cryogenic Liquid $H_2$ Generation | NFPA 2 | US | - | $H_2$ technologies code |
| **$H_2$ Blending** | Natural Gas/Biomethane: Gas Infrastructure | EN 16726 (EN 16723-1) | EU | - | $H_2$ as blend with natural gas/biomethane (esp. Wobbe Index, Oxygen and total sulfur content, $H_2$ and relative density) |
| | | CEN/CLC JTC 6, ISO/TC 197, CEN/TC 234 | EU | - | $H_2$ quality in industry |
| | Converted/ Rededicated Gas Systems, Fuel | CEN/TS XXX (WI 00234096) | EU | - | Standards for $H_2$ purity and gas quality handling, including blending |
| **Fuel** | PEM FC applications | EN 17124 | EU | - | Methodologies for analysis and measurement of impurities in $H_2$, norms for quality of hydrogen to all utilization's way (including directing $H_2$ to NG pipelines) |
| **$H_2$ Blending: Natural Gas** | Metrology | EN ISO 6145 | EU | - | Preparation of calibration gas mixtures using dynamic volumetric methods |
| | Receptacles | EN ISO 10715 | EU | - | Natural Gas Sampling Guidelines |
| **$H_2$ Blending: Infrastructure** | Receptacles: Stationary | ISO 26142 : 2010 | International | **IS 16253 : 2016** | Leaks, damage, or corrosion |

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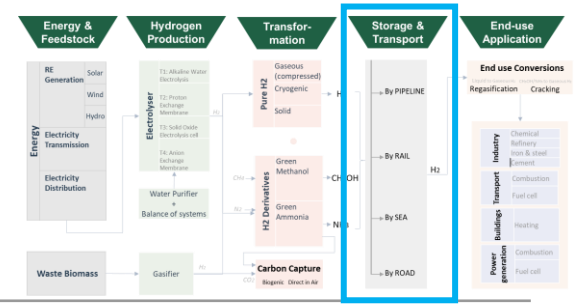
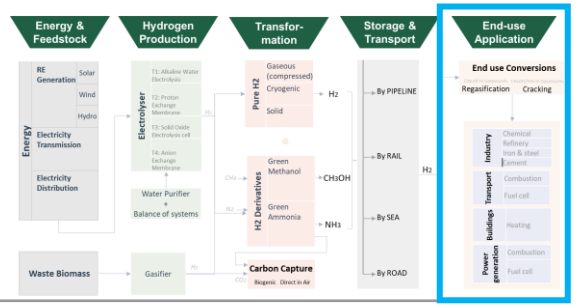
# Hydrogen Storage & Transport




| Sub Elements L1 | Sub Elements L2 | International Standards/ Guidelines | Country | Indian standards | Description |
|---|---|---|---|---|---|
| Storage | Gas Cylinders | EN ISO 11114-4 | International | - | Material testing standards |
| | Gas Cylinders | ISO/TC 58 | International | - | Compatibility of cylinder and valve materials with gas contents – metallic, non-metallic, plastic liners, |
| | Gas Cylinders | EN 17339 | EU | - | Fully wrapped carbon composite cylinders and tubes for hydrogen |
| | Gas Cylinders | EN 17533 | EU | **IS 8198 : 2004** | Cylinders and tubes for stationary storage of gaseous hydrogen |
| | Liquid $H_2$ | EIGA Doc 06/19 | EU | - | Safety in storage, handling and distribution of liquid $H_2$ |
| | Tanks | ASME STP/PT-005 | US | - | Design factor guidelines for high-Pressure composite $H_2$ tanks |
| | Tanks | CGA H-3 | US | **IS 5931 : 1970** | Standard for cryogenic $H_2$ storage |
| | Gas | NFPA 55 | US | - | Compressed Gases and Cryogenic Fluids Code |
| Transport | Pipes | ISO 3183 | International | **-** | Steel pipe for pipeline transportation systems |
| | Storage | ISO 16111: 2018 | International | - | Transportable gas storage devices- $H_2$ absorbed in metal hydride |
| | Gas Cylinders | CEN/TC 23 | EU | **IS 11114 : 2017** | Transportable Gas Cylinders |
| | Pipelines and Caves | CEN/TC 234 | EU | **-** | Gas infrastructure |
| | Pipes | EN 1555 | EU | - | Pipes/material - plastic pipes |
| Transport & Storage | Gas Infrastructure | CEN/TC 69 | EU | **IS 16749 : 2018** | Industrial valves |
| | Receptacles: Stationary | EN 437 | EU | | Gas families and test gases for $H_2$ |

** International standards list are not exhaustive and study is in progress*

# Hydrogen End-use Application




| Sub Elements L1 | Sub Elements L2 | International Standards/ Guidelines | Country | Indian standards | Description |
|---|---|---|---|---|---|
| **Industry** | Heat | EN 16726 | EU | - | Max. hydrogen content allowed /guaranteed for end-use, |
| | Heat | EN 16726 | EU | - | Wobbe index, oxygen |
| | Heat | EN 437 | EU | - | Appliance testing - missing test gases |
| | Heat | CEN/TC 234 - WG11 | EU | - | Purity of hydrogen/ impurities like inert gases/Wobbe index from repurposed infrastructure |
| | Heat | ISO 14687:2019 | International | - | Purity of volatile blends max 30 % |
| | Heat | EN 16726 | EU | - | Gas fired central heating boilers |
| | Heat | CEN/TC 237, ISO/TC 30 | EU | **IS 23828 : 2013** | Gas metering devices metrology - measurement |
| **Transport** | Fuel Cell | CEN/TC 268 | EU | **-** | Hydrogen fuel - product specification and quality assurance - proton exchange membrane (PEM) fuel cell applications for road vehicles |
| | Fuelling stations, installation - Refueling | EN 17127 | EU | **IS/ISO 13985 : 2006** | Slow fuelling stations – need fueling protocol and requirements, |
| | installation - Refuelling | CEN/TC 268 | EU | **IS17268 : 2020** | Gaseous hydrogen land vehicle refuelling connection devices, outdoor hydrogen refuelling points dispensing gaseous hydrogen and incorporating filling protocols |

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# Green Hydrogen Standards Importance for India

India has potential to become a major exporter of $GH_2$ due to abundance of RE resources. Local manufacturers can supply necessary equipment and technologies for $GH_2$ production, such as electrolysers, etc.

International standard landscape for $GH_2$ is still evolving, and there is an opportunity to play a leading role in shaping these standards

India can work collaboratively with other countries and organizations *(leveraging its G20 Presidency)* to develop common standards and certifications for $GH_2$, which can help facilitate trade and promote adoption of $GH_2$ on global scale

Countries with focus on R&D and component manufacture are observed to be leaders. India should focus on it's $GH_2$ R&D

Value chain specific investment channelisation

India has potential to direct standards on solar capture for electrolysis application

Pivotal to direct R&D to the most challenging part of the value chain: Storage & Distribution

# Thank you